Changes in the distribution of body mass index among college students in Shandong, China from 1985 to 2005

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Received 15 October 2009; accepted 30 November 2009

Abstract This article analyzes the changes in the distribution of body mass index (BMI) among college students aged 19–22 in Shandong, China from 1985 to 2005. In the past 20 years, the P50 (percentile 50) of BMI increased, from 20.44 kg/m2 in 1985 to 21.00 kg/m2 in 2005 for males, and from 19.97 kg/m2 in 1985 to 20.42 kg/m2 in 2005 for females. The proportion of overweight or obese (defined as BMI ≥ 25 kg/m2) increased from 1.35% in 1985 to 7.17% in 2005. Overweight and obesity among college students has become a serious public health problem. Comprehensive evidence-based strategies of intervention should be introduced, including periodic monitoring.

Key words: body mass index, overweight, obesity, college student, prevalence

Introduction

The International Obesity Task Force (IOTF) has noted that body mass index (BMI) is an important index for estimating body fat and the prevalence of obesity, and may be used to evaluate adiposity in adolescents (Dietz and Bellizzi, 1999; Fredriks et al., 2000). The BMI now appears to be a widely accepted index for classifying adiposity in adults. A consensus is the use of a BMI above the 85th percentile as a screening index for overweight, and a BMI above the 95th percentile as an index of excess adiposity in adolescents (e.g. Himes and Dietz, 1994; Must et al., 1991). The Working Group on Obesity in China (WGOC) has provided a BMI reference norm for screening overweight and obesity in Chinese adults and adolescents, respectively (WGOC, 2004a, b), and this has been used extensively. This article reports the distribution of BMI and the prevalence rates of overweight and obesity among college students over the last 20 years (1985–2005) in Shandong Province, China. Shandong Province, located in the lower reaches of the Yellow River between 34°25' and 38°23' N and 114°25' and 112°43' E, is an important littoral province in East China (Figure 1). It borders the Bohai Sea and the Yellow Sea, facing Japan and the Korean Peninsula to the east. The total area of Shandong is 156700 km2 and the population was 92.48 million in 2005. Shandong Province is one of the birthplaces of Chinese culture and is the hometown of Confucius, who is considered to be the greatest philosopher in Chinese history. In particular, since China adopted the policy of reform and opening up to the world, Shandong has maintained sustained and rapid economic growth and is one of the most economically developed provinces in China (http://www.stats.com.cn/tjsj/tjsj.asp). The aim of the present study is to report secular trends in BMI of college students from Shandong Province over the period 1985–2005.

Subjects and Methods

A total of 5115 college students of Han nationality in Shandong Province, aged 19–22 years old participated in the National Surveys on Chinese Students’ Constitution and Health, which were carried out in 1985, 1995 and 2005. (In 1985, the government education and health departments established 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.

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Published online 21 January 2010 in J-STAGE (www.jstage.jst.go.jp) DOI: 10.1537/ase.091015

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(Research Section of the Constitution and Health of Chinese Students, 2007) drawn from Shandong normal university, all of the subjects were Shandong cadastral Han ancestry non-sports and arts students. All subjects had a thorough medical examination before the measurements were taken. They were all in apparently good health, free from overt diseases or deformities. The apparatus recommended by Cameron (1978) was used to measure height and weight. Metal column height-measuring stands (each 200 cm long with 0.1 cm precision) were used to measure height. The subjects were required to stand straight on the instruments barefoot and at ease. Weight was measured with lever scales (each weighs up to 120 kg with 0.1 kg precision) while the subjects wore only their underwear. Most importantly, the method and quality control of measurements of three surveys was the same.

BMI is calculated as weight in kilograms divided by height squared in metres (kg/m$^2$). The WHO-defined cutoff points classifying participants into underweight (BMI < 18.5 kg/m$^2$), normal (18.5 ≤ BMI < 25 kg/m$^2$), overweight (25 ≤ BMI < 30 kg/m$^2$) and obese (BMI ≥ 30 kg/m$^2$) (James, 2004) and the WGOC reference norm (underweight: BMI < 18.5 kg/m$^2$; normal: 18.5 ≤ BMI < 24 kg/m$^2$; overweight: 24 ≤ BMI < 28 kg/m$^2$; obese: BMI ≥ 28 kg/m$^2$) were applied (WGOC, 2004b). The statistical treatment was carried out using SPSS 11.0.

**Results**

Over the 20 years of the study period, the $P_{50}$ (percentile 50) of BMI increased, from 20.44 kg/m$^2$ in 1985 to 21.00 kg/m$^2$ in 2005 for males, and from 19.97 kg/m$^2$ in 1985 to 20.42 kg/m$^2$ in 2005 for females, at the rates of 2.74% for males and 2.25% for females. Figure 2 and Figure 3 show the changes in BMI percentiles for college students from 1985 to 2005. The difference is mainly at the $P_{95}$ level. For example, the $P_{95}$ of BMI for males increased from 23.12 kg/m$^2$ in 1985 to 26.72 kg/m$^2$ in 2005, and for females from 22.78 kg/m$^2$ in 1985 to 24.86 kg/m$^2$ in 2005, at the rates of 15.56% for males and 9.13% for females. In contrast, BMI differences at the $P_{5}$ level were not as evident. The BMI distribution showed shifts to the right, and there is proportionately much more shifting of the distribution curve at the upper end than at the lower (Figure 4, Figure 5).

Table 2 and Table 3 show the changes in nutrition status of college students from 1985 to 2005. The overall proportion of underweight (defined as BMI < 18.5 kg/m$^2$) increased from 11.06% in 1995 to 14.28% in 2005 ($P < 0.01$). Using the WHO reference norm, the proportion of overweight or obese (defined as BMI ≥ 25 kg/m$^2$) increased from 1.35% in 1985 to 7.17% in 2005 ($P < 0.001$), and using the China reference norm, the proportion of overweight or obese (defined as BMI ≥ 24 kg/m$^2$) increased from 2.70% in 1985 to 11.14% in 2005 ($P < 0.001$). The changes in nutrition status of college students came about mainly between

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<tbody>
<tr>
<td>19.5</td>
<td>300</td>
<td>200</td>
<td>199</td>
<td>200</td>
<td>197</td>
<td>197</td>
</tr>
<tr>
<td>20.5</td>
<td>300</td>
<td>200</td>
<td>203</td>
<td>200</td>
<td>170</td>
<td>170</td>
</tr>
<tr>
<td>21.5</td>
<td>300</td>
<td>200</td>
<td>201</td>
<td>200</td>
<td>170</td>
<td>170</td>
</tr>
<tr>
<td>22.5</td>
<td>290</td>
<td>200</td>
<td>211</td>
<td>135</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Total</td>
<td>1190</td>
<td>800</td>
<td>814</td>
<td>735</td>
<td>800</td>
<td>776</td>
</tr>
</tbody>
</table>

Figure 2. Changes of BMI percentile curves in the sample for boys, 1985–2005.

Figure 3. Changes of BMI percentile curves in the sample for girls, 1985–2005.

Figure 4. BMI distribution in the sample for boys, 1985–2005.

Figure 5. BMI distribution in the sample for girls, 1985–2005.
The prevalence of overweight and obesity markedly in recent decades, and is likely to continue in industrialized countries, engenders many medical, psychosocial, and economic issues. The WHO 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” (Seng et al., 2008). The prevalence of obesity has increased “escalating global epidemic of overweight and obesity” and uses the term “globesity” to reflect an “day’s most blatantly visible—yet most neglected—public health issues” and uses the term “globesity” to reflect an “escalating global epidemic of overweight and obesity” (Seng et al., 2008). The prevalence of obesity has increased since the early 1990s. The prevalence rates of obesity plus overweight 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 (Ji et al., 2004). 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% (boys aged 7–9), 25.5% (boys aged 10–12), 17.0% (girls aged 7–9) and 14.3% (girls aged 10–12) in 2000 (Ji et al., 2004). Based on data of the longitudinal China Health and Nutrition Surveys (CHNS) conducted in 1989, 1997 and 2000, the prevalence of overweight and obesity among adults aged 20–45 increased from 6.5% (male), 11.4% (female) in 1989 to 20.2% (male), 19.3% (female) in 2000 (Wang et al., 2006).

There are few reports about the prevalence of overweight and obesity among college students in different countries. For example, the overall prevalence rates of overweight (BMI = 25.0–29.9 kg/m²) and obesity (BMI ≥ 30 kg/m²) among Jordan university students aged 17–28 were 28.5% and 10.2%, respectively, in 2005 (Ahmad et al., 2009).

### Discussion

Obesity, a widespread and growing problem in industrialized countries, engenders many medical, psychosocial, and economic issues. The WHO 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” (Seng et al., 2008). The prevalence of obesity has increased markedly in recent decades, and is likely to continue in industrialized and developing countries (Flegal et al., 1998; Mokdad et al., 1999; Pi-Sunyer, 2002; Ogden et al., 2006). Childhood obesity and the associated chronic disease risk factors are becoming increasingly significant public health issues (Troiano and Flegal, 1998; Chinn and Rona, 2001; Ogden et al., 2002; Hedley et al., 2004). The recent increases in prevalence of both overweight and obesity in children merit particular attention. In the USA, rates of obesity increased from 5% to 10% between 1963 and 1990 amongst 6–11-year-olds (Troiano et al., 1995). In a North American low-income population, the prevalence of overweight in preschool children based on the 85th cutoff point for weight-for-height increased from 18.6% in 1983 to 26.3% in 1995 (Mei et al., 1998). The prevalence of overweight and obesity among children and adolescents aged 6–18 increased significantly in Taiwan from 1991 to 2003; the prevalence of overweight and obesity increased from 5.7% and 7.9% to 14.2% and 17.4% for boys, and from 11.1% and 3.1% to 13.4% and 4.1% for girls, respectively (Liou et al., 2009). In China, the prevalence rates 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 (Ji et al., 2004). 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% (boys aged 7–9), 25.5% (boys aged 10–12), 17.0% (girls aged 7–9) and 14.3% (girls aged 10–12) in 2000 (Ji et al., 2004). Based on data of the longitudinal China Health and Nutrition Surveys (CHNS) conducted in 1989, 1997 and 2000, the prevalence of overweight and obesity (BMI ≥ 25 kg/m²) among adults aged 20–45 increased from 6.5% (male), 11.4% (female) in 1989 to 20.2% (male), 19.3% (female) in 2000 (Wang et al., 2006).

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### Table 2. Nutrition status of college students from 1985 to 2005 (*WHO reference norm*)

<table>
<thead>
<tr>
<th>Nutrition status</th>
<th>1985</th>
<th>1995</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males (%)</td>
<td>Females (%)</td>
<td>Total (%)</td>
</tr>
<tr>
<td>Normal</td>
<td>88.91</td>
<td>81.50</td>
<td>86.06</td>
</tr>
<tr>
<td>Overweight</td>
<td>1.18</td>
<td>1.63</td>
<td>1.35</td>
</tr>
<tr>
<td>Obesity</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

* Significant difference between 1995 and 2005 (P < 0.01).
* Significant difference between 1985 and 2005 (P < 0.001).
* Significant difference between 1995 and 2005 (P < 0.001).
* Significant difference between 1985 and 1995 (P < 0.05).
* Significant difference between 1985 and 2005 (P < 0.001).
* Significant difference between 1995 and 2005 (P < 0.001).
* Underweight (BMI < 18.5), normal (18.5 ≤ BMI < 25), overweight (25 ≤ BMI < 30), obesity (BMI ≥ 30).

### Table 3. Nutrition status of college students from 1985 to 2005 (*China reference norm*)

<table>
<thead>
<tr>
<th>Nutrition status</th>
<th>1985</th>
<th>1995</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males (%)</td>
<td>Females (%)</td>
<td>Total (%)</td>
</tr>
<tr>
<td>Normal</td>
<td>87.98</td>
<td>79.46</td>
<td>84.73</td>
</tr>
<tr>
<td>Overweight</td>
<td>2.10</td>
<td>3.67</td>
<td>2.70</td>
</tr>
<tr>
<td>Obesity</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

* Significant difference between 1995 and 2005 (P < 0.01).
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* Underweight (BMI < 18.5), normal (18.5 ≤ BMI < 24), overweight (24 ≤ BMI < 28), obesity (BMI ≥ 28).
study has shown that the overall prevalence rates of overweight (BMI = 25.0–29.9 kg/m²) and obesity (BMI ≥ 30 kg/m²) among college students in Shandong were 6.67% and 0.50%. The prevalence level of overweight and obesity among college students in Shandong, China was lower significantly than those in Jordan, which may be related to the differences in eating habits, education, social culture and genetic constitution between different countries.

A secular trend in growth is an important biological phenomenon. 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 (Ji et al., 2007). These secular growth changes result from socioeconomic development: the socioeconomic status of Shandong Province, including economy, average income, and living conditions, improved rapidly from 1985 to 2005 (Table 4, http://www.stats.com.cn/tjsj/tjsj.asp), in particular the GDP per capita, income per capita in city and country increased by 21.7, 13.4 and 12.9 times, respectively, which enabled the positive secular trends of growth in children and adolescents. However, these increases 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 (Must et al., 1992; Dipietro et al., 1994). Potentially most harmful is increasing prevalence of overweight and obesity (Ji, 2007).

The Shandongese have long been known as ‘Shandong burly fellows.’ Within China, the BMI of children and adolescents in Shandong is higher than in other provinces (Zhang, 2005). We have collected the data of BMI for Chinese college students in National Surveys on Chinese Students’ Constitution and Health in 2005 (Research Section of the Constitution and Health of Chinese Students, 2007), and compared them with the data in Shandong. The BMIs of Shandong college students were higher than the average levels in the National Surveys on Chinese Students’ Constitution and Health in 2005 (Figure 6). For example, the $P_{50}$, $P_{95}$ and $P_{99}$ of BMI of college students in Shandong is above the National Surveys on Chinese Students’ Constitution and Health average level by 0.7, 0.6, and 1.0 kg/m² for boys, and 0.7, 0.5, and 0.9 kg/m² for girls, respectively. This suggests that prevention and control of overweight and obesity in Shandong should be urgently addressed.

This study has shown that both high prevalence rates of overweight and overweight were also found in that period.

### Table 4. Changes of some demographic and socioeconomic characteristics in Shandong, China, between 1985 and 2005

<table>
<thead>
<tr>
<th>Targets</th>
<th>1985</th>
<th>1995</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total population (million)</td>
<td>77.11</td>
<td>87.05</td>
<td>92.48</td>
</tr>
<tr>
<td>Birth rate (%)</td>
<td>15.12</td>
<td>9.82</td>
<td>12.14</td>
</tr>
<tr>
<td>Natural increase rate (%)</td>
<td>8.48</td>
<td>3.35</td>
<td>5.83</td>
</tr>
<tr>
<td>GDP per capita (Yuan)</td>
<td>887</td>
<td>5758</td>
<td>20096</td>
</tr>
<tr>
<td>Income per capita in city (Yuan)</td>
<td>748</td>
<td>4264</td>
<td>10745</td>
</tr>
<tr>
<td>Income per capita in country (Yuan)</td>
<td>408</td>
<td>1715</td>
<td>5676</td>
</tr>
<tr>
<td>Housing area per capita in city (m²)</td>
<td>7.77</td>
<td>12.35</td>
<td>21.90</td>
</tr>
<tr>
<td>Housing area per capita in country (m²)</td>
<td>15.13</td>
<td>21.56</td>
<td>29.64</td>
</tr>
</tbody>
</table>

On the one hand, the prevalence rate of underweight (BMI < 18.5 kg/m²) was continuously above 10% over the period 1985–2005; on the other hand, as urbanization progresses, overweight has increased rapidly over time: the rate of overweight or obesity (BMI ≥ 25 kg/m²) increased from 1.35% in 1985 to 7.17% in 2005. However, the prevalence of obesity (BMI ≥ 30 kg/m²) was still low: 0.74% for males and 0.26% for females in 2005. Special attention should be paid to controlling the tendency towards obesity of overweight people.

In summary, these results demonstrated positive secular increases in BMI among college students aged 19–22 in a recent 20 year period (1985–2005) in Shandong Province, China. The prevalence of obesity in college students was considered to be still relatively low. However, the rapid increase of both obesity and overweight, is a cause of particular concern. Obesity and overweight have become threats to the health of children and adolescents. As urbanization progresses, obesity might double; hence prevention and control of this hazard are urgently needed. Comprehensive strategies of intervention should include periodic monitoring, education on nutrition, oxygen-consuming physical exercises, and healthy dietary behavior.

### References


Fredriks A.M., Buuren S.V., Wit S.P.V., and Verloove-Vanhoeik


