

Application of the WHO Growth Reference (2007) to Assess the Nutritional Status of Children in China

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Objective To assess the nutrition status of children and adolescents in China using the WHO growth reference (2007) in comparison with that defined by the International Obesity Task Force (IOTF) and the Working Group on Obesity in China (WGOC). **Methods** Overweight and obesity were defined by age-, sex-, specific BMI reference developed by WHO (2007), IOTF (2000), and WGOC (2004), respectively. Stunting and thinness were defined as height and BMI less than two standard deviations (SD) of the WHO growth reference (2007), respectively. Data of children and adolescents aged 5 to 19 years ($n=54\ 857$, 28 273 boys, 26 584 girls) from the 2002 China National Nutrition and Health Survey (CNNHS) were used in the study. **Results** The prevalence of overweight, obesity, stunting and thinness among Chinese children and adolescents aged 5-19 years was 5.0%, 1.2%, 13.8%, and 7.4%, respectively when the WHO growth reference (2007) was used, whereas the estimated absolute total number affected by these 4 conditions were 14.6, 3.7, 40.6, and 21.8 million, respectively. The prevalence of overweight and obesity was 18.1% in large cities, while the stunting prevalence was 25.1% in rural 4. Obesity prevalence assessed by the WHO growth reference was higher than that as assessed by the IOTF reference, and obesity prevalence assessed by the WGOC reference was lower than that as assessed by the IOTF reference. **Conclusion** The nutritional status of children and adolescents is not equal in different areas of China. Stunting is still the main health problem of the poor, while overweight and obesity are the main health problems in large cities.

Key words: WHO; Obesity; Stunting; Children; Adolescents; China

INTRODUCTION

In order to plot growth curves for school-aged children and adolescents in accord with the WHO Child Growth Standards for preschool children and the body mass index (BMI) cut-offs for adults, the WHO growth reference for school-aged children and adolescents was developed in 2007^[1], which provided an appropriate growth reference for the screening and monitoring of nutritional status of school aged children and adolescents internationally. The 2007 reconstruction permits the extension of the BMI reference to five years, where the curves match WHO under-five curves^[2] in a virtually perfect way. Furthermore, at 19 years of age, the 2007 BMI values for both sexes at +1 SD (25.4 kg/m^2 for boys and 25.0 kg/m^2 for girls) are equivalent to the overweight cut-off points used for adults ($>25.0\text{ kg/m}^2$), while the

+2 SD value (29.7 kg/m^2 for both sexes) compares closely with the cut-off points for obesity ($>30.0\text{ kg/m}^2$)^[3]. As weight-for-age is inadequate for monitoring growth beyond childhood due to its inability to distinguish between relative height and body mass, the WHO growth reference (2007) provides BMI-for-age to complement height-for-age in the assessment of thinness (low BMI-for-age), overweight and obesity (high BMI-for-age), and stunting (low height-for-age) in school-aged children and adolescents^[1].

In order to assess the nutritional status with a single international growth reference, the WHO growth reference (2007) including thinness, stunting, overweight and obesity was applied among children and adolescents aged 5-19 years in China. This was for the first time to report the thinness, stunting, overweight and obesity in Chinese children and

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adolescents aged 5 to 19 years with one single reference, especially stunting in this age group. The findings will be useful for international comparison. The second purpose of the study was to compare the WHO growth reference (2007) with the IOTF^[5] and WGO^[6] references in defining overweight and obesity in China. The IOTF^[5] standard for 2-19 years was developed based on the data of Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the United States. However, children from Hong Kong are not national representative. Then the Working Group for Obesity in China (WGO^[6]) organized by International Life Science Institute Focal Point in China conducted an analysis on BMI of children and adolescents aged 7-18 years in 2002. The age-, sex-specific BMI 85th and 95th percentiles were developed respectively by using B-Spline curve to adjusted the curve that pass through a BMI of 24 kg/m² and 28 kg/m² (the cut-off points used for Chinese adults to define overweight and obesity, respectively) at 18 years of age.

MATERIALS AND METHODS

Sampling and Subjects

The 2002 China National Nutrition and Health Survey (CNNHS) is a nationally representative cross-sectional survey that covered 31 provinces, autonomous regions and municipalities directly under the Central Government (Hong Kong, Macao and Taiwan excluded)^[4]. Multistage cluster sampling method was used for subject selection. Detailed information about sampling method has been already described elsewhere^[7]. In stage 1, all 2 860 counties/districts/cities of China were divided into six categories (big cities, medium and small cities, rural 1, 2, 3, and 4) based on type and level of economic development (from high to low). Twenty-two counties/districts/cities were randomly selected from each category, thus a total of 132 counties/districts/cities were randomly selected at this stage. In stage 2, three townships/sub-districts were randomly selected from each of the selected counties/districts/cities, resulting in 396 townships/sub-districts being randomly selected at this stage. In stage 3, two villages/neighbourhood committees were randomly selected from the selected townships/sub-districts, giving a total of 792 villages/neighbourhood committees. In stage 4, 90 households were randomly selected from each selected village/neighbourhood, which resulted in a final total of 71 971 households that were randomly selected to represent the national data.

The assessment of nutritional status was based

on samples aged 5 to 19 years (61 months to 228 months) ($n=54\ 857$), subgroups of the 2002 CNNHS.

Anthropometrical Measurements

Fasting body weight was measured in the morning to the nearest 0.10 kg with a balance-beam scale while the subjects were wearing lightweight clothing. Height was measured to the nearest 0.1 cm using a standard steel strip height measure in bare footed subjects^[4].

Definitions

The estimation of the prevalence of overweight and obesity was based on age-, sex-specific BMI cut-off points developed by the WHO^[1] International Obesity Task Force (IOTF)^[5] and the Working Group on Obesity in China (WGO^[6]), respectively.

Thinness and stunting were defined as BMI-for-age and height-for-age (Z-score), below two standard deviations from the relative median value of the WHO growth reference (2007), respectively^[11].

The survey protocol was approved by the Ethical Committee of the National Institute for Nutrition and Food Safety, Chinese Center for Disease Control and Prevention. Signed written consents were obtained from both the parents or guardians and the children themselves.

Statistical Analysis

Considering the sampling method of equal-sample-size of the six areas and the proportion difference between the sampled subjects and the general population, the prevalence of thinness, stunting overweight and obesity in 2002 was weighted by the population proportion in six classified areas and age according to the data from the Fifth China National Population Census^[8]. Stunting proportion among the overweight and obese subjects was also calculated in order to estimate the coexistence of stunting and overweight/obesity.

RESULTS

A total of 54 857 children and adolescents aged 5-19 years (61-228 months), including 28 273 boys and 26 584 girls were included in the present study.

The prevalence of overweight and obesity in children and adolescents aged 5-19 years was 5.0% and 1.2%, respectively, and it was higher in boys than in girls when the WHO growth reference (2007) was used. The overweight and obesity were more prevalent in urban children and adolescents than in their rural counterparts. Higher prevalence of overweight and obesity was observed in children than

in adolescents (Table 1).

On the contrary, the stunting prevalence was higher in girls than in boys. The stunting was more prevalent in rural children (5-12 yrs) and adolescents (13-19 yrs) than in their urban counterparts. The prevalence of stunting was higher in adolescents than

in children. The overall prevalence of stunting in children and adolescents aged 5-19 years was 13.8% (Table 1).

The overall prevalence of thinness was 7.4%, with similar socioeconomic characteristics as stunting (Table 1).

TABLE 1
Prevalence of Malnutrition in Children and Adolescents Aged 5-19 Years¹ in China-as Assessed by the WHO Growth Reference (2007)² (%)

	Overweight	Obesity	Stunting	Thinness
Total				
Prevalence	5.0	1.2	13.8	7.4
Estimated Number (10 ⁶)	14.6	3.7	40.6	21.8
Sex				
Boys	5.1	1.5	13.0	8.2
Girls	4.9	1.0	14.6	6.5
Age group				
Children (5-12 yrs)	5.1	1.6	16.5	7.2
Adolescents (13-19 yrs)	4.7	0.9	10.4	7.6
Region				
Urban	9.4	2.1	5.7	5.3
Rural	3.5	1.0	16.4	8.1
Areas				
Large Cities	14.4	3.7	2.1	4.1
M & S Cities	7.9	1.5	6.8	5.7
Rural 1	4.5	1.4	14.8	10.0
Rural 2	3.3	1.0	15.0	8.1
Rural 3	4.4	1.1	12.5	5.1
Rural 4	2.8	0.5	25.1	7.8
Family income (Yuan/Year/Person)				
<800	4.1	1.0	21.3	8.8
800-	4.4	0.9	15.7	7.2
2 000-	6.8	1.7	8.9	6.2
5 000-	9.8	2.7	4.4	4.9
10 000-	13.2	3.1	3.9	4.1
20 000-	12.0	4.5	2.4	4.0

Great differences in nutritional status were found between children living in different areas and between families with different incomes. In large cities, stunting prevalence was much lower (2.1%), while overweight and obesity prevalence was very high (18.1%). On the contrary, in rural 4, one fourth children were stunting while 3.3% were overweight or obese (Table 1).

The estimated absolute total number of

overweight and obese youngsters aged 5-19 years were 18.3 million in China based on the WHO growth reference (2007) and another 21.8 million were affected with thinness, while 40.6 million Chinese youngsters were stunting in 2002. A total of 73.3 million children and adolescents were affected by overweight, obesity, stunting and/or thinness (1.6 million co-affected with stunting and overweight/obesity, and 5.8 million co-affected with stunting

and thinness).

The overweight and obesity prevalence defined by the WHO, IOTF, and WGOC references is shown in Figs. 1-4. Overweight prevalence in children younger than 12 years of age was the highest as defined by the WHO growth reference. The highest

obesity prevalence was observed as defined by the WGOC reference, while the lowest by the IOTF. The obesity prevalence defined by the WHO reference was between the two. Slight difference was found in the overweight prevalence when the three definitions were applied.

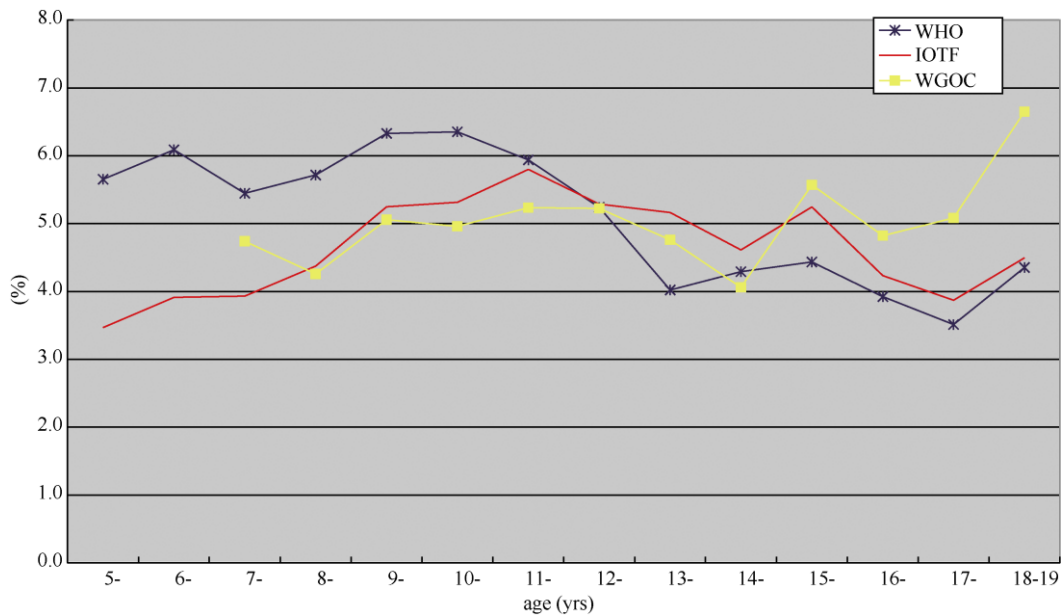


FIG. 1. Overweight prevalence of boys (%).

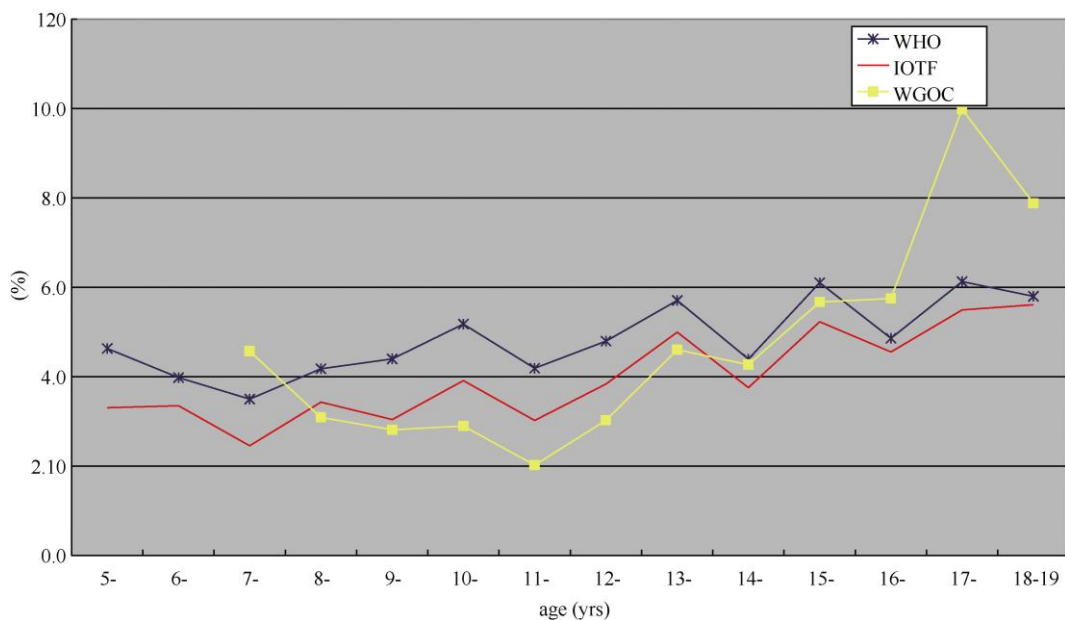


FIG. 2. Overweight prevalence of girls (%).

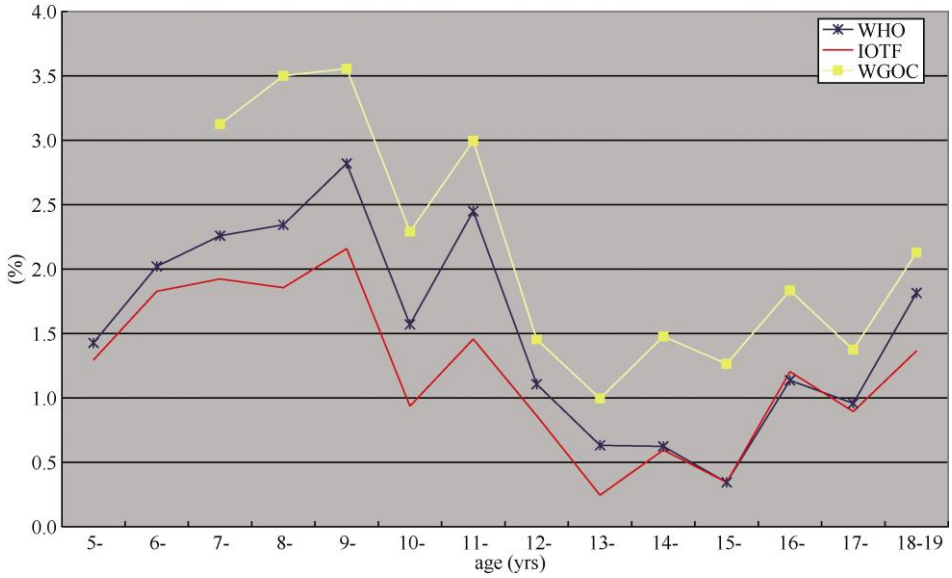


FIG. 3. Obesity prevalence of boys (%).

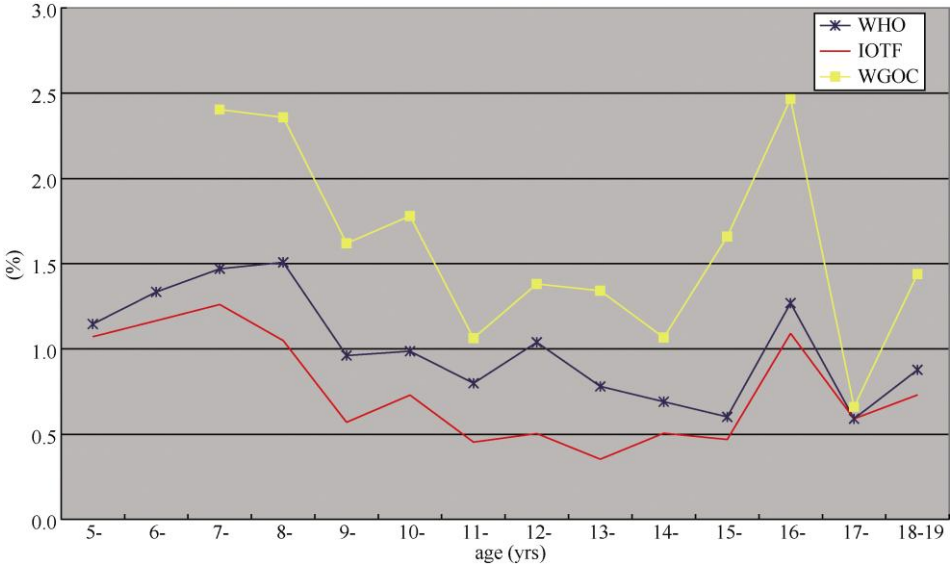


FIG. 4. Obesity prevalence of girls (%).

DISCUSSION

The WHO growth reference (2007) was reconstructed based on the 1977 NCHS/WHO growth reference for subjects aged 5 to 19 years by using the original sample (a non-obese sample with expected heights), which was supplemented with data from the WHO Child Growth Standards and the state-of-the-art statistical methods^[9-10] used to develop standards for preschool children, namely the Bos-Cox power exponential method with appropriate diagnostic tools for the selection of best models^[11]. As the WHO

growth reference (2007) was applied, the estimated absolute total number of overweight, obesity, stunting and/or thinness in children and adolescents aged 5-19 years were 73.3 million, including 6.2% of overweight or obese subjects, and 13.8% of stunted subjects.

The nutritional status was not equal among children and adolescents aged 5-19 years in different areas of China. Among the poorest, one quarter children and adolescents in rural 4 were faltered in linear growth, and 7.4% were affected with thinness. Malnutrition remained one of the main nutritional

problems among the poor. Undernourished children were more likely to be below the average height when they reached adulthood and had lower educational background than those who were nourished adequately^[11]. Stunting during developmental ages also had a long reach and increased the likelihood that people would suffer from chronic diseases at middle and even late ages^[12]. Therefore, good nutrition not only has positive economic outcomes, but is also an important prerequisite for economic development^[12-14]. Nutrition should be a priority at national and sub-national levels, especially in the poor areas of China.

The main challenge in large cities of China is the control and prevention of overweight and obesity, as stunting is rare in the urban population. The ratio of overweight to obesity in large cities is almost 4, which predicts the rapid increase of obesity prevalence, obesity-related health risks^[15], high persistence of childhood obesity to adult obesity^[16] in the future and the challenge of childhood obesity treatment^[3,17], and therefore prevention of childhood obesity should be given high priority as a public action in large cities.

Three reference, namely the WHO, IOTF, and WGO reference, can be used to define overweight and obesity among Chinese children and adolescents aged 7-17 years. There is no significant difference in overweight prevalence defined by these three references and so is in obesity. The highest obesity prevalence is observed as assessed by the WGO reference and the lowest is by the IOTF. The figure of obesity prevalence as assessed by the WHO reference is in between the two. Since the appropriateness of the WGO reference was verified by the disease risks in the 2002 survey^[15,18], it seems that the country-specific reference possesses a greater public health significance. There is another difference in the WHO reference complements, namely the height-for-age in the assessment of stunting and the low BMI-for-age for thinness.

In conclusion wide nutritional inequality does exist in China. Chinese children and adolescents are still faced with dual challenges of obesity and stunting.

ACKNOWLEDGEMENTS

National Nutrition and Health Survey 2002 was supported by Ministry of Health and Ministry of Science and Technology (2001DEA30035, 2003DIA6N008), China. We thank all the team members and all participants from 31 provinces. We appreciate the supports of UNICEF, WHO, Unilever

China and Danone Nutrition Institute, China.

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(Received November 20, 2006 Accepted April 15, 2007)