Regional and population variability of body mass index among Chinese schoolchildren and adolescents

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Background: **The raising prevalence of childhood obesity is becoming a major public health concern in many countries, but little is known about the prevalence of childhood obesity in China. This study was undertaken to establish a screening standard for body mass index (BMI) in Chinese school children and adolescents on the basis of data obtained from different geographic regions and populations.**

Methods: **The data were obtained from 228 250 students aged 6 to 18 years who had participated in the 2000 National Surveillance Program on Students' Health and Physical Fitness, China. Analysis was made between groups of students from different geographic regions, from urban and rural areas, and from regions with different socioeconomic development. The percentiles of 5%, 50% and 95% were calculated and compared.**

Results: **Differences in BMI between the various groups were seen in the percentile of 95%. The BMI on the percentile of 95% for 13-year-old boys was 25.7 in the group from large and developed cities, compared with 21.1 for peers living in underdeveloped rural areas. The corresponding figures for girls were 22.8 in urban and 20.8 in rural areas. Significant geographical north-south differences were found, particularly during the adolescent growth spurt. Among 11-year-old girls, the average BMI was 22.3 in north and 21.0 in south China, whereas in 14-year-old boys the average BMI was 25.4 in the north and 23.5 in the south. The results of this study showed clearly that obesity is particularly prevalent in the metropolitan areas and in north China. Significant differences in BMI between developed and developing areas are already visible in primary school children. Differences in BMI on the percentile of 5% were less pronounced, showing that malnutrition and underweight are still prevalent in all subgroups.**

Conclusions: **As the national criteria for obesity screening in China, a reference group from developed metropolitan areas may best reflect the current situation and may also represent the general tendency of development. However, significant rural-urban and north-south differences exist along with gross inequalities in terms of material living standards, which should be taken into consideration.**

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Key words: **adolescence; students; body mass index; obesity; nutritional status**

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Introduction

The prevalence of obesity in children has been increasing rapidly in China in recent years; but to date there have no generally accepted criteria for the screening of obesity.[1-3] In 1997, the international obesity task force (IOTF) confirmed that in children, adolescents and adults alike the body mass index (BMI) is the most suitable marker for overweight and obesity.[4,5] China is a country with a large population who reside in vast areas with varying climatic, geographic and socioeconomic conditions. To establish the screening criteria for childhood obesity in China is desirable to take international screening criteria as an example.[6,7] In addition, a large study population is necessary so as to be truly representative of the highly diverse Chinese population.[8,9] The 2000 National Surveillance Program on Students' Health and Physical Fitness has provided representative national data on growth and development of students in China, which can be used to establish the screening criteria for obesity.[10] In this study, we analysed regional and population differences in the BMI of 6- to 18-year-old students with reference to the original survey data so as to provide a scientific basis for the on-going discussion regarding the criteria for obesity screening.[11-13]

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Methods

Subjects

A stratified random cluster sampling procedure was applied to choose subjects from 30 provinces all over China excluding Tibet, for which no data on populations of Han ethnics were available, and Taiwan, forming four groups of urban girls, urban boys, rural girls and rural boys. These groups were subgrouped according to their economic status marked as "good", "average" and "poor". Each subgroup consisted of 104-147 individuals. The severely disabled or those with major diseases were excluded, and at last a total of 228 250 students aged between 6 and 18 years were selected. The percentiles of BMI were calculated and the average BMI was compared between the subgroups.[10]

Methods

The BMI was calculated as body weight (kg) divided by the square of body height (m) for a specific gender and age. According to the status of economic development, the students were divided into 4 groups: group 1 from highly developed metropolitan areas and large cities; group 2 from moderately developed urban areas, as found in medium-sized and smaller cities; group 3 from wealthy rural areas; and group 4 from less and poorly developed rural areas. The distribution of the sample population in the four groups showed a ratio of 17:1:30:50.[14]

For the north-south comparison, the 14 provinces and cities of Heilongjiang, Jilin, Liaoning, Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Shandong, Shanxi, Gansu, Qinghai, Ningxia and Xinjiang were defined as north China, whereas the 16 provinces and cities of Henan, Hubei, Hunan, Guangdong, Guangxi, Hainan, Sichuan, Chongqing, Guizhou, Yunnan, Shanghai, Jiangsu, Zhejiang, Anhui, Jiangxi and Fujian were defined as south China.

Finally, students from the urban areas in Beijing, Tianjin, Shanghai, Liaoning and Shandong were selected to represent developed regions with a population of strong body constitution. On the other hand, the rural areas of Sichuan, Guizhou, Guangxi, Hunan and Hainan were selected to represent under-developed regions with a population of less physically developed.

Results

The groups were compared in terms of economic development showing significant differences in average BMI. The economic status of urban and rural areas did not show much impact on BMI, the most obvious difference was found between cities and the countryside. This was particularly striking for the percentile of 95% among students of pubertal age. Among 13-year-old boys, the average BMI in the four groups was 25.7, 25.1, 22.1, and 21.1 respectively, showing a 4.6 point difference between metropolitan areas and underdeveloped rural areas, and a 2.5 point difference in 11-year-old girls. This finding can be explained by a large number of overweight and obese individuals in large cities.

Differences were generally less pronounced on the 50% percentile, but they reflected the heavier build of the children from urban areas. Inequalities in BMI between urban and rural areas were less marked among the older age groups, possibly because adolescents from rural areas had a lower final body height than their peers from urban areas.

BMI was almost evenly distributed between the groups on the percentile of 5%, showing that although the material living standard is generally higher in the cities, very lean or even malnutritioned individuals are still common. This finding indicates that the imbalance in the nutritional state is even greater within the urban population.

The distribution of BMI is affected by the onset of puberty, and can be seen at the percentile of 95% of boys from large cities and those from smaller cities. The boys developed earlier into the period of rapid pubertal growth (become tall and lean sooner), and those from smaller cities overtook them in terms of BMI at the age of 10 to 11 years. When the pubertal growth spurt starts among the boys from smaller cities after the age of 12 years, however, they again fall back behind their peers from large metropolitan areas.

As for the north-south comparison (Figs. 1,2), a higher BMI in the northern population was seen. This was particularly obvious on the percentile of 95%. The mean BMI for 11-year-old girls was 22.3 in north China and 21.0 in south China, resulting in a difference of 1.3 points. The corresponding figures for 14-year-old boys were 25.4 and 23.5 with a difference of 1.9 points. The significant difference for both boys and girls on the percentile of 50% continued to the age of 18. At this age, the mean BMI on the percentile of 50% was 20.5 in north China and 19.8 in south China for boys and 20.5 in north China and 20.0 in south China for girls. Unlike the difference between urban and rural areas at least in this group, there was no tendency to have a smaller difference as the children grow up.

The data on children from different areas of varied economic status (Figs. 3,4) showed that those from

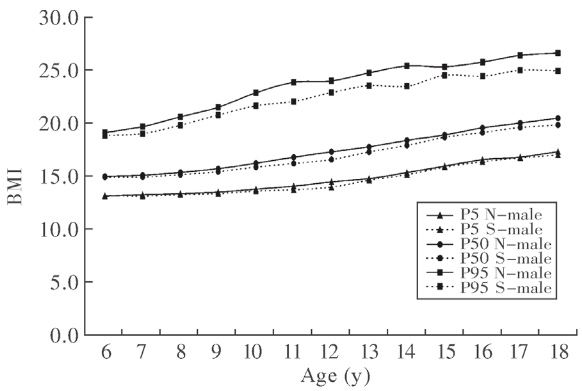

Fig. 1. Comparison of the 5%, 50% and 95% percentiles of BMI in boys aged 6 to 18 years from north and south China.

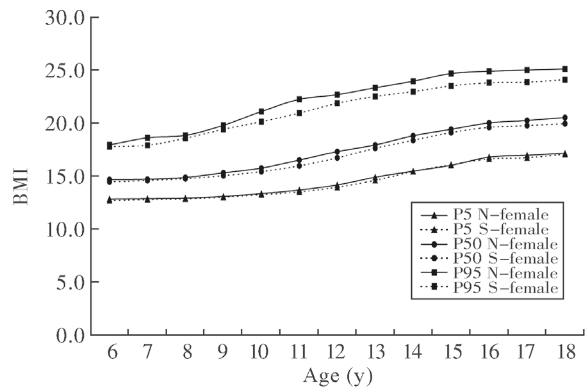

Fig. 2. Comparison of the 5%, 50% and 95% percentiles of BMI in girls aged 6 to 18 years from north and south China.

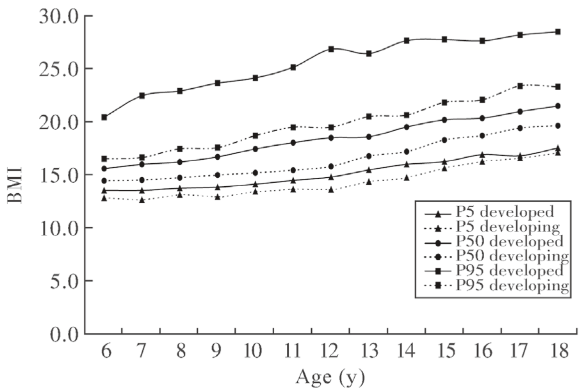

Fig. 3. Comparison of the 5%, 50% and 95% percentiles of BMI in boys from different socioeconomic backgrounds.

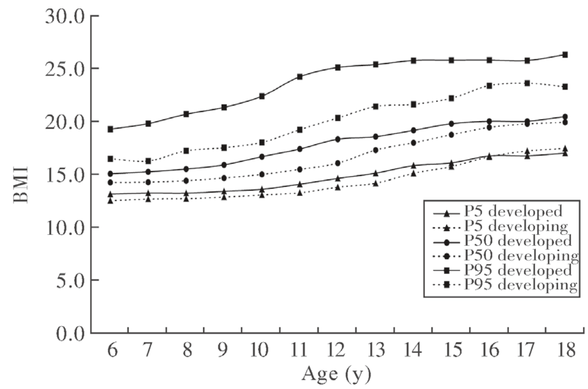

Fig. 4. Comparison of the 5%, 50% and 95% percentiles of BMI in girls from different socioeconomic backgrounds.

developed urban areas had the highest average values for body height, weight, and BMI nationwide, whereas those from underdeveloped rural areas had the lowest values. A huge difference existed between the two groups.

In 7-year-old boys, the mean BMI on the percentile of 95% was 22.5 in developed areas and 16.7 in the less developed. The corresponding figures were 26.5 and 20.5 at age of 13 years and 28.5 and 23.3 at age of 18 years. Among girls at age of 7 years, the mean BMI on the percentile of 95% was 19.8 in developed cities and 16.3 in less developed areas. They reached 24.2 and 19.2 at age 11 and 26.3 and 23.3 at age of 18 years. Large difference also existed in the percentiles of 50% and 5%, especially in puberty. This difference persisted on the 50% percentile for boys until the age of 18 years, but it is less marked on the 5% percentile for boys and on both the 50% and 5% percentiles for girls, particularly after the age of 16 years.

Discussion

BMI as an ideal marker of overweight and obesity in the screening process is closely associated with fat distribution.[15,16] Unlike the widely accepted BMI of 25 for overweight and 30 for obesity for obesity screening in adults, it is far more difficult to decide cut-off values for the screening of children and adolescents, who are in the midst period of rapid growth and development.[17] Similarly, the cut-off values for adults have been chosen to represent actual clinical levels of risk, for instance, for cardiovascular mortality, the clinical significance of childhood obesity cannot be assessed easily.[18-20] Again unlike infants and pre-school children, the rapid physical development during puberty is strongly affected by both genetic and environmental factors, resulting in a gradual formation of an individual physical build. In particular, the genetic difference in body height between individuals from different ethnic backgrounds becomes most obvious only after a child enters the pubertal stage of development.[21] Therefore, one should be very careful when applying international criteria to Chinese adolescents. The aim of this study was to analyze the distribution of BMI between regions of different geographic and economic conditions and between

Table 1. Comparison of the 5%, 50% and 95% percentiles of BMI in boys from urban and rural areas in the year 2000

Age (y)	P_5				P_{50}				P_{95}			
	Large cities	Medium/ small cities	Wealthy rural areas	Average/poor rural areas	Large cities	Medium/ small cities	Wealthy rural areas	Average/ poor rural areas	Large cities	Medium/ small cities	Wealthy rural areas	Average/poor rural areas
6	13.5	13.3	13.0	13.1	15.2	15.1	14.7	14.7	19.7	19.5	17.7	17.9
7	13.2	13.3	13.1	13.2	15.3	15.2	14.8	14.8	20.5	20.2	18.0	17.5
8	13.4	13.4	13.2	13.2	15.7	15.5	15.0	15.0	21.2	21.2	18.7	18.2
9	13.5	13.5	13.3	13.5	16.1	15.8	15.3	15.3	22.3	21.8	19.4	18.5
10	13.7	13.8	13.6	13.7	16.8	16.5	15.6	15.6	23.0	23.1	20.7	19.9
11	14.0	14.0	13.7	13.9	17.2	17.1	16.0	15.9	23.2	24.1	21.0	20.9
12	14.4	14.4	14.0	14.1	17.6	17.4	16.5	16.4	24.9	24.4	21.7	21.0
13	14.8	14.8	14.6	14.6	18.2	17.9	17.2	17.0	25.7	25.1	22.2	21.1
14	15.3	15.3	15.1	15.2	18.7	18.4	17.8	17.8	26.2	25.4	22.6	21.7
15	15.8	16.0	15.7	15.9	19.2	19.1	18.4	18.5	26.3	25.9	23.4	22.4
16	16.5	16.5	16.5	16.4	19.7	19.5	19.1	19.1	26.7	26.0	23.7	23.1
17	16.7	16.7	16.8	17.0	20.2	20.1	19.5	19.5	26.5	26.9	24.4	23.8
18	16.9	17.1	17.2	17.2	20.4	20.3	19.9	19.9	27.1	26.4	24.5	23.8

Table 2. Comparison of the 5%, 50% and 95% percentiles of BMI in girls from urban and rural areas in the year 2000

Age (y)	P_5				P_{50}				P_{95}			
	Large cities	Medium/ small cities	Wealthy rural areas	Average/poor rural areas	Large cities	Medium/ small cities	Wealthy rural areas	Average/ poor rural areas	Large cities	Medium/ small cities	Wealthy rural areas	Average/poor rural areas
6	12.9	12.8	12.5	12.8	14.8	14.7	14.4	14.3	18.5	18.6	17.1	16.8
7	12.9	12.9	12.7	12.9	14.8	14.8	14.5	14.5	18.8	18.7	17.8	16.9
8	13.0	13.0	12.7	12.9	15.0	15.0	14.6	14.6	19.7	19.3	17.9	17.5
9	13.1	13.1	12.9	12.9	15.5	15.4	14.9	15.0	20.4	20.0	18.6	19.0
10	13.4	13.3	13.2	13.3	16.0	16.0	15.3	15.3	21.4	21.3	19.3	19.4
11	13.7	13.7	13.4	13.6	16.6	16.6	15.8	15.9	22.8	22.7	20.3	20.3
12	14.0	14.2	13.9	13.9	17.4	17.4	16.6	16.6	23.7	23.1	21.2	21.2
13	14.7	14.9	14.7	14.6	18.0	18.0	17.5	17.6	23.6	23.8	22.1	22.0
14	15.6	15.6	15.3	15.4	18.9	18.8	18.3	18.6	24.7	23.6	22.6	22.8
15	15.9	16.1	16.0	16.0	19.4	19.4	19.1	19.2	24.8	24.6	23.3	23.2
16	16.5	16.7	16.8	16.9	19.8	19.7	19.7	20.0	24.9	24.8	23.9	23.9
17	16.6	16.7	17.2	17.1	19.8	19.8	20.1	20.2	25.4	24.8	23.9	24.2
18	16.9	17.0	17.3	17.4	20.0	20.2	20.3	20.4	25.1	24.9	24.4	24.1

different populations of Chinese school children and adolescents.

The results of this study showed that huge difference exists between urban and rural areas. The cause of this discrepancy is probably multifactorial and leads to lower body height and weight in rural populations across all age groups. Therefore, it is essential to consider rural-urban differences when setting screening criteria because it directly affects the value of such criteria.[22] The north-south variation is less pronounced and mostly expresses itself in a heavier physical build among the northern populations, but it is a factor independent of the socioeconomic status and thus deserves consideration. The results of this study are consistent with the previously reported.[8,9] Few other countries have shown such marked and complex differences.[23-25] The differences between cities and rural areas, discrepancies in socioeconomic development between regions, and variations in geographical and climatic conditions all need to be taken into account. For instance, factors as abundant sunlight in northern China, combined with a low average temperature over the year and large day-night temperature differences all promote the accumulation of body fat during the period of pubertal growth.[9] If the cut-off values of a nationwide screening criteria are chosen relatively low, a certain proportion among well-developed adolescents who are both tall and heavy may not be identified in the screening as their tallness results in a relatively low BMI (Figs. 3, 4). On the other hand, a relatively high cut-off value may include a very small number of individuals in less developed rural areas only, where the problem of obesity would then be underestimated and neglected.

So is there anything as the ideal screening criteria for Chinese youth? From the data of this study we can see that if there is hope to arrive at such criteria some day, it is necessary to recognize the complexity of the issue.[26] The higher percentiles in this study almost reach up to the level of developed countries and may serve well for screening purposes, especially when individuals with the corresponding degree of obesity are becoming numerous. On the other hand, we need to be aware of two major issues. First, virtually all subpopulations in this study included a certain percentage of underweight and malnutritioned individuals, which affected the distribution curve of the overall population. Second, although we now witness a rapid increase in the prevalence of overweight and obesity in China, one can assume that this is not more than the beginning of a trend which is likely to continue. In fact, extremely obese children are still relatively uncommon in China, so that at present it is hard to anticipate the future trends and to define clear cut-off values for prevention and intervention programs.[27-29] Therefore, we think that at present there are two important possible approaches to obesity screening among Chinese youth. First, reference populations should be selected from well-developed regions so as to ensure comparability in the future. Second, screening criteria need to be adjusted for rural-urban and north-south differences (as the data from this study have shown) to improve the effectiveness of nationwide screening. Detailed measures to be taken may include: (1) not only should the level of development be considered in the sample, but also the long-term changes that may occur; (2) in addition to sampling from both northern and southern China, an adequate proportion of individuals from rural areas need to be included as well; (3) presently available body height-specific criteria weight curves, and age-specific body height standard curves[3] should be employed to identify individuals with temporary malnutrition (wasting) and long-term malnutrition (stunting) so as to work towards a better distribution of the nutritional status within populations.[30,31]

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