

# Secular trends in body mass index and the prevalence of overweight and obesity among children and adolescents in Shandong, China, from 1985 to 2010

Zhang Ying-Xiu<sup>1</sup>, Wang Shu-Rong<sup>2</sup>

<sup>1</sup>Shandong Center for Disease Control and Prevention, 16992 Jingshi Road, Jinan, Shandong 250014, China

<sup>2</sup>Shandong Blood Center, 22 Shanshidong Road, Jinan 250014, China

Address correspondence to Zhang Ying-Xiu, E-mail: sdcdezxy@163.com

## ABSTRACT

**Background** There is strong evidence of a positive secular trend in body mass index (BMI) and the prevalence of obesity has increased substantially over the last several decades. However, no studies on this trend have been reported in Shandong Province, China. The present study assessed the decennial change in BMI in Shandong Province during the past 25 years and the prevalence of overweight and obesity among children and adolescents.

**Methods** The BMI of children and adolescents aged 7–18 was calculated using data from five national surveys on students' constitution and health carried out by the government in 1985, 1995, 2000, 2005 and 2010 in Shandong Province, China. The distribution of BMI was reported, and the prevalence of overweight and obesity was obtained according to the screening criteria of overweight and obesity for Chinese students using BMI [Working Group on Obesity in China (WGO) standard]. Overweight and obesity prevalence were also computed using the International Obesity Task Force (IOTF) cutoffs.

**Results** In the past 25 years, the  $P_{50}$  (50th percentile) of BMI increased. The average increments of BMI were 2.18 kg/m<sup>2</sup> for boys and 1.21 kg/m<sup>2</sup> for girls, respectively. The prevalence of overweight and obesity increased rapidly: using WGO standard, the prevalence of overweight increased from 1.91% for boys and 2.02% for girls in 1985 to 17.34% for boys and 11.97% for girls in 2010, and the prevalence of obesity increased from 0.27% for boys and 0.23% for girls in 1985 to 15.83% for boys and 7.12% for girls in 2010; using IOTF standard, the prevalence of overweight increased from 1.54% for boys and 1.27% for girls in 1985 to 19.06% for boys and 13.42% for girls in 2010, and the prevalence of obesity increased from 0.04% for boys and 0.03% for girls in 1985 to 9.33% for boys and 2.42% for girls in 2010, respectively.

**Conclusions** The average value of BMI has increased over time; overweight and obesity among children and adolescents have become a serious public health problem. Comprehensive evidence-based strategies of intervention should be introduced, including periodic monitoring.

**Keywords** body mass index, obesity, overweight, prevalence

## Introduction

The prevalence of obesity has increased substantially over the last several decades and indications are such that this trend will continue not only in developed but also in developing countries.<sup>1–7</sup> Obesity has become an increasingly important public health problem in children and adolescents. Many of the outcomes associated with obesity that were previously thought of as diseases of adults are now affecting children as well. Childhood obesity increases the risk of

obesity in adulthood and is associated with cardiovascular disease risk factors such as hypertension, diabetes mellitus and dyslipidemia.<sup>8–10</sup> Previous reports suggested that the epidemic of childhood overweight and obesity in China has

Zhang Ying-Xiu, Associate professor in public health

Wang Shu-Rong, Research assistant

spread all over the country since the end of twentieth century, although there are differences among different regions.<sup>11</sup> The geographical distribution of childhood obesity in China is mainly caused by the disparity in the socioeconomic status (SES) related to dietary and lifestyle changes in modern China.<sup>12</sup>

Body mass index (BMI) has recently been recommended as an important index for estimating body fat and the prevalence of obesity and may be used to evaluate adiposity in adolescents.<sup>13,14</sup> The International Obesity Task Force (IOTF) cutoffs are recommended for use in international comparisons of the prevalence of overweight and obesity. Considering the differences in body composition across different ethnic groups, the Working Group for Obesity in China (WGOC) organized by International Life Science Institute Focal Point in China conducted an analysis on BMI of children and adolescents aged 7–18 years, the age-, sex-specific BMI 85th and 95th percentiles were developed, respectively, by using the B-spline curve to adjust the curves passing through a BMI of 24 and 28 kg/m<sup>2</sup> (the cutoff points used for Chinese adults to define overweight and obesity, respectively) at 18 years of age, and a new BMI classification reference was recommended by WGOC in 2004.<sup>15</sup> This standard is the most appropriate one and has been applied extensively in recent years.

Shandong Province, located in the lower reaches of the Yellow River between 34°25' and 38°23'N latitude, and 114°25' and 112°43'E longitude, is an important littoral province in East China. Shandong Province is one of the birthplaces of Chinese Culture and is the hometown of Confucius, widely considered to be the greatest philosopher

in Chinese history. Particularly, since China adopted the policy of reform and opening up to the world, Shandong has maintained sustained and rapid economic growth. This article reports the changes in BMI and the prevalence of overweight and obesity among children and adolescents over the last 25 years (1985–2010) in Shandong Province, China.

## Subjects and methods

The study was approved by the Ethical Committee of the Shandong Center for Disease Control and Prevention, Shandong, China.

### Study population

Data for this study were obtained from five national surveys on students' constitution and health carried out by the government in 1985, 1995, 2000, 2005 and 2010 in Shandong Province, China. (In 1985, the government education and health department set up a system of National Surveys on Chinese Students' Constitution and Health. The first author is a member of the leading group in Shandong Province.) All subjects voluntarily joined this study with informed consents. The sample size of age groups of each survey is given in Table 1. The sampling method was stratified multistage sampling based on economic status, drawn from Jinan (the capital and the political, economic and cultural center of Shandong Province: this city has an area of 8227 km<sup>2</sup>, and a population of 6.81 million in 2010, the GDP per capita is 64 738 Yuan in 2010), Yantai (an eastern coastal and developed city, with an area of 13 739 km<sup>2</sup> and a population of

**Table 1** The sample size of the five surveys

Age (years)	1985		1995		2000		2005		2010	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
7.5	612	612	300	300	318	357	344	343	316	302
8.5	612	612	300	300	361	364	371	362	318	323
9.5	612	612	300	300	331	334	357	359	305	315
10.5	612	612	300	300	395	376	377	388	320	325
11.5	612	612	300	299	376	379	354	366	301	317
12.5	611	612	300	300	337	326	362	343	340	303
13.5	611	612	300	300	363	361	355	365	305	308
14.5	612	612	300	300	325	323	350	324	305	320
15.5	612	612	300	300	368	370	363	340	314	328
16.5	612	612	300	300	372	353	371	359	306	305
17.5	612	612	300	300	363	324	386	352	310	306
18.5	612	595	300	299	358	364	343	334	343	342
Total	7342	7327	3600	3598	4267	4231	4333	4235	3783	3794

6.97 million in 2010; people's living standards and seafood intake were relatively higher, the GDP per capita is 66 936 Yuan in 2010) and Jining (a western inland developing city, with an area of 11 000 km<sup>2</sup>, and a population of 8.08 million in 2010; people's living standards were relatively lower, the GDP per capita is 30 159 Yuan in 2010) as survey areas, and using randomly selected primary and secondary schools, the sample proportions in these three areas in each survey were equal. All of the subjects were primary and secondary students, covering the range from 7 to 18 years of age, and all of them were of Han ancestry that accounts for ~99.32% of the total population in Shandong. Most importantly, the schools from which the subjects were selected were relatively stable since 1985, and the method and quality control of measurements of five surveys was the same.<sup>16</sup>

### Measurements

All subjects had a thorough medical examination before the measurements were taken, and overt disease or physical or mental deformities were excluded. From 1985 to 2010, the apparatus recommended by Cameron<sup>17</sup> was used by doctors to measure height and weight, and the subjects were required to go barefoot and wore only their underwear. The age groups were divided following the criteria of 'exact age', so that, for example, cohort 7.5 (represented by '7.5' in the plots) designates students aged 7.0–7.9 years.

### Statistical analyses

The BMI of children and adolescents aged 7–18 was calculated from their height and weight, the distribution of BMI was reported, and the prevalence of overweight and obesity were obtained according to the screening criteria of overweight and obesity for Chinese students using BMI (Table 2). In order to provide information for comparison with other countries, the prevalence of overweight and obesity was also computed using the International Obesity Task Force (IOTF) cutoffs.<sup>18</sup> The statistical treatment was carried out using SPSS 11.0.

## Results

### Decennial change in BMI

The 5th, 50th and 95th percentile values of BMI for children and adolescents aged 7–18 years in 1985, 1995, 2000, 2005 and 2010 are given in Tables 3 and 4. In the past 25 years, the percentile values of BMI increased, and the average increments of 5th, 50th and 95th percentile values of BMI were 0.36, 2.18 and 7.81, register an average

**Table 2** BMI reference norm for screening overweight and obesity in Chinese children and adolescents (WGOC 2004)

Age (years)	Boys overweight	Boys obesity	Girls overweight	Girls obesity
7	17.4	19.2	17.2	18.9
8	18.1	20.3	18.1	19.9
9	18.9	21.4	19.0	21.0
10	19.6	22.5	20.0	22.1
11	20.3	23.6	21.1	23.3
12	21.0	24.7	21.9	24.5
13	21.9	25.7	22.6	25.6
14	22.6	26.4	23.0	26.3
15	23.1	26.9	23.4	26.9
16	23.5	27.4	23.7	27.4
17	23.8	27.8	23.8	27.7
18	24.0	28.0	24.0	28.0

increase of 2.56%, 13.06% and 39.34%, respectively, for boys, and 0.17, 1.21 and 4.64, and register an average increase of 1.34%, 7.41% and 23.55%, respectively, for girls. The average increments of BMI were bigger for boys than girls. The difference in BMI between 1985 and 2010 is mainly at the  $P_{95}$  (the 95th percentile) level; in contrast, the difference at the  $P_5$  (the 5th percentile) level is not as evident. Figure 1 shows the increments of BMI for adolescents by age groups, the biggest increment was found in 12-year-old boys (3.61), a rate of 1.44 per decade, and 11-year-old girls (2.06), a rate of 0.82 per decade.

### Prevalence of overweight and obesity

Table 5 gives the overall overweight and obesity rates of children and adolescents aged 7–18 in different years. Using WGOC standard, the prevalence of overweight increased from 1.91% for boys and 2.02% for girls in 1985 to 17.34% for boys and 11.97% for girls in 2010, and the prevalence of obesity increased from 0.27% for boys and 0.23% for girls in 1985 to 15.83% for boys and 7.12% for girls in 2010. Using IOTF standard, the prevalence of overweight increased from 1.54% for boys and 1.27% for girls in 1985 to 19.06% for boys and 13.42% for girls in 2010, and the prevalence of obesity increased from 0.04% for boys and 0.03% for girls in 1985 to 9.33% for boys and 2.42% for girls in 2010. The overall prevalence of overweight and obesity increased from 2.18% (boys) and 2.25% (girls) in 1985 to 33.17% (boys) and 19.08% (girls) in 2010 by WGOC reference norm and from 1.58% (boys) and 1.30% (girls) in 1985 to 28.39% (boys) and 15.84% (girls) in 2010 by IOTF reference norm, respectively.

**Table 3** The 5th, 50th and 95th percentile value for BMI of boys for different years (kg/m<sup>2</sup>)

Age (years)	1985			1995			2000			2005			2010		
	P <sub>5</sub>	P <sub>50</sub>	P <sub>95</sub>	P <sub>5</sub>	P <sub>50</sub>	P <sub>95</sub>	P <sub>5</sub>	P <sub>50</sub>	P <sub>95</sub>	P <sub>5</sub>	P <sub>50</sub>	P <sub>95</sub>	P <sub>5</sub>	P <sub>50</sub>	P <sub>95</sub>
7.5	13.12	14.75	16.76	13.33	14.98	19.02	13.46	15.37	22.66	13.35	15.44	21.66	13.41	16.27	23.44
8.5	13.36	14.91	17.26	13.57	15.38	19.89	13.47	15.84	22.45	13.59	16.07	23.43	13.53	16.64	24.22
9.5	13.59	15.18	17.58	13.74	15.65	20.50	13.81	16.18	22.92	13.69	16.61	23.32	13.75	17.63	24.79
10.5	13.70	15.39	18.33	13.97	15.94	21.29	14.36	17.23	25.08	13.96	17.70	25.97	14.32	18.38	26.23
11.5	13.91	15.75	18.91	13.99	16.59	20.85	14.44	17.57	25.44	14.14	18.01	26.70	14.66	19.12	28.60
12.5	14.29	16.31	19.74	14.47	16.99	23.48	14.38	17.83	27.07	14.80	18.55	27.75	15.42	19.92	29.25
13.5	15.08	17.20	20.40	14.84	17.68	23.88	15.41	18.39	26.42	15.22	19.21	28.10	15.86	19.04	29.51
14.5	15.47	17.96	21.23	15.74	18.52	26.01	15.87	19.12	26.97	15.74	19.68	28.32	16.14	19.91	28.80
15.5	16.09	18.78	22.11	16.21	19.35	26.55	16.18	19.52	28.33	16.22	19.82	28.30	16.52	20.79	30.11
16.5	17.04	19.39	22.63	16.71	19.89	25.73	16.79	20.03	28.37	16.99	20.18	27.89	16.92	21.13	30.57
17.5	17.39	19.91	23.13	17.58	20.53	25.99	16.96	20.69	28.35	16.98	20.50	28.19	17.10	21.42	29.90
18.5	17.94	20.27	23.26	17.56	20.31	26.89	17.51	21.23	28.49	17.63	20.85	28.61	17.66	21.67	29.66

**Table 4** The 5th, 50th and 95th percentile value for BMI of girls for different years (kg/m<sup>2</sup>)

Age (years)	1985			1995			2000			2005			2010		
	P <sub>5</sub>	P <sub>50</sub>	P <sub>95</sub>	P <sub>5</sub>	P <sub>50</sub>	P <sub>95</sub>	P <sub>5</sub>	P <sub>50</sub>	P <sub>95</sub>	P <sub>5</sub>	P <sub>50</sub>	P <sub>95</sub>	P <sub>5</sub>	P <sub>50</sub>	P <sub>95</sub>
7.5	12.95	14.38	16.29	12.81	14.57	17.71	13.09	15.00	19.62	12.90	14.95	19.96	13.18	15.79	21.43
8.5	12.80	14.60	16.88	12.88	14.65	17.73	13.30	15.19	20.39	13.07	15.37	20.98	13.01	15.92	21.52
9.5	13.19	14.85	17.43	13.07	15.01	18.97	13.26	15.58	21.22	13.32	15.80	21.98	13.22	15.95	22.39
10.5	13.47	15.23	18.04	13.44	15.59	20.17	13.55	16.55	22.56	13.15	16.73	23.09	13.86	17.01	23.65
11.5	13.69	15.69	19.00	13.56	16.38	21.93	13.94	17.14	23.75	13.65	17.22	24.83	14.22	17.75	25.01
12.5	14.05	16.56	20.36	14.34	17.37	23.31	14.44	17.68	23.65	14.67	17.76	25.89	15.15	18.60	26.33
13.5	15.20	17.97	21.13	14.88	17.99	23.78	14.96	18.12	25.60	15.05	18.89	27.31	15.22	19.03	25.86
14.5	15.71	18.64	22.44	15.79	19.00	25.14	15.95	19.16	25.89	15.89	19.45	26.33	16.25	20.11	27.18
15.5	16.29	19.11	22.84	15.87	19.40	24.80	15.90	19.74	25.33	16.20	19.83	26.57	15.69	19.98	26.72
16.5	17.12	19.76	22.94	16.74	19.70	23.71	17.04	20.22	27.34	16.68	19.82	24.81	17.51	20.69	26.98
17.5	17.45	20.14	23.49	17.08	20.05	24.36	16.96	20.43	24.97	17.07	20.27	25.73	16.94	20.26	27.44
18.5	17.47	20.16	24.29	17.31	20.36	24.22	17.45	20.83	26.59	17.28	20.60	26.62	17.22	20.54	26.25

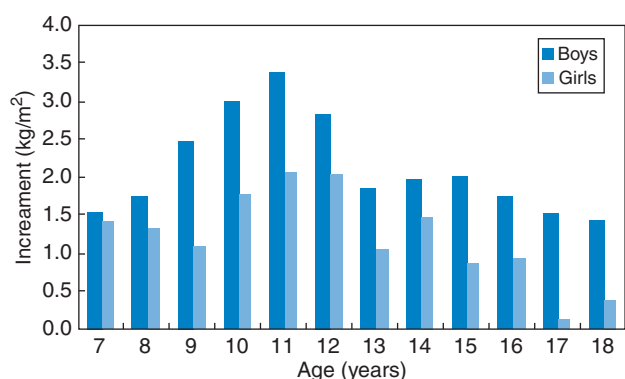
## Discussion

A secular trend in growth is an important biological phenomenon and has been well documented in many developed and developing countries. China is now experiencing a positive secular trend, which is reflected not only in faster growth in childhood, earlier puberty and steady increments in adult height, but also by dramatic changes in body shape.<sup>19</sup> These secular growth changes result from socio-economic development; however, they also have negative effects, as higher BMI may lead to hypertension, hyperglycemia, type 2 diabetes mellitus and other adulthood diseases,

such as the metabolic syndrome, which may even occur early in childhood and adolescence.<sup>20,21</sup>

The prevalence of overweight and obesity in children and adolescents is increasing rapidly worldwide. The World Health Organization describes obesity as 'one of today's most blatantly visible—yet most neglected—public health problems' and uses the term 'globesity' to reflect an 'escalating global epidemic of overweight and obesity'.<sup>22</sup> In the USA, the prevalence of obesity among children and adolescents aged 2–19 increased from 14.0% (boys) and 13.8% (girls) in 1999 to 18.2% (boys) and 16.0% (girls) in 2004.<sup>23</sup> In China, the prevalence of obesity reported by the National

Surveys on Chinese Students' Constitution and Health in 1985 were only 0.2 and 0.1% for boys and girls, and the prevalence of overweight was between 1 and 2% indicating no obesity epidemic at that time.<sup>24</sup> However, a rapid increase in the prevalence of overweight has been noticed since the early 1990s. The prevalence rates of obesity plus overweight reported by the National Surveys on Chinese Students' Constitution and Health had reached 25.4, 25.5, 17.0 and 14.3% in 2000 for boys aged 7–9 and 10–12 years, and girls aged 7–9 and 10–12 years, respectively.<sup>24</sup> Overweight and obesity in children and adolescents should no longer be regarded as variations of normality, but as a disease with an extremely high risk for future development of atherosclerosis and cardiovascular complications in adulthood. Preventing excess weight gain and obesity among children and adolescents is important in obesity control and will lead to a decreased risk of chronic diseases among adults.<sup>25</sup> Comprehensive strategies of intervention should include periodic monitoring, education on pattern of nutrition, oxygen-consuming physical exercises and healthy dietary behavior.



**Fig. 1** Increments of BMI for children and adolescents aged 7–18, 1985–2010.

The population distribution of childhood obesity is related to the SES. Studies from developed countries showed that the diet of the high SES groups usually consist of more vegetables and fruits which are less energy-dense than their low SES peers, high SES youths are less likely to be obese than their lower SES counterparts; in contrast, in developing countries such as China, high SES youths are more likely to be obese than their lower SES counterparts.<sup>12,26</sup> The traditional Chinese diet is shifting toward a diet with high fat, high energy density and low dietary fiber, these changes resulted in rapid increases in the prevalence of overweight and obesity and dietary-related chronic non-communicable diseases.<sup>27</sup> This environmental transformation is especially conspicuous in China with the increased availability and consumption of sugared products, such as candy, soft drinks and snacks, proliferation of fast food restaurants and the abundance of enticements that lead to reduced physical activity, such as watching television and playing computer games.<sup>28</sup> Television viewing besides reducing physical activity also leads to increased consumption of energy-rich foods through incessant commercial advertisement.<sup>29,30</sup> This study has shown that the prevalence of overweight and obesity among children and adolescents has a rapid increase from 1985 to 2010 in Shandong province, and the overall prevalence rates of obesity plus overweight were increased in multiple times when compared with those in 1985, from 2.18% (boys) and 2.25% (girls) in 1985 to 33.17% (boys) and 19.08% (girls) in 2010. The reasons include mainly over consumption of energy, serious inactivity and the lifestyle change from being active to sedentary, as well as the unhealthy living and dietary habits. The reasons why the increase in the prevalence of overweight and obesity appears to be greater in boys than girls in this context needs to be more clearly understood, so that effective intervention can be developed.

**Table 5** The prevalence of overweight and obesity of children and adolescents aged 7–18 for different years by Chinese and international standard

Year	Boys				Girls			
	Overweight <sup>a</sup> (%)	Overweight <sup>b</sup> (%)	Obesity <sup>a</sup> (%)	Obesity <sup>b</sup> (%)	Overweight <sup>a</sup> (%)	Overweight <sup>b</sup> (%)	Obesity <sup>a</sup> (%)	Obesity <sup>b</sup> (%)
1985	1.91	1.54	0.27	0.04	2.02	1.27	0.23	0.03
1995	7.53	6.50	2.92	1.64	4.89	4.28	1.72	0.53
2000	12.98	13.83	9.12	4.57	7.90	8.23	4.32	1.75
2005	14.31	15.79	10.66	5.42	8.76	9.66	5.69	1.96
2010	17.34	19.06	15.83	9.33	11.97	13.42	7.12	2.42

<sup>a</sup>Using WGOC standard.

<sup>b</sup>Using IOTF standard.

For epidemiological and research purpose, it is useful to have a common definition of overweight and obesity. The IOTF definition is used in epidemiological research to classify overweight and obesity, and the major advantage of the definition is that it allows international comparison of trends in overweight and obesity. Considering the differences in body composition across different ethnic groups, the WGOC has provided a BMI reference norm for screening overweight and obesity in Chinese children and adolescents. The present study, using China's own national reference norm, examines the prevalence of overweight and obesity among children and adolescents in Shandong, China, and the results of this paper will provide some conclusive evidence for the control of obesity. However, we also reported the prevalence of overweight and obesity by using IOTF reference norm, and it allows international comparison of trends in overweight and obesity. This study has several limitations. Data for this study were acquired from five independent cross-sectional surveys spanning 25 years rather than from a longitudinal cohort study, thus preventing further assessment of cohort and time effects.

In summary, these results demonstrated positive secular increases in BMI among children and adolescents aged 7–18 years for the period from 1985 to 2010 in Shandong Province, China. However, the rapid increase in both obesity and overweight should arouse special attention. Obesity and overweight have become a threatening hazard to children and adolescents, and as the urbanization increases, obesity might show further increase. Thus, the prevention and control of this hazard is urgently needed. Comprehensive strategies of intervention should include periodical monitoring, education on pattern of nutrition, oxygen-consuming physical exercises and healthy dietary behavior.

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