

Original Article



Secular Changes of Stature in Rural Children and Adolescents in China, 1985-2010*

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Abstract

Objective To analyze and assess secular change in stature in rural children and adolescents in China from 1985 to 2010.

Methods Data were obtained from the 6 rounds of the Chinese National Survey on Student's Constitution and Health. The subjects enrolled in the study were children and adolescents aged 7-18 years in rural areas of provincial capitals.

Results An overall positive secular trend in stature occurred in rural areas of provincial capitals in China from 1985 to 2010. The overall average increase rates were 3.1 and 2.4 cm/decade for boys and girls, respectively. The total body height increases for grown up boys and girls were 3.6 and 2.3 cm and the increase rates were 1.4 and 0.9 cm/decade, respectively. There were differences in body height increase among eastern, central and western regions. The average body height of the children or adolescents in eastern region was highest, followed by central region and western region. The overall increase rates in central region were highest among the three regions. The difference between eastern/central region and western region was obvious.

Conclusion Positive secular trend in stature of children or adolescents has occurred in rural area of China, and rural boys and girls showed a great potential for continuous growth. More attention should be paid to the differences in children's body height between western region and eastern/central region.

Key words: Secular change; Stature; Rural population; Regional difference; Child and adolescent

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INTRODUCTION

Secular changes in growth and development are the outcome of the combined and continuous effect of genetic and environmental factors. Growth is considered a mirror of social conditions^[1], and therefore secular change in growth, especially in stature, is regarded as an indicator of nutrition, hygienic and health status in the same ethnical population^[2-3] and

stature is taken as an indicator of welfare.

Secular growth trends have been well documented in a large number of human populations since the 19th century, especially in developed countries^[2-5]. Nevertheless, the rate of stature increase has slowed down and reached a plateau in many northern European countries since the middle of 1980s^[4,6-8]. In developing countries the secular changes to increasing stature have occurred with the improvement of economy, living conditions

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and nutrition status^[9-12], whereas negative or opposite secular changes have been reported as well^[13-16].

In China positive secular changes in growth of children and adolescents were reported in urban younger population, for instance in children residing in Hong Kong and Shandong^[21-22], some minor ethnic groups^[23-24], children aged 0-7 years^[25], and some children from the 1950s to 2010^[17-20]. However, there has been no study focusing on the stature of rural children and adolescents in China. As we know, the rapid rural economic development has occurred simultaneously with urban economic growth in China over the past decades. It is important for us to clarify whether the positive secular change in growth has occurred in rural Chinese and what its extent is, whether there has been a constant increasing rate in different periods, whether there are differences in secular changes between rural and urban areas and among different rural regions, and how the differences have changed over the past few decades.

In this study we used national survey data which were collected systematically and successively among school-aged children and adolescents. We analyzed secular trends in stature of children and adolescents aged 7-18 years in rural areas of provincial capitals from 1985 to 2010. The differences between rural area and urban areas, among eastern region, central region and western region, as well as the differences with other populations were discussed.

METHODS

Study Population and Data Sources

Data were obtained from 6 rounds of Chinese National Survey on Student's Constitution and Health (CNSSCH) conducted in 1985, 1991, 1995, 2000, 2005, and 2010 respectively. The CNSSCH survey was jointly launched by the Ministry of Education, the Ministry of Health, the Ministry of Science and Technology, the State Nationality Affairs Commission, and the State Physical Culture and Sports General Administration^[26-31]. There were four subpopulations stratified by sex and area of residence, i.e. males and females, urban and rural areas in each province, and each had an equal size of sample from different socioeconomic classes. This survey is, so far, the largest nationwide representative sampling survey of school-aged children and adolescents in China, and the results

have been widely used to produce national prevalence estimates for a variety of health indicators of children and adolescents.

Subjects under study were primary and middle school students aged 7-18 years selected with stratified cluster randomized sampling from rural areas of capitals of 26 provinces and Beijing, Shanghai, Tianjin, and Chongqing, excluding Lhasa of Tibet where Han people are minority. To reflect the impact of regional socioeconomic development on body height, the regions surveyed were divided into three groups, i.e. eastern region, central region and western region, which is quite similar to the administrative division of regions of China. Eastern region includes Beijing, Tianjin, Shijiazhuang, Shenyang, Shanghai, Nanjing, Hangzhou, Fuzhou, Jinan, Guangzhou, and Haikou. Central region includes Taiyuan, Changchun, Harbin, Hefei, Nanchang, Zhengzhou, Wuhan, and Changsha. Western region includes Hohhot, Guilin, Chongqing, Chengdu, Guiyang, Kunming, Xi'an, Lanzhou, Xining, Yinchuan, and Urumqi. Table 1 shows the gender and age specific sample sizes of children or adolescents in rural areas of 30 cities mentioned above in different rounds of the survey. The numbers of subjects surveyed were 83 310 in 1985, 70 151 in 1991, 42 528 in 1995, 49 416 in 2000, 51 220 in 2005, and 63 673 in 2010 respectively.

Description of Variables and Data Analysis

All subjects had a thorough medical examination before measurement, and those with diseases or physical/mental deformities were excluded. The body height (cm) has been measured in a standard way by using metal column height measuring stand recommended by Cameron^[32]. All the staff participating the survey received the training of anthropometric measurement.

Age groups were divided by calculating 'exact age'. The 7-year-old cohort (represented by '7+') included students aged 7 years and 1 month-7 years and 12 months. T-tests were conducted to analyze the differences in mean statures among the subjects surveyed. All statistical tests were performed using the statistical package, SPSS/PC version 18.0.

RESULTS

Overall Secular Change in Stature

Figure 1 shows overall consecutive increases of stature from 1985 to 2010, while the mean values and increments are showed in Table 2. As shown in

Table 2, average increase rates were 3.1 and 2.4 cm/decade for boys and girls aged 7-18 years, respectively. Mean body height was compared for different survey, and *t*-tests indicated that the gender specific body height in most age groups were significantly higher than those recorded in previous survey, and average body height in each age group in 2010 were significantly higher than those in 1985. The secular changes occurred from the early ages. The average body height of boys and girls aged 7 years increased from 118.1 and 117.1 cm in 1985 to 125.2 and 123.1 cm in 2010, the increase rate was 2.8 cm/decade and 2.6 cm/decade, respectively. The largest increases were found in adolescents, i.e. 10.4 cm (4.1 cm/decade) for boys aged 12-14 years and 8.7 cm (3.5 cm/decade) for girls aged 10-12-years. The maximum height difference with the former age in 1985 occurred in 13 years old boys and girls, while it changed to 12 and 10 years old in 2010 for boys and girls, respectively. It indicated that the growth peak shifted to earlier age. The average

body height of boys and girls aged 18 years increased from 167.4 and 156.4 cm in 1985 to 171.0 and 158.7 cm in 2010, the increase rate was 1.4 cm/decade and 0.9 cm/decade, respectively. Generally boys had more increase in body height than girls had. The average increase rate for the children aged 7-18 years during 1991-1995 and during 2005-2010 were higher than increase rate in other survey periods.

Secular Change in Different Regions

Table 3 shows successively positive increases in different regions. Almost in every age group and every survey year, the body height of boys and girls in eastern region were higher than those in central region, and the body height of boys and girls in western region was lowest. The body height of boys and girls aged 18 years in eastern region were 2.1 cm and 2.7 cm higher than those in western region in 2010.

Table 1. Gender Specific Sample Sizes in Different Rounds of Survey

Age	1985		1991		1995		2000		2005		2010	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
7+	3 465	3 460	2 976	2 861	1 684	1 686	2 111	2 140	2 135	2 138	2 661	2 645
8+	3 463	3 467	2 949	2 911	1 785	1 703	2 078	2 050	2 104	2 108	2 734	2 624
9+	3 462	3 466	2 971	2 904	1 689	1 665	2 035	2 087	2 211	2 175	2 632	2 603
10+	3 465	3 567	2 894	2 866	1 789	1 799	2 083	2 079	2 241	2 149	2 751	2 701
11+	3 465	3 464	2 918	2 936	1 795	1 784	2 085	2 067	2 127	2 178	2 668	2 637
12+	3 466	3 466	2 911	2 921	1 797	1 785	2 051	2 065	2 147	2 111	2 725	2 650
13+	3 462	3 466	2 912	2 897	1 780	1 749	2 043	2 097	2 119	2 121	2 688	2 633
14+	3 463	3 461	2 919	2 925	1 846	1 786	2 069	2 090	2 107	2 087	2 692	2 640
15+	3 464	3 464	2 962	2 926	1 884	1 775	2 084	2 079	2 174	2 165	2 681	2 622
16+	3 466	3 462	2 959	2 934	1 852	1 773	2 069	2 072	2 157	2 123	2 736	2 622
17+	3 465	3 463	2 962	2 916	1 827	1 780	2 021	2 015	2 112	2 150	2 659	2 608
18+	3 497	3 501	2 965	2 856	1 773	1 742	1 961	1 885	2 045	2 036	2 559	2 502
Total	41 603	41 707	35 298	34 853	21 501	21 027	24 690	24 726	25 679	25 541	32 186	31 487

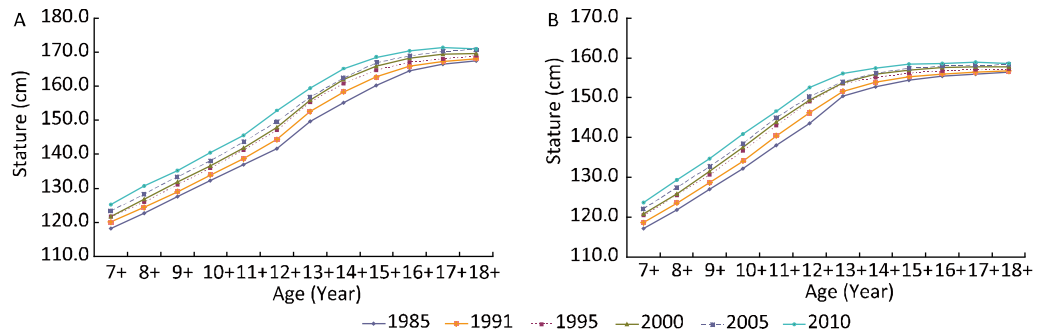


Figure 1. Secular Changes in Stature for Rural Boys (A) and Girls (B) in China, 1985-2010.

As shown in Figure 2, in most age groups, the boys and girls in central region had highest increase rates compared with those in eastern and western region from 1985 to 2010, with the average increase rates of 3.4 and 2.6 cm/decade, respectively. The boys and girls aged 18 years had an increase of 3.7 cm and 2.7-2.8 cm in eastern and central regions, higher than those in western region. Therefore, the differences in body height for 18-year-old boys and girls between eastern and western regions increased from 1.7 cm and 1.5 cm to 2.1 cm and 2.7 cm from 1985 to 2010, respectively.

The increase extents were different in different survey periods among the three regions. In eastern region the highest average increase rate of in subjects aged 7-18 years was found during 1991-1995 and the lowest was during 2005-2010. In central region the highest average increase rate was

found during 2005-2010. Meanwhile, in western region average increase rates in different survey periods seemed similar and were relatively lower than those in eastern and central regions. It was similar for subjects aged 18 years (Figure 3). The average increase rates in western region were lower than those in eastern and central regions during most survey periods. All the three regions still showed much potential for growth.

Differences between Rural Area and Urban Area

Figure 4 shows the age specific stature increase for boys and girls in rural areas of province capital cities and urban areas which we have analyzed^[19]. At every age the body height of rural boys and girls were lower than that of urban boys and girls, but rural boys and girls had more increase than urban boys and girls. Over the past 25 years between 1985

Table 2. Secular Changes of Stature for Rural Boys and Girls Aged 7-18 Years in China, 1985-2010 (cm)

Age	1985	1991	1995	2000	2005	2010	I ₈₅₋₉₁	I ₉₁₋₉₅	I ₉₅₋₀₀	I ₀₀₋₀₅	I ₀₅₋₁₀	It	Ia
Boys													
7+	118.1	120.0 ^{***}	121.6 ^{***}	121.7	123.3 ^{***}	125.2 ^{***}	3.2	4.0	0.2	3.2	3.8	7.1	2.8
8+	122.7	124.4 ^{***}	125.9 ^{***}	126.9 ^{***}	128.3 ^{***}	130.6 ^{***}	2.8	3.8	1.9	2.8	4.7	7.9	3.2
9+	127.6	129.0 ^{***}	131.0 ^{***}	131.9 ^{***}	133.4 ^{***}	135.3 ^{***}	2.2	5.1	1.8	2.9	3.8	7.6	3.0
10+	132.2	133.9 ^{***}	135.9 ^{***}	136.5 ^{**}	138.1 ^{***}	140.4 ^{***}	2.7	5.0	1.2	3.2	4.7	8.2	3.3
11+	136.9	138.7 ^{***}	141.3 ^{***}	141.8 [*]	143.6 ^{***}	145.5 ^{***}	3.0	6.6	1.0	3.7	3.8	8.6	3.5
12+	141.6	144.3 ^{***}	147.0 ^{***}	147.9 ^{**}	149.6 ^{***}	152.9 ^{***}	4.5	6.7	1.7	3.4	6.6	11.3	4.5
13+	149.6	152.5 ^{***}	155.4 ^{***}	156.0 [*]	156.8 ^{**}	159.4 ^{***}	4.8	7.2	1.2	1.6	5.3	9.8	3.9
14+	155.2	158.3 ^{***}	160.8 ^{***}	162 ^{***}	162.4	165.2 ^{***}	5.3	6.1	2.5	0.7	5.6	10.0	4.0
15+	160.3	162.7 ^{***}	164.8 ^{***}	165.8 ^{***}	166.9 ^{***}	168.5 ^{***}	4.0	5.1	2.1	2.2	3.2	8.2	3.3
16+	164.5	165.8 ^{***}	167.0 ^{***}	168.3 ^{***}	168.9 ^{***}	170.3 ^{***}	2.2	3.0	2.5	1.3	2.7	5.8	2.3
17+	166.5	167.2 ^{***}	168.0 ^{***}	169.3 ^{***}	170.2 ^{***}	171.4 ^{***}	1.2	2.0	2.7	1.8	2.4	4.9	2.0
18+	167.4	168.1 ^{***}	168.9 ^{***}	169.6 ^{**}	170.8 ^{***}	171.0	1.1	2.1	1.3	2.4	0.5	3.6	1.4
Average							3.1	4.7	1.7	2.4	3.9	7.8	3.1
Girls													
7+	117.1	118.6 ^{***}	120.4 ^{***}	120.7	122.0 ^{***}	123.7 ^{***}	2.5	4.6	0.6	2.6	3.3	6.6	2.6
8+	121.7	123.5 ^{***}	125.5 ^{***}	125.8	127.4 ^{***}	129.3 ^{***}	2.9	5.0	0.7	3.1	3.7	7.5	3.0
9+	126.9	128.6 ^{***}	130.6 ^{***}	131.5 ^{***}	132.7 ^{***}	134.7 ^{***}	2.8	5.0	1.7	2.5	4.1	7.8	3.1
10+	132.1	134.1 ^{***}	136.7 ^{***}	137.6 ^{***}	138.5 ^{***}	140.8 ^{***}	3.2	6.5	1.8	1.9	4.7	8.7	3.5
11+	138.0	140.4 ^{***}	143.0 ^{***}	143.8 ^{***}	145 ^{***}	146.6 ^{***}	3.9	6.4	1.7	2.3	3.3	8.6	3.4
12+	143.6	146.2 ^{***}	149.0 ^{***}	149.5	150.2 ^{***}	152.5 ^{***}	4.3	7.0	0.9	1.6	4.5	8.9	3.6
13+	150.3	151.6 ^{***}	153.5 ^{***}	153.7	154.0	156.0 ^{***}	2.1	4.7	0.4	0.5	4.1	5.7	2.3
14+	152.7	153.9 ^{***}	155.1 ^{***}	155.9 ^{***}	156.2	157.5 ^{***}	2.0	3.1	1.7	0.5	2.6	4.8	1.9
15+	154.4	155.3 ^{***}	156.2 ^{***}	157.0 ^{***}	157.3 [*]	158.4 ^{***}	1.4	2.3	1.6	0.7	2.1	4.0	1.6
16+	155.4	156 ^{***}	156.8 ^{***}	157.6 ^{***}	157.9	158.6 ^{***}	1.0	2.0	1.8	0.6	1.2	3.2	1.3
17+	156.0	156.4 ^{**}	157.0 ^{***}	157.7 ^{***}	158.1 ^{**}	158.9 ^{***}	0.6	1.7	1.3	0.9	1.5	2.9	1.2
18+	156.4	156.7 [*]	157.3 ^{***}	157.8 ^{**}	158.3 ^{**}	158.7 [*]	0.5	1.5	1.0	1.1	0.7	2.3	0.9
Average							2.3	4.2	1.3	1.5	3.0	5.9	2.4

Note. I: Increments of stature per decade and the subscript indicate start/end year (cm/decade); It: Total increments of stature from 1985 to 2010 (cm); Ia: Average rates derived from It (cm/decade); t-test: Compared with the former year; **P*<0.05, ***P*<0.01, ****P*<0.001.

Table 3. Secular Changes of Stature for Rural Boys and Girls Aged 7-18 Years in Eastern, Central and Western Regions, China, 1985-2010 (cm)

Age	Boys								Girls							
	2010	l ₈₅₋₉₁	l ₉₁₋₉₅	l ₉₅₋₀₀	l ₀₀₋₀₅	l ₀₅₋₁₀	It	la	2010	l ₈₅₋₉₁	l ₉₁₋₉₅	l ₉₅₋₀₀	l ₀₀₋₀₅	l ₀₅₋₁₀	It	la
Eastern region																
7+	126.6	2.8***	4.5***	1.2*	3.4***	2.4***	7.0	2.8	125.4	2.3***	6.3***	1.2*	3.2***	2.0***	7.1	2.8
8+	131.9	3.0***	5.7***	1.4**	4.6***	1.8***	8.0	3.2	130.8	3.5***	6.0***	0.8	4.2***	1.6**	7.8	3.1
9+	136.8	2.3***	6.5***	1.6**	4.0***	1.8***	7.7	3.1	136.6	2.8***	5.8***	2.8***	3.2***	2.4***	8.2	3.3
10+	141.9	3.0***	5.2***	2.0**	4.0***	2.6***	8.2	3.3	142.7	3.7***	6.3***	3.8***	2.6***	2.4***	9.1	3.6
11+	147.5	3.5***	7.5***	1.0	5.8***	1.4*	9.2	3.7	148.6	4.3***	7.2***	2.2**	4.0***	0.6	8.9	3.6
12+	155.2	4.7***	8.8***	2.0*	4.2***	5.0***	11.9	4.8	154.3	4.3***	6.8***	2.4***	2.2***	2.4***	8.8	3.5
13+	161.6	4.8***	6.8***	3.4***	1.6*	3.4***	9.8	3.9	157.6	1.7***	4.0***	1.8***	0.4	3.8***	5.6	2.2
14+	167.4	5.0***	7.3***	3.2***	2.6***	3.2***	10.4	4.2	158.5	1.3***	4.0***	2.8***	1.0*	0.8	4.7	1.9
15+	170.3	4.0***	6.0***	2.0**	3.8***	2.0**	8.7	3.5	159.7	1.2***	2.5***	2.4***	1.6***	1.6**	4.5	1.8
16+	172.0	1.7***	3.5***	3.8***	2.4***	2.0***	6.5	2.6	159.5	0.8*	2.0***	2.8***	1.6***	0.0	3.5	1.4
17+	172.7	0.5	2.5***	3.6***	2.4***	1.6**	5.1	2.0	160.0	0.0	3.0***	1.6***	2.6***	0.2	3.4	1.4
18+	172.0	0.5	2.7***	2.2***	3.2***	-0.8	3.7	1.5	159.7	-0.2	2.5***	1.8**	1.6**	0.2	2.7	1.1
Average		3.0	5.6	2.3	3.5	2.2	8.1	3.2		2.2	4.7	2.2	2.4	1.5	6.2	2.5
Central region																
7+	125.6	4.3***	0.3	1.2	5.6***	4***	8.1	3.2	123.8	3.7***	-1.3	2.2**	4.4***	4.0***	7.0	2.8
8+	131.2	3.2***	0.2	4.2***	4.4***	5.2***	8.9	3.6	129.4	3.0***	1.3	2.2**	3.8***	5.4***	8.0	3.2
9+	135.9	2.7***	1.0	5.2***	2.4**	6.0***	8.8	3.5	134.6	3.3***	1.5	3.0***	2.2*	6.2***	8.3	3.3
10+	141.0	2.8***	4***	1.4	4.2***	6.6***	9.4	3.8	140.5	3.7***	3.8***	1.2	4.4***	5.0***	9.0	3.6
11+	145.8	3.7***	4.5***	1.6	3.2**	6.6***	9.7	3.9	146.7	4.5***	3.5**	2.2*	3.4**	5.4***	9.6	3.8
12+	153.4	5.7***	1.7	3.2**	4.6***	9***	12.5	5.0	153.2	5.8***	4.5***	1.6	2.2*	7.4***	10.9	4.4
13+	160.2	4.8***	8***	-4.6***	7.6***	7.8***	11.5	4.6	156.3	3.7***	3.5***	-0.4	2.4**	4.4***	6.8	2.7
14+	165.1	6.2***	6***	1.4	1.6	6.6***	10.9	4.4	157.7	3.3***	0.7	0.6	2.0*	3.6***	5.4	2.2
15+	167.7	4.8***	2.3*	3.6***	1.6	3.0**	7.9	3.2	158.0	2.3***	1.7*	1.6*	1.2	1.0	4.0	1.6
16+	169.6	2.8***	4.0***	1.6*	0.8	2.4**	5.7	2.3	158.8	1.0*	2.2**	1.2	-0.2	3.2***	3.6	1.4
17+	171.1	2.3***	2.0*	1.0	2.6**	2.6**	5.3	2.1	158.8	1.5***	0.5	0.6	0.6	2.8***	3.1	1.2
18+	170.5	2.5***	2.5**	-1.6	1.6	2.4***	3.7	1.5	159.0	1.3**	0.2	1.0	0.2	2.6***	2.8	1.1
Average		3.8	3.0	1.5	3.4	5.2	8.5	3.4		3.1	1.9	1.4	2.2	4.3	6.6	2.6
Western region																
7+	123.1	3.5***	4.0***	-2.0**	4.4***	3.6***	6.7	2.7	121.4	2.8***	4.0***	-1.2*	3.6***	2.8***	5.9	2.4
8+	128.5	3.5***	1.8*	0.8	2.6***	5.8***	7.4	3.0	127.1	3.3***	3.8***	-0.2	3.8***	3.6***	7.1	2.8
9+	132.8	2.8***	3.3***	0.4	4.6***	3.0***	7.0	2.8	132.4	3.7***	3.5***	-0.2	4.4***	3.2***	7.3	2.9
10+	137.9	3.5***	2.3*	0.8	4.8***	3.4***	7.5	3.0	138.4	3.5***	5.8***	-0.2	2.6***	4.8***	8.0	3.2
11+	142.6	3.2***	3.3***	1.2	4.6***	2.6***	7.4	3.0	144.0	4.5***	3.5**	1.4	3.2***	3.0***	7.9	3.2
12+	149.3	4.8***	4.0***	0.8	5.0***	4.8***	9.8	3.9	149.6	4.8***	5.8***	-1.6	3.6***	3.4***	7.9	3.2
13+	155.9	6.8***	2.5*	1.0	3.4***	3.4***	9.0	3.6	153.7	2.8***	4.3***	-0.8	1.8**	2.8***	5.3	2.1
14+	162.1	6.3***	1.5	2.0	2.0*	5.2***	9.0	3.6	155.8	2.5***	1.5	1.4*	1.2	2.4***	4.6	1.8
15+	166.9	4.8***	3.8***	1.4	2.8***	3.6***	8.3	3.3	157.1	1.7***	1.0	1.0	1.0	2.4***	3.6	1.4
16+	168.6	3.2***	0.2	1.6*	2.4***	2.4***	5.2	2.1	157.2	1.8***	0.5	1.0	1.0	0.8	2.7	1.1
17+	169.8	2.2***	-0.5	3.0***	2.0**	1.8**	4.5	1.8	157.4	1.0**	-0.5	2.0**	0.6	0.8	2.1	0.8
18+	169.9	1.3***	-0.5	2.8***	2.6***	0.0	3.3	1.3	157.0	1.0**	0.5	0.6	1.6**	-0.8	1.5	0.6
Average		3.8	2.1	1.1	3.4	3.3	7.1	2.8		2.8	2.8	0.3	2.4	2.4	5.3	2.1

Note. l: Increments of stature per decade and the subscript indicate start/end year (cm/decade); It: Total increments of stature from 1985 to 2010 (cm); la: Average rates derived from It (cm/decade); t-test: Compared between start and end year as the subscript indicate, **P*<0.05, ***P*<0.01, ****P*<0.001.

and 2010, the overall average stature increase of rural boys and girls were 1.7 cm and 1.5 cm higher than that of urban boys and girls. The rural boys and girls aged 18 years had more 1.0 cm and 0.6 cm increase in body height than their urban counterparts.

DISCUSSION

The study indicated that a strong secular change in children and adolescents' stature occurred in rural

areas of provincial capitals in China during the past 25 years. The overall increase was positive in all the school-aged boys and girls in eastern, central, and western regions during the whole survey period.

Overall Secular Change in Stature

We found that the overall average stature increases were 3.1 and 2.4 cm/decade for boys and girls aged 7-18 years, respectively. Averagely boys and girls aged 7 years in 2010 were 7.1 and 6.6 cm taller than those at the same age in 1985. The largest

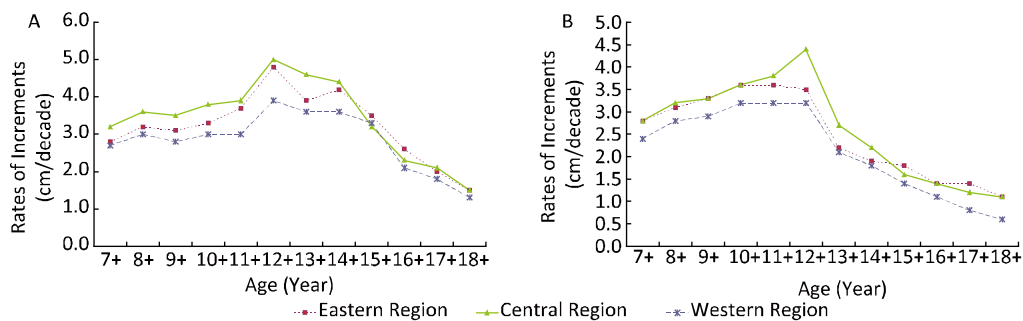


Figure 2. Increase Rates of Stature for Rural Boys (A) and Girls (B) in Eastern, Central and Western Regions, China, 1985-2010.

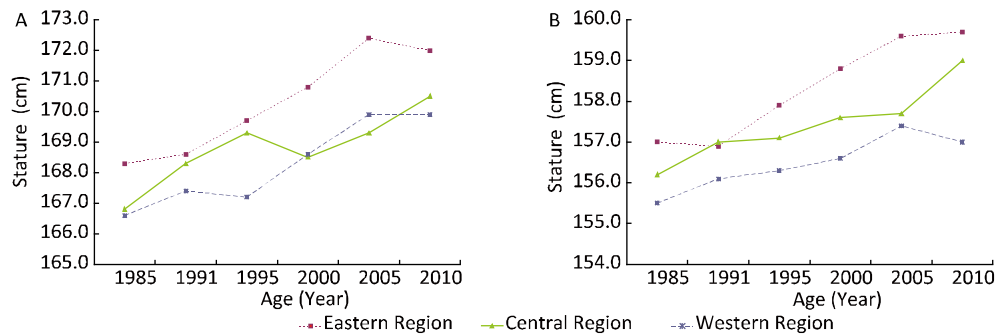


Figure 3. Secular Changes in Stature for Rural Boys (A) and Girls (B) Aged 18 Years in Eastern, Central and Western Regions, China, 1985-2010.

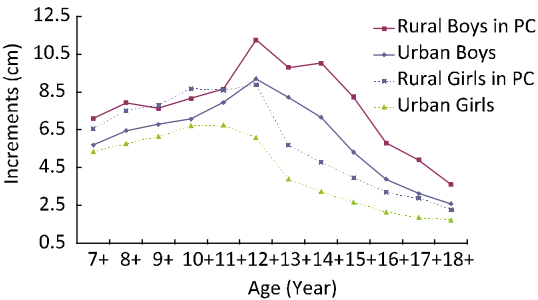


Figure 4. Increase in Stature of Boys and Girls between Rural Area and Urban Area, 1985-2010. (PC: provincial capitals).

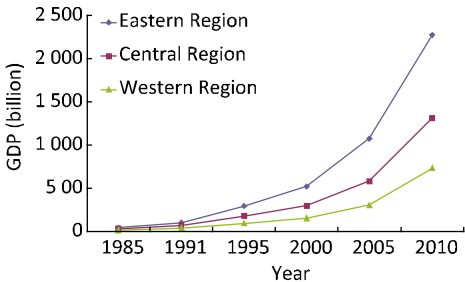


Figure 5. Gross Domestic Product (GDP) in three regions 1985-2010.

increases occurred in adolescents. The average increases were 10.4 cm for boys aged 12-14 years and 8.7 cm for girls aged 10-12 years, the increase rates were 4.1 and 3.5 cm/decade, respectively. Averagely boys aged 15 years and girls aged 14 years in 2010 were 1.1 cm taller than those aged 18 years in 1985. The increase rates for boys and girls aged 18 years were 1.4 and 0.9 cm/decade, respectively. The increase of body height in rural boys and girls in China was consistent with our previous report about the body height increase in boys and girls in urban areas^[18-19] which indicated that an overall long term increase in children's body height had occurred both in urban area and in rural area in China. More notably, the increase in rural area was larger than those in urban areas, where the average increase rates for boys and girls aged 7-18 years were 2.4 and 1.7 cm/decade respectively and average increase rates for boys and girls aged 18 years were 1.0 and 0.7 cm/decade, respectively^[19]. Secular body height increase varied in different populations during different periods. The increases were larger than those reported in Europe and North America between 1880 and 1980, i.e. about 1-2 cm/decade in childhood, 2-3 cm/decade in adolescence and about 1 cm/decade in adulthood^[3,33]. The increase rates were similar to those reported in Taiwan between 1964 and 1988, i.e. 2.5 and 2.5 cm/decade in childhood, 4 and 3 cm/decade in adolescence and 1.5 and 0.7 cm/decade in adulthood for males and females, respectively^[34]. And the increase rates were similar to those of South Korean between 1956 and 1994^[35-36] and rural Mexico between 1968 and 2000 as well^[37]. Meanwhile, the increase rates were lower than those in Japan between 1950 and 1960, where 7.5 cm/decade was reported in adolescents and 3 cm/decade in adults^[38].

Region Specific Difference in Body Height Increase

Mean body height in eastern region was higher than that in central region, and mean body height in western area was lowest for all age groups in each survey in generally. This result was in accordance with the economic status of the three regions. Data from the National Bureau of Statistics of China indicated that the increase of Gross Domestic Product (GDP) showed the same trend (Figure 5). The overall average increase rate for children/adolescents aged 7-18 years in central region was slightly higher than that in eastern region and much higher than that in western region. The increase rate was similar in age group 18 years,

which was similarly high in central region and eastern region and low in the western region. The difference between eastern/central region and western region was obvious. For instance, the boys and girls aged 18 years in eastern region were 1.7 cm and 1.5 cm higher than those in western region in 1985, while the difference increased to 2.1 cm and 2.7 cm in 2010, respectively. At the same time the difference between eastern region and central region remained nearly unchanged. Some previous studies^[3,39-40] reported that the secular increase in stature was more obvious in lower socioeconomic groups, however, such phenomenon wasn't observed in these three regions. There might be some explanations. Firstly, the baseline body heights in rural areas of the three regions were all low. Individuals even in the region with better socioeconomic status were far from their growth genetic potential. Secondly, it also indicated that western region is less developed than eastern and central regions and the body increase might be affected in this region, while the socioeconomic development in central region was relatively 'enough' and could supply the necessary energy and nutrition for the growth of children. Thirdly, there might be some confounders of genetic or geographic factors which needed further study. Generally, the policymakers need to pay more attention to the living conditions and nutrition improvement in western region.

The largest increase rates in different regions occurred in different survey periods. In eastern region the largest increase rates for children or adolescents aged 7-18 years was observed between 1991 and 1995, which was 5.6 cm and 4.7 cm for boys and girls, respectively, while in central region the largest increase rate was observed between 2005 and 2010, which was 5.2 cm and 4.3 cm for boys and girls, respectively. The body height increase in grown up boys and girls also reached 2.4-2.7 cm in these survey periods in the two regions. The growth rate was almost similar to the dramatic increases in Japan between 1950 and 1960, whereas the largest body height increase for the boys and girls aged 7-18 years in western region were below 3.8 cm and 2.8 cm in five survey periods, respectively, indicating that boys and girls in this region were far from their genetic potential and more efforts would be needed to improve their growth.

Difference of Secular Change in Rural Area and Urban Area

The average body height of children or

adolescents in rural areas of 30 cities were lower than those in urban areas in China^[19]. The gender specific overall average increase rates of the children aged 7-18 years and the increase rates of the grown up children aged 18 years in rural area were higher than those in urban areas. This difference was similar to the report about rural and urban children in Mexico^[12]. The overall average increase rates in western region were lowest among the three regions, but still higher than those in the group with highest increase in urban area. The increase rate in boys aged 18 years was similar. The increase rate in girls aged 18 years in western region was lower than that in urban area, which might indicate that girls in western rural area had not suitable environment for them to reach their genetic growth potential. We found an interesting phenomenon that the stature secular growth trend in rural areas with low socio-economic status was more obvious than that in urban areas, while the stature secular growth trend in western region with the low socio-economic status was weak. The result was similar to the report^[25] about Chinese children aged 0-7 years. We have tried to discuss this interesting 'paradox' phenomenon in previous part of this article, which reminded researchers to explain the results with caution.

At the same time, the increase rates in different survey periods in rural regions varied, which was different from that in urban areas, especially in coastal large cities with more stable trend.

There are some limitations in the study. The national data were collected from 1985 while as shown by some studies, secular trends in China occurred early even from 1939^[18,22-23]. Lack of information before 1985 might limited the understanding of true secular trend outline in rural Chinese. Data in the present study were from rural areas in 30 cities. There are two reasons for this. Firstly, the data of 1991 were only collected from subjects from 30 cities. Secondly, the national rural sample is comprised of three socioeconomic classes (high, moderate, and low) and the sample from 30 cities represents the high socioeconomic class. The analysis of single socioeconomic class can avoid some confounding factors. At the same time it did not fully reflect the situation of rural China certainly and only represented a relatively affluent part of rural area, so we will continue to analyze and discuss the effect of socioeconomic factors on stature increase in the future study.

A strong positive secular change in stature for

children and adolescents in rural area of provincial capitals in China occurred simultaneously with urban change during the past 25 years, while China experienced an overall rapid economic growth. The secular trend in stature increase in rural areas was more obvious than that in urban areas and there are differences among eastern, central and western regions. The boys and girls in rural area would have more genetic potential to grow higher. The policy maker should pay more attention to it and do more effort to improve the living condition and nutrition status of children in western region.

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