Original Article

Trend in gender disparities of BMI and height between 2004 and 2011 among adolescents aged 17-18 years in Changzhou China

Wenying Chen MD[1], Zumin Shi MD, PhD[2]

[1]*Changzhou Center for Disease Control and Prevention, Changzhou, China*
[2]*The University of Adelaide, Adelaide, Australia*

Objectives: to describe the trend in gender disparities of overweight/obesity and underweight, as well as height, among Chinese adolescents. Methods: the study is based on population-based data from annual health checks of approximately 7,000 students finishing high school each year between 2004-2011. Height and weight were measured. Overweight/obesity and underweight were defined using International Obesity Task Force (IOTF) criteria. School level socioeconomic status (SES) was constructed based on real-estate prices near each school. Results: there was a slight increase in the prevalence of obesity between 2004 and 2011; 3.7% to 4.7% in boys and 1.1% to 1.5% in girls. The prevalence of overweight was quite stable in both genders (boys: 12%-15%; girls: 7%-10%). In most years, the prevalence of underweight was above 10%. The prevalence of underweight in girls born after 1991 increased dramatically. However, the opposite trend was seen in boys. School SES was positively associated with overweight and inversely associated with underweight among boys. There was a significant increase in height in both genders. Height and BMI was positively associated in boys but this relation was inversely associated in girls. Conclusion: between 2004 and 2011, the prevalence of overweight/obesity was plateauing among adolescents finishing high school. A substantial increase in the prevalence of underweight was observed among girls born after 1991 but this seemed to be positively associated with high SES.

Key Words: Chinese, adolescent, overweight, trend

INTRODUCTION

Obesity among adolescents is a public health problem in both developing and developed countries. In countries like the USA, Australia, and New Zealand, the prevalence of overweight/obesity among adolescents is higher than 20%.[1] The prevalence of obesity among Chinese adolescents has increased rapidly since the 1980s.[2-8] In China, obesity, in general, is more prevalent in urban and high socioeconomic status (SES) groups than their counterparts in rural areas and in low socioeconomic strata.[5] This pattern is also seen in other developing countries, e.g. Vietnam [9] and India.[10] However, the opposite is true in developed countries (e.g. USA, Canada), where obesity rates are higher in rural population groups and those with low socioeconomic status.[11,12] Changes in traditional diet and lifestyle contribute to the obesity epidemic in China.[13]

In recent years, there has been evidence showing that the prevalence of childhood overweight is plateauing in some areas including Jiangsu Province in China.[1] Potential causes have been hypothesised including intervention, saturation equilibrium and selection bias.[1]

A positive association between the prevalence of obesity and SES as well as the coexistence of over- and undernutrition suggests that China is still at the early stage of nutrition transition.[14,15] Because obesity is positively related to SES, it will be important to know the burden as well as the trend of obesity in economically developed areas in China. Such information will help to estimate the future burden of obesity in China with expected further economic development.

Worldwide, there has been a large reduction in the prevalence of underweight among children during the past several decades. However, it remains a significant problem for adolescents especially in developing countries.[16,17] In China, studies on the change of prevalence of underweight are limited.[17] One study reported that the prevalence of underweight among children aged 6-18 years decreased from 14.8% in 1991 to 9.4% in 2004.[18] Interestingly, the prevalence of underweight was similar among Chinese children with different household incomes in 2004.[18]

The objective of the study is to describe an eight-year trend and gender disparity in the prevalence of overweight/obesity and underweight, as well as height, between 2004 and 2011 among school adolescents aged 17-

Corresponding Author: Dr Zumin Shi, Discipline of Medicine, The University of Adelaide, 122 Frome St, Adelaide, SA 5000, Australia.
Tel: +61 8 8313 1188; Fax: +61 8 8313 1228
Email: zumin.shi@adelaide.edu.au
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18 years in Changzhou City, an economically developed region in China.

SUBJECTS AND METHODS

In China when a student finishes the high school (at 17-18 years old in general), he/she is required to take a health check before the National University Entrance Examination without exception. It is part of the university enrolment application process. The current study is a population-based study using such annual health check data from students living in Changzhou City, Jiangsu Province, China. Changzhou is one of the most affluent cities in China with a population of 3.6 million.[19] It is approximately 185 km from Shanghai.

Between 2004 and 2011, year twelve students living in Changzhou City attended the annual health check at Changzhou Center for Disease Control and Prevention. Students' height without shoes was measured to the nearest 0.1 cm, and weight in light clothes was measured to the nearest 0.1 kg according to standardized protocol. The health check was taken in March each year. In total 57,202 students participated in the health examination during this 8 years period. Of these, 3,635 (6.4%) students were aged <17.0 or >18.9 years and were thus excluded. The final sample size included in the analysis was 53,567.

Overweight and obesity was defined using International Obesity Task Force IOTF criteria.[20] The criteria uses BMI cut-offs corresponding to 25 and 30 kg/m^2 in adults to define overweight and obesity respectively. Underweight was defined using age and gender specific IOTF cut-off points for BMI (corresponding to adult BMI<18.5 kg/m^2).[21]

A school SES variable was constructed based on real-estate prices (June 2012) near each school: low (<5000 Yuan/m^2), medium (5000-10000 Yuan/m^2) and high (≥10000 Yuan/m^2). Real-estate prices were extracted from a local website in June 2012.[22] Overall, 45.8%, 25.3% and 28.9% of the students were from low, medium and high SES schools, respectively. Over eight years, the percentage of students attending high SES schools ranged from 27.5% to 30.9%.

As this study was based on secondary data using anonymous information, written consent was not gained from the students.

Data analysis

All statistical analyses were performed using Stata (version 12, Stata Corp, College Station, TX). Linear regression was used to test the trends of change in height, weight and BMI during the study period, with the year as a continuous variable in the model. Multinominal or ordinary logistic regression was performed to assess the trends of overweight, obesity and underweight between 2004 and 2011. Marginsplot syntax in Stata was used to visually show the trends of overweight/obesity, underweight and height by year of birth in logistic regression or linear regression, adjusting for age at measurement. We took the advantage of the new margins function in Stata (latest version 12) to calculate and visulally show the adjusted probility of overweight/obesity after logistic regression (instead of the traditional use of odds ratio). Statistical significance was achieved at $p<0.05$.

RESULTS

Table 1 shows the sample characteristics by gender. The mean age of the sample was 18.1 (range: 17.0-18.9) years in both boys and girls. The mean height was 173.7 cm in boys and 161.1 in girls in the whole sample. The mean BMI was 22.0 and 21.3 kg/m^2 in boys and girls, respectively. There was a significant increase in height among both boys and girls between 2004 and 2011.

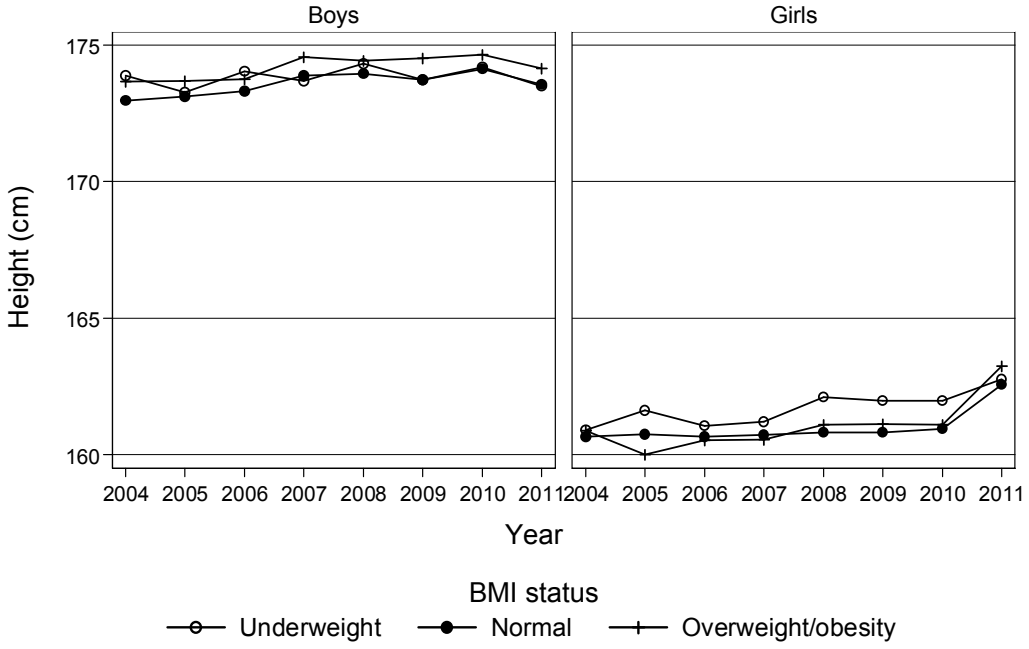

Figure 1. Trend of mean height according to BMI status among adolescents in Changzhou, China. Marginsplot syntax was used to make the graph after adjusting for age at measurement. The values represent the age adjusted mean height.

Table 1. Anthropometric measurement of adolescents aged 17-18 years in Changzhou between 2004 and 2011

	2004		2005		2006		2007		2008		2009		2010		2011		Total		*p* for trend*
Boys																			
n	3,070		3,200		3,692		3,654		3,698		3,539		3,479		3,371		27,703		
age	18.2	0.4	18.2	0.4	18.2	0.4	18.1	0.4	18.2	0.4	18.2	0.4	18.1	0.4	18.1	0.4	18.1	0.4	<0.001
Height (cm)	173.2	5.7	173.2	5.7	173.4	5.9	174.0	5.6	174.1	5.7	173.8	5.6	174.2	5.9	173.7	5.8	173.7	5.7	<0.001
Weight (kg)	66.1	11.4	67.2	11.4	67.1	11.6	66.3	12.0	66.2	11.6	65.6	12.7	65.7	12.5	66.7	12.0	66.4	11.9	0.002
BMI (kg/m^2)	22.0	3.5	22.4	3.4	22.3	3.5	21.9	3.5	21.8	3.5	21.7	3.8	21.6	3.8	22.1	3.6	22.0	3.6	<0.001
Girls																			
n	2,625		2,883		3,460		3,514		3,556		3,170		3,396		3,260		25,864		
age	18.1	0.4	18.1	0.4	18.1	0.4	18.1	0.4	18.1	0.4	18.1	0.4	18.0	0.4	18.0	0.4	18.1	0.4	<0.001
Height (cm)	160.7	5.3	160.8	5.3	160.7	5.3	160.8	5.3	161.0	5.4	160.9	5.4	161.1	5.4	162.7	5.4	161.1	5.4	<0.001
Weight (kg)	55.2	7.8	54.2	7.7	54.5	8.2	55.8	8.0	55.8	8.4	56.2	8.3	56.1	8.8	54.7	8.9	55.3	8.3	<0.001
BMI (kg/m^2)	21.3	2.7	21.0	2.8	21.1	2.8	21.6	2.8	21.5	2.9	21.7	2.9	21.6	3.1	20.6	3.0	21.3	2.9	<0.001

Values are mean and SD

* *p* values derived from linear regression using year as continuous variable.

Table 2. Prevalence of under and overweight among adolescents aged 17-18 years in Changzhou China

	2004	2005	2006	2007	2008	2009	2010	2011	*p*
Boys									
BMI (kg/m^2) levels (%)									
<18.5	10.0	6.9	7.9	12.5	12.7	16.8	18.4	9.8	<0.001
25-30	13.8	15.5	15.0	12.6	13.6	12.2	12.6	13.3	0.222
>30	3.7	3.6	3.8	3.9	3.7	4.5	4.2	4.7	0.001
Extreme levels (%)*									
BMI<17	1.6	0.8	1.0	1.8	2.2	4.0	4.4	2.4	<0.001
BMI>35	0.4	0.5	0.6	0.4	0.2	0.8	0.5	0.4	0.696
Girls									
BMI (kg/m^2) levels (%)									
<18.5	10.7	15.4	13.6	8.7	9.9	7.7	10.3	22.4	<0.001
25-30	8.5	6.8	6.8	9.6	9.4	10.0	9.0	6.9	0.020
>30	1.1	1.1	1.5	1.4	1.6	1.6	2.7	1.5	<0.001
Extreme levels (%)*									
BMI<17	1.4	2.7	2.3	1.2	1.3	1.0	1.2	5.1	<0.001
BMI>35	0.1	0.1	0.3	0.1	0.2	0.2	0.2	0.2	0.221

* Among those aged 18 years.

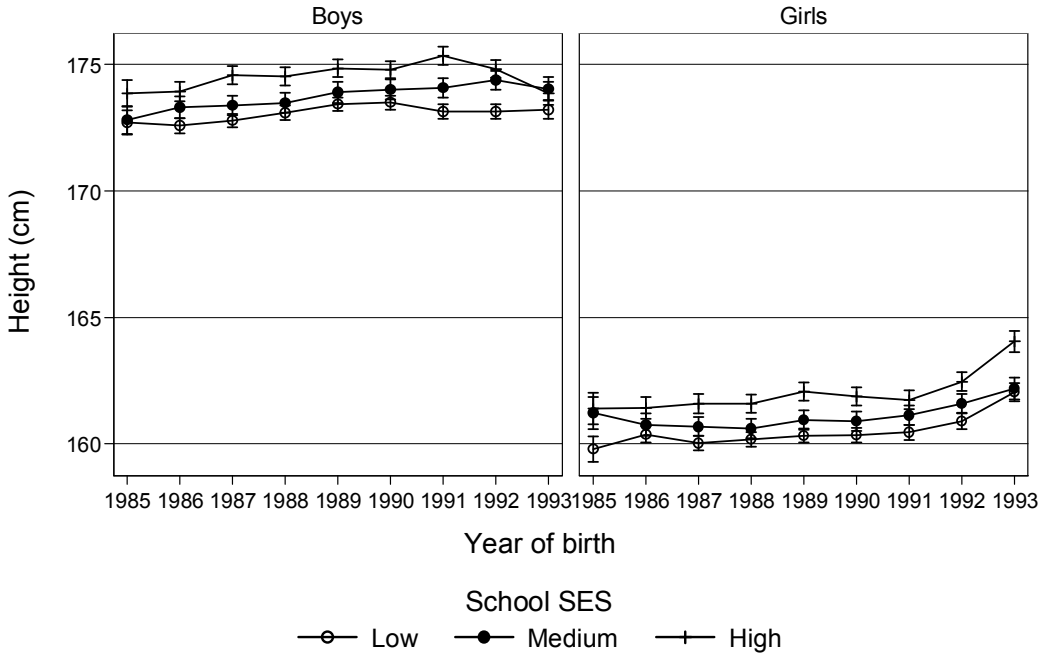

Figure 2. Trends in height by year of birth and school SES among boys and girls in Changzhou, China. School SES was constructed based on real-estate price near each school. Marginsplot syntax was used to make the graph after adjusting for age at measurement. The values represent the age adjusted mean height and 95% CI.

Table 2 shows the trend within different levels of BMI over time. There was a slight increase in the prevalence of obesity among both boys and girls between 2004 and 2011. The prevalence of obesity was 4.7 in boys and 1.5% in girls in 2011. The corresponding figure was 3.7% and 1.1% in 2004. The prevalence of underweight increased significantly in girls and reached 22.4% in 2011. In boys, the highest prevalence of underweight was observed in 2009 (16.8%) and 2010 (18.4%). In total, 2.4% of the boys and 5.1% of the girls had BMI<17 kg/m^2 in 2011.

Figure 1 shows the trend in mean height according to BMI status. In most years, the mean height among underweight girls was higher than in normal or overweight/obese girls. In boys, the mean height was higher among overweight/obese than in underweight or normal weight since 2007. There was a trend of increasing height in all three BMI categories in the later years. Overall, the mean (SD) height was 173.9 (5.7) and 161.8 (5.2) cm among underweight boys and girls. Girls born in 1992 and 1993 and measured in 2010 and 2011 were taller by 1.2 cm (95%CI 0.7-1.6) and 2.0 cm (95%CI 1.5-2.5), respectively, than those born in 1991. This phenomenon was not found among boys. Height was normally distributed among underweight students in both genders. Height was inversely associated with BMI among girls but positively associated with BMI among boys (data not shown). In all birth cohorts, school SES was positively associated with height in both genders (Figure 2).

Figures 3 and 4 show the trends of overweight/obesity and underweight by year of birth and school SES among boys and girls. Over the eight years, boys from high SES schools were more likely to be overweight/obese than those from low SES schools. Among girls, there was a significant increase in the probability of overweight among those from low SES schools. The SES disparity of overweight/obesity was narrowing in the latest birth cohorts, both in boys and girls. However, disparities in underweight by school SES were consistent across the eight years and showing a higher risk among boys with low SES. In girls, the disparity disappeared among those born after 1991, when there was a significant increase in the probability of being underweight. This was not the case among boys, in whom the opposite trend was found.

DISCUSSION

Based on data from the annual population based health examination among high school students in Changzhou City, China, we observed that the prevalence of overweight/obesity was quite stable during the eight years, although it remains high. In general, boys had a higher prevalence of obesity than girls. Over the eight years, school SES was positively associated with overweight/obesity but inversely associated with underweight among boys. Among girls from low SES schools, there was a significant increase in the prevalence of overweight/obesity. It is worth noting that the prevalence of underweight increased substantially among girls born after 1991, while the opposite is true in boys. There was a dramatic increase in girls and a decrease in boys in the prevalence of underweight in 2011. There was a significant increase of height in boys and girls. Height was positively associated with BMI in boys but inversely associated with BMI in girls.

The slight increase in the prevalence of obesity as well as the plateauing of overweight/obesity is in line with findings in several other studies. For instance, data from the Chinese national nutrition survey [4] showed a slow increasing trend of overweight and obesity from 1992 to 2002 (ie 4.3% to 5.6%). Moreover, these findings are quite similar with findings from a recent review of data from nine countries (including data in Jiangsu province

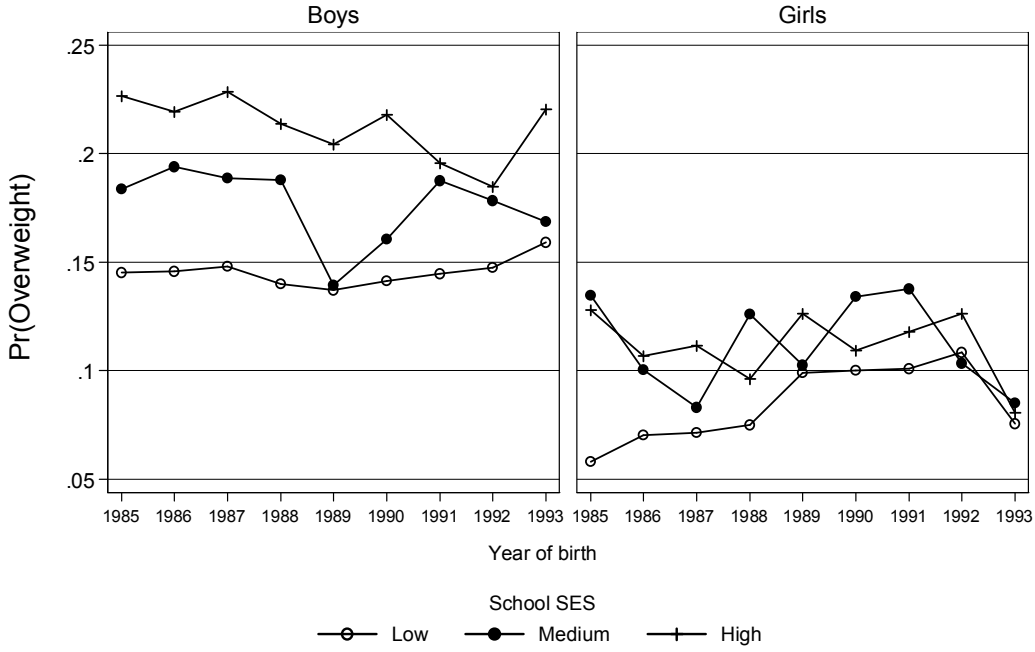

Figure 3. Trend of overweight/obesity by year of birth and school SES among boys and girls in Changzhou, China. School SES was constructed based on real-estate price near each school. Marginsplot syntax was used to make the graph after adjusting for age at measurement. The values represent the age adjusted probability of overweight/obesity.

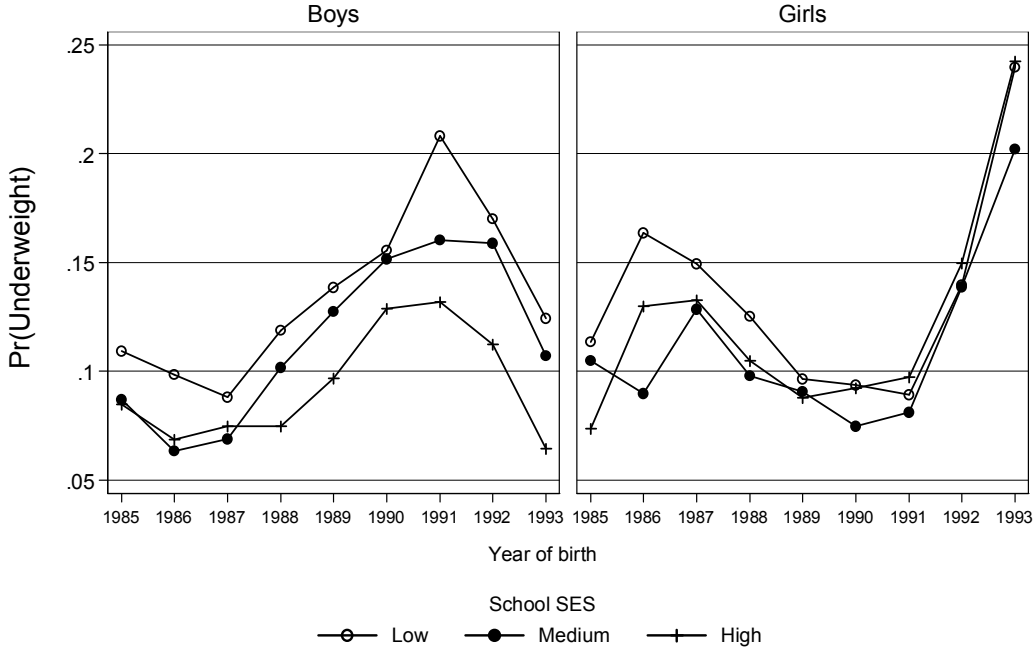

Figure 4. Trend of underweight by year of birth and school SES among boys and girls in Changzhou, China. School SES was constructed based on real-estate price near each school. Marginsplot syntax was used to make the graph after adjusting for age at measurement. The values represent the age adjusted probability of underweight.

from 2002 to 2007),[1] suggesting that the rise in the prevalence of overweight and obesity has slowed appreciably or even plateaued. While the prevalence of overweight and obesity appears to be stabilizing at different levels in different countries, it remains high and is a significant public health issue.

The reason for the flattening out in overweight/obesity prevalence is unclear. The weight change among adults in the province is only about 0.8 kg between 2002 and 2007.[23] Several possible reasons are hypothesized. Firstly, our study was done among year twelve students who were facing high competition for the national university entrance examination. Achieving a good academic performance and gaining entry to the university is a priority for both students and their parents. The study load among these Chinese students is substantial. It has been reported that Chinese students aged 12-14 years spend about eleven hours on study per day.[24] This amount of time in sedentary activity was expected to be much higher in our sample, since the final exam was imminent. Any change in other forms of physical activity or inactivity is unlikely to be significant. Secondly, because of the one child policy, many parents and grandparents pay a great attention to the only child when he/she goes to high school. This

may include some families renting apartments near the schools in order to take care of their children. Further, providing the child with nutritious meal is one of the daily priorities for most of the parents: therefore consumption of fast food is also unlikely during the study period. The staple food in the region is rice. Based on a five year follow up among adults in the province, it was found that the percentage of rice in staple food is inversely related to weight gain in the province.[25] Thirdly, during the last decade, the Chinese government put a substantial amount of effort in the prevention of obesity and other chronic diseases.[26] Health promotion school initiatives including obesity prevention, healthy eating and physical activity were launched in the region. However, caution needs to be taken with this speculation.

The increase in the prevalence of underweight in recent years is surprising. Underweight used to be a major health problem in China before its economic development. With the increase of the burden of overweight and obesity, under-nutrition attracts less attention in the research community. At the national level, there was a non-significant decrease in the prevalence of underweight (using the IOTF cut-off) between 1991 (15.4%) and 1997 (14.7%) among adolescents aged 10-18 years.[27] Using WHO definition, another national study showed that the prevalence of underweight was 18.6%, 15.5%, 14.2% and 16.0% among urban adolescents aged 18 years in 1985, 1995, 2000, and 2005, respectively.[28] A study in Shandong China showed that there was no change in the prevalence of underweight among children aged 7-18 years in 1995 and 2005, both were about 10%.[29]

In our study, the distribution of underweight according to gender differed across the eight years. The mean height among the underweight girls was higher than those with normal weight or overweight/obese girls, which excludes the possibility of long term malnutrition among these students. School level SES was consistently inversely associated with the risk of underweight among boys in our study. However, the same association was reversed among girls born after 1991. Among these girls, there was a significant increase in height, which may imply better nutrition in early life and increased linear growth, whereas present nutrition may not have been adequate. One possible explanation could be slimming behaviours. Similar to other parts in the world and particularly in Western civilizations, Chinese girls tend to want to lose weight even if they have a normal weight.[30] Chinese girls in general have lower body esteem than boys.[31] A study from Hong Kong suggested that eating disorders among adolescents was common.[32] It could also be that the nutrition transition has reached a phase where adolescents, especially girls, in rich communities have become more health conscious and eat more healthy foods. Girls in the high SES groups are slimmer than the ones in the low SES group, a phenomenon which is seen in developed countries. Whether eating disorders, stress and study load play a role in the high prevalence of underweight among girls needs further research.

One limitation of the study was that it focused only on those who wanted to apply for university entrance, not those planning to apply to vocational schools. The selection bias could have changed through the eight year period if there was a change in the recruitment of students from different SES strata. However, there was no measurement of individual socioeconomic status. Nevertheless, school SES may give a good indication of individual SES because of the income required to meet the increased fees for high SES schools compared to low SES schools. The positive association between school SES and overweight/obesity was consistent with another study comparing individual SES and overweight in the province.[5] One strength of the study was that in each year height and weight were measured by trained health workers and at the same time each year.

In conclusion, between 2004 and 2011, the prevalence of overweight/obesity was quite stable in boys and girls living in an economically developed city - Changzhou in China. However, the probability of overweight increased among girls from low SES schools. The prevalence of underweight increased substantially among girls born after 1991, while the opposite is true in boys. School SES was positively associated with overweight/obesity but inversely associated with underweight among boys. There was a significant increase in height among both genders. Height was positively associated with BMI in boys, but inversely associated in girls.

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Authors' contributions

Wenying Chen has full access to the dataset. Wenying Chen and Zumin Shi analyzed the data and drafted the paper. The authors would like to thank Professor Gerd Holmboe-Ottesen at University of Oslo for constructive comments and interpretation of the results.

Ethical approval

This study was based on anonymous secondary data. Ethical approval was not sought.

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AUTHOR DISCLOSURES

The authors have no conflict of interest.

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Original Article

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Wenying Chen MD[1], Zumin Shi MD, PhD[2]

[1]*Changzhou Center for Disease Control and Prevention, Changzhou, China*
[2]*The University of Adelaide, Adelaide, Australia*

2004 到 2011 年间中国常州市 17-18 岁青少年体质指数和身高变化趋势的性别差异

目的：描述中国青少年超重、肥胖、低体重及身高变化趋势的性别差异。方法：本研究使用 2004 到 2011 年间常州市高中毕业生的健康体检数据(每年约 7000 人)。身高和体重由测量获得。超重、肥胖及低体重的定义采用国际肥胖工作组(IOTF)的标准。学校的经济水平根据学校周围房地产价格来决定。结果：2004 到 2011 年间肥胖率略有增长(男性由 3.7%增长到 4.7%，女性由 1.1%增长到 1.5%)，男女生超重率趋于稳定(男性在 12%-15%之间，女性在 7%-10%之间)。在大多数年份，低体重的比例在 10%以上；1991 年后出生的女生低体重比例显著上升，男生低体重率则明显下降。在男生中，学校经济状况和超重及肥胖呈正相关，与低体重呈负相关。男女身高均有显著增长。男生身高与体质指数呈正相关，女生身高和体质指数则反而呈负相关。结论：2004 到 2011 年间高中毕业生中超重及肥胖率趋于稳定。1991 年后出生的女生的低体重率明显增加，这一现象可能和经济收入增加有关。

关键词：中国、青少年、超重、趋势