Original Article

Secular Change in Stature of Urban Chinese Children and Adolescents, 1985–2010*

CHEN Tian Jiao and JI Cheng Ye#

Institute of Child and Adolescent Health, School of Public Health, Peking University Health Science Center, Beijing 100191, China

Abstract

Objective Research evidence shows a secular trend in Chinese physical growth in recent years. The aim of this study was to analyze and assess changes in stature of children and adolescents during the 25 years from 1985-2010, using national data.

Methods Data came from successive cycles of the Chinese National Survey on Students' Constitution and Health (CNSSCH). Subjects were 7- to 18-year-old children and adolescents.

Results An overall positive secular trend occurred in urban China during 1985-2010. The overall average rates of increment were 2.4 and 1.7 cm/decade for boys and girls, respectively. Total increases in adult stature for boys and girls were 2.6 and 1.7 cm, yielding rates of 1.0 and 0.7 cm/decade, respectively. Cities with different socioeconomic levels had different characteristic trends. Mean stature increases in big cities were larger than those in moderate and small cities, and boys and girls in moderate and small cities showed greater potential for growth in stature.

Conclusion An overall positive secular growth trend was associated with socioeconomic progress and differed with area socioeconomic levels. School policies and strategies should be developed based on increased stature, and should continue narrowing the inequity between different socioeconomic populations.

Key words: Secular change; Stature; Growth; Socioeconomic disparity; Children and adolescents

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INTRODUCTION

Secular growth trends of increasing body size and accelerated growth tempo have been clearly documented since approximately 1850 in Europe and reported in a large number of human populations, especially in developed countries[1-3].

Although the mechanism underlying these secular trends is not fully understood, a complex interplay between genes, physiology and environment has been suggested[4]. Environmental factors are believed to constitute a major cause of secular increase in growth, and stature is a powerful proxy for childhood living conditions. The study of secular growth trends provides markers of public health as it changes over time and highlights inequalities of health, nutrition and social wealth within populations, which provide important biological evidence to help policy makers identify strategies to improve children's health and welfare[3,5].

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#Correspondence should be addressed to JI Cheng Ye. Tel: 86-10-82805109. Fax: 86-10-82805109. E-mail: jichengye@263.net

Biographical note for the first author: CHEN Tian Jiao, female, born in 1977, Ph.D, associate professor, majoring in growth and development in children and adolescents.

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Since the 1980s, the rate of increase has slowed, appearing close to a plateau in some developed countries such as the Netherlands and Italy as well as in Scandinavian countries[2,4,6]. In developing countries, there are various trends in growth. However, many studies in recent decades have reported that similar acceleration trends have begun[7-9], although negative secular changes or absence of secular changes have also been reported[10-12].

In China, several studies have reported positive secular trends in growth of children and adolescents since the 1950s. However, such studies were limited from 1950 to 1985[13]. Ji et al.[14] reported positive secular changes in stature and body mass index during the past few decades, but only focused on 16 major cities in China. Some provincial and local data have shown increasing trends as well[15-16]. Some studies have suggested general rapid positive trends occurring even in minor ethnic groups[17-18] and children aged 0-7 years[19]. However, there are still no data reporting whether the stature trend exists or its magnitude in most Chinese cities over the past few decades as the national economy has rapidly developed. It is still not clear whether stature has been increasing at a constant rate in different periods and whether stature trends are different in different socioeconomic areas of China. In this study, we used national survey data collected systemically and successively since 1985 on school-aged children and adolescents to address these issues.

The purpose of the present study is to analyze secular trends in stature of 7- to 18-year-old children and adolescents in urban China from 1985-2010. The impact of area socioeconomic level on secular trend, differences between males and females, the relationship between stature change and environmental factors, and the trend differences between other populations (especially Asian populations) are discussed.

METHODS

Study Population and Data Sources

Data were obtained from the 1985, 1995, 2000, 2005, and 2010 cycles of the Chinese National Survey on Students' Constitution and Health (CNSSCH). The CNSSCH survey, which has been conducted every five years since 1985, was jointly launched by the Ministry of Education, Ministry of Health, Ministry of Science and Technology, State of National Affairs, and the State Sports General Administration in China[20-23]. This survey is, so far, the largest nationally representative sample of school-aged children and adolescents in China, and has been widely used to produce national and state prevalence estimates for a variety of health indicators of children and adolescents.

All the subjects were primary and high school students aged 7-18 years randomly selected from 30 of the 31 mainland provinces, excluding Tibet where Han people are the minority. Four subpopulations were stratified by sex and area of residence (urban or rural) as well as by males and females in each province. Each subpopulation comprised an equal size sample from three socioeconomic classes (high, moderate and low). There were approximately 100 subjects from the 1985 data and 50 subjects from the other survey years in each age-specific subgroup. Criteria for defining the class strata were based on five indices: regional gross domestic product, total yearly income per capita, average food consumption per capita, natural growth rate of the population, and regional social welfare index, all of which were province specific[14]. To present a comparison of socioeconomic-specific temporal changes in stature, based on three classes, the subpopulations were re-divided into three groups: Group I (coastal big cities), II (other big cities), and III (moderate and small cities). Group I comprised the nine most advanced metropolises, including Beijing, Shanghai, Tianjin, Shijiazhuang, Shenyang, Dalian, Jinan, Qingdao, and Nanjing. Group II included other provincial capital cities, and Group III comprised cities with moderate and low socioeconomic level. All cities in the groups were province specified in 1985 and have been basically fixed since then. Therefore, Han ethnic people living in urban areas of 82 cities were studied in this paper. Table 1 presents the sample sizes of sex-age subgroups for urban Chinese individuals in different survey cycles. In total, the numbers of participants were 204 727 in 1985, 103 740 in 1995, 100 622 in 2000, 116 726 in 2005, and 146 812 in 2010.

Description of Variables and Data Analysis

All subjects had a thorough medical examination before measurement, and those with overt disease or physical/mental deformities were excluded. Since 1985, stature (cm) has been measured following the same standardized procedure using a metal column height measuring stand recommended by Cameron[24]. All technicians were specially trained in anthropometry.

Table 1. Sample Sizes of Sex-Age Subgroups for Urban Chinese Individuals in Different Survey Cycles

Age	1985		1995		2000		2005		2010	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
7+	8 560	8 559	4 123	4 120	4 141	4 207	4 880	4 860	6 072	6 012
8+	8 561	8 561	4 119	4 127	4 240	4 229	4 934	4 862	6 211	6 180
9+	8 557	8 561	4 119	4 125	4 265	4 193	4 945	4 892	6 180	6 223
10+	8 557	8 559	4 391	4 402	4 283	4 351	4 916	4 932	6 306	6 229
11+	8 561	8 559	4 396	4 413	4 211	4 189	5 051	4 846	6 178	6 171
12+	8 558	8 557	4 398	4 399	4 213	4 217	4 917	4 785	6 154	6 117
13+	8 558	8 558	4 394	4 395	4 242	4 217	4 914	4 925	6 259	6 180
14+	8 560	8 561	4 403	4 383	4 236	4 204	4 852	4 859	6 244	6 126
15+	8 556	8 556	4 403	4 394	4 250	4 209	4 979	4 931	6 214	6 092
16+	8 559	8 557	4 343	4 396	4 234	4 205	4 889	4 915	6 155	6 059
17+	8 532	8 537	4 394	4 403	4 199	4 168	4 900	4840	6 169	6 021
18+	8 324	8 159	4 335	4 365	3 895	3 824	4 550	4 352	5 722	5 538
Total	102 443	102 284	51 818	51 922	50 409	50 213	58 727	57 999	73 864	72 948

Age groups were divided by calculating “exact age”. For example, cohort 7-year-olds (represented by “7+”) designated students aged 7.00-7.99 years. “Increment per decade” and “average increment for 7-to 18-year-olds” were calculated to show the increased intensity of growth changes. Curves of cross-sectional mean statures were created. *t*-tests were used to analyze differences in mean statures between samples. All statistical tests were performed using the statistical package SPSS PC version 13.0.

RESULTS

Overall Secular Change

Figure 1 shows overall successively positive increases in stature from 1985 to 2010. Mean values and increments are displayed in Table 2. Average rates of increment for “7- to 18-year-olds” were 2.4 and 1.7 cm/decade for males and females, respectively. Stature values compared between survey years by *t*-tests indicated that for both sexes, mean statures of all age groups in 2010 were significantly higher than the values in 1985. The secular changes had occurred from early ages. Mean statures in the 7-year-old group increased from 121.4 and 120.3 cm in 1985 to 127.1 and 125.6 cm in 2010, yielding increments of 5.7 cm (2.3 cm/decade) and 5.3 cm (2.1 cm/decade) for boys and girls, respectively. The largest gains were found at approximately puberty age, i.e. 9.2 cm (3.7 cm/decade) for 12-year-old boys and 6.7 cm (2.7 cm/decade) for 10- and 11-year-old girls. In addition, mean statures at age 18 years for males and females increased successively from 169.7 and 158.2 cm in 1985 to 172.3 and 159.9 cm in 2010, yielding rates of 1.0 and 0.7 cm/decade and 2.6 cm and 1.7 cm of total increments, respectively. The largest increments occurred during the period of 1995 to 2000 with rates of 2.3 and 1.3 cm/decade for males and females, respectively. In addition, average rates of increment for “7- to 18-year-olds” from 1985 to 1995 were 3.0 cm/decade for males and 2.2 cm/decade for females, higher than for any other survey period from 1995 to 2010.

Secular Change in Different City Groups

Table 3 shows successively positive increases in stature in different city groups. In almost every age group and every survey year, changes in stature of boys and girls were greater in Group I (coastal big cities) than in Group II (other big cities), and changes in stature were greater in Group II than in Group III (moderate and small cities).

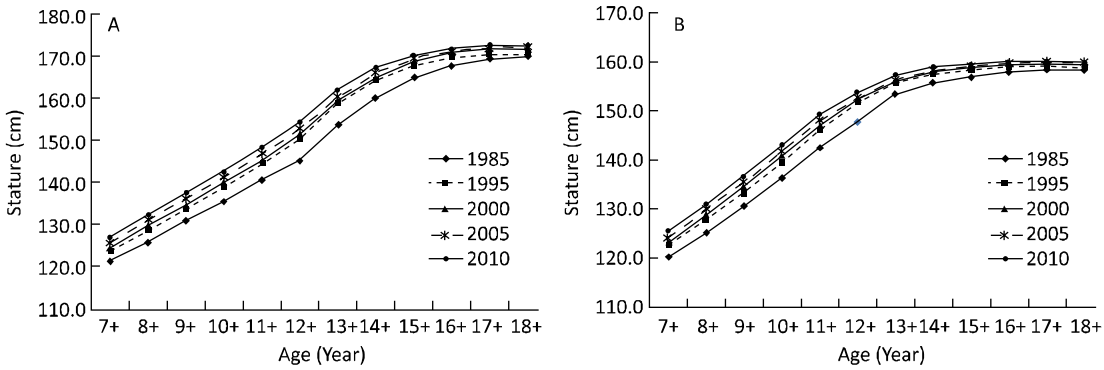

Figure 1. Secular Growth Changes in Stature of Chinese Urban Boys (A) and Girls (B), 1985-2010.

Table 2. Secular Changes in Stature of 7- to 18-year-old Chinese Urban Boys, 1985-2010 (cm)

Age	1985	1995	2000	2005	2010	I_{85-95}	I_{95-00}	I_{00-05}	I_{05-10}	It	Ia
Boys											
7+	121.4	123.8***	124.3***	125.8***	127.1***	2.4	0.9	3.0	2.6	5.7	2.3
8+	125.9	128.5***	129.9***	131.2***	132.3***	2.6	2.9	2.6	2.2	6.5	2.6
9+	130.9	133.7***	134.6***	136.1***	137.7***	2.8	1.9	2.8	3.2	6.8	2.7
10+	135.5	138.8***	140***	141.1***	142.6***	3.3	2.4	2.1	3.0	7.1	2.8
11+	140.5	144.5***	145.2***	146.7***	148.5***	4.0	1.5	2.9	3.6	7.9	3.2
12+	145.3	150.4***	151.5***	152.8***	154.5***	5.1	2.3	2.5	3.4	9.2	3.7
13+	153.7	158.7***	159.4***	160.1***	161.9***	5.0	1.5	1.3	3.6	8.2	3.3
14+	160.1	164.3***	164.9***	165.9***	167.2***	4.2	1.2	1.9	2.8	7.2	2.9
15+	164.8	167.6***	168.8***	169.4***	170.1***	2.8	2.4	1.3	1.4	5.3	2.1
16+	167.7	169.5***	170.8***	171.1*	171.6***	1.8	2.7	0.6	0.9	3.9	1.6
17+	169.2	170.3***	171.6***	171.8	172.4***	1.0	2.7	0.4	1.1	3.1	1.3
18+	169.7	170.3***	171.5***	171.9**	172.3**	0.6	2.3	0.8	0.8	2.6	1.0
Average						3.0	2.1	1.9	2.4	6.1	2.4
Girls											
7+	120.3	122.6***	123.2***	124.1***	125.6***	2.3	1.2	1.7	3.0	5.3	2.1
8+	125.1	127.7***	128.7***	129.8***	130.8***	2.6	2.0	2.2	2.0	5.8	2.3
9+	130.5	133.4***	134.5***	135.4***	136.7***	2.8	2.3	1.7	2.6	6.1	2.5
10+	136.3	139.5***	140.7***	141.5***	143.0***	3.3	2.4	1.6	3.0	6.7	2.7
11+	142.5	146.2***	147.0***	148.0***	149.3***	3.6	1.7	1.9	2.6	6.7	2.7
12+	147.6	151.7***	152.3***	152.6	153.7***	4.0	1.2	0.5	2.3	6.1	2.4
13+	153.4	155.7***	156.1**	156.3	157.3***	2.3	0.8	0.4	2.0	3.9	1.6
14+	155.7	157.2***	158.1***	158.1	159.0***	1.5	1.6	0.2	1.6	3.2	1.3
15+	156.8	158.3***	158.9***	159.1	159.4***	1.5	1.3	0.3	0.8	2.7	1.1
16+	157.8	158.7***	159.5***	159.5	159.9***	0.9	1.6	0.1	0.9	2.1	0.9
17+	158.2	158.9***	159.6***	159.9*	160.0	0.7	1.4	0.6	0.3	1.9	0.7
18+	158.2	158.6***	159.3***	159.8***	159.9	0.5	1.3	1.0	0.2	1.7	0.7
Average						2.2	1.6	1.0	1.8	4.4	1.7

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: Rates get from It (cm/decade); *t*-test: compared with the former year, $^{*}P<0.05$, $^{**}P<0.01$, $^{***}P<0.001$.

Table 3. Secular Changes in Stature of 7- to 18-year-old Chinese Urban Boys and Girls in Three City Groups, 1985-2010 (cm)

Age	Male						Female					
	I_{85-95}	I_{95-00}	I_{00-05}	I_{05-10}	It	Ia	I_{85-95}	I_{95-00}	I_{00-05}	I_{05-10}	It	Ia
Group I												
7+	2.4***	1.6**	2.1***	1.8***	5.1	2.0	2.5***	2.1***	1.3*	1.6**	5.1	2.0
8+	2.5***	3.3***	2.9***	0.4	5.8	2.3	2.6***	2.8***	2.4***	-0.1	5.1	2.0
9+	2.9***	2.4***	2.5***	1.7**	6.2	2.5	2.9***	2.9***	1.9**	0.8	5.7	2.3
10+	3.3***	2.0***	3.5***	1.6*	6.9	2.8	2.8***	3.6***	2.3***	0.5	6.0	2.4
11+	3.8***	1.3*	5.1***	1.8*	7.9	3.2	3.0***	2.9***	1.7*	2.2***	6.4	2.6
12+	5.2***	4.1***	2.5**	2.1**	9.5	3.8	3.5***	2.4***	1.0	0.8	5.5	2.2
13+	5.0***	2.0**	0.7	1.9**	7.2	2.9	2.2***	0.0	1.3*	0.3	3.0	1.2
14+	3.5***	1.9**	2.7***	1.2	6.4	2.6	1.6***	1.7***	0.8	-0.2	2.8	1.1
15+	2.2***	3.3***	1.3*	1.3*	5.1	2.0	1.3***	1.8***	1.1*	0.4	2.9	1.2
16+	1.7***	3.5***	0.1	0.5	3.8	1.5	1.6***	1.1*	-0.2	0.8	2.4	1.0
17+	1.3***	2.3***	0.8	0.4	3.1	1.2	1.1***	1.5**	1.2*	-0.9	2.0	0.8
18+	0.7**	3.6***	0.8	-0.6	2.5	1.0	1.2***	1.1*	0.8	0.1	2.3	0.9
Average	2.9	2.6	2.1	1.2	5.8	2.3	2.2	2.0	1.3	0.5	4.1	1.6
Group II												
7	2.2***	1.7***	3.4***	3.1***	6.3	2.5	2.3***	0.8	3.6***	2.6***	5.8	2.3
8	2.9***	1.5**	4.1***	2.9***	7.1	2.8	2.5***	0.8	3.7***	3.1***	6.3	2.5
9	3.0***	1.5**	4.4***	3.5***	7.7	3.1	2.5***	1.8**	3***	3.1***	6.5	2.6
10	3.2***	2.7***	2.3***	4.2***	7.8	3.1	3.0***	1.0	3.1***	4.0***	7.1	2.8
11	3.6***	0.4	5.0***	3.8***	8.2	3.3	3.1***	1.2	4.7***	2.7***	7.4	3.0
12	4.7***	0.4	5.6***	4.5***	10.0	4.0	3.6***	-0.8	3.2***	3.4***	6.5	2.6
13	5.5***	-0.5	2.8***	5.1***	9.2	3.7	2.2***	0.4	0.3	3.5***	4.3	1.7
14	4.4***	0.6	3.1***	3.2***	7.9	3.2	1.7***	1.4**	0.5	2.2***	3.7	1.5
15	3.3***	1.6**	2.7***	0.7	5.8	2.3	2.1***	0.9	0.2	0.9*	3.1	1.2
16	2.3***	0.9	3.0***	-0.2	4.2	1.7	1.2***	1.5**	0.2	0.8	2.5	1.0
17	1.3***	2.7***	0.8	1.0*	3.6	1.4	1.1***	1.0*	0.6	0.5	2.2	0.9
18	0.8***	2.5***	-0.2	2.3***	3.0	1.2	0.6**	1.7***	1.3**	-0.3	1.9	0.8
Average	3.1	1.3	3.1	2.8	6.7	2.7	2.1	1.0	2.0	2.2	4.8	1.9
Group III												
7	2.8***	-0.3	3.6***	2.9***	5.9	2.4	2.5***	0.1	2.0***	4.0***	5.6	2.2
8	2.7***	2.6***	2.9***	2.6***	6.7	2.7	2.9***	1.4***	2.5***	2.4***	6.1	2.4
9	2.9***	1.1**	3.3***	3.7***	6.9	2.8	3.2***	1.5***	1.9***	3.2***	6.5	2.6
10	3.5***	1.5***	2.7***	3.1***	7.2	2.9	3.8***	1.8***	1.7***	3.5***	7.3	2.9
11	4.3***	1.4**	2.4***	4.4***	8.4	3.4	4.3***	0.7	1.7***	3.3***	7.2	2.9
12	5.4***	1.5**	2.5***	3.8***	9.3	3.7	4.7***	0.8*	0.1	3.0***	6.6	2.6
13	5.1***	1.0*	2.6***	3.2***	8.5	3.4	2.4***	0.7	1.1**	1.9***	4.2	1.7
14	4.6***	0.4	2.1***	3.4***	7.5	3.0	1.5***	1.1***	0.7*	2.1***	3.5	1.4
15	2.9***	1.8***	1.5***	1.8***	5.5	2.2	1.3***	0.8*	0.9**	1.1***	2.7	1.1
16	1.7***	2.4***	0.4	1.7***	4.0	1.6	0.6***	1.3***	0.9**	0.8**	2.0	0.8
17	1.0***	2.3***	0.8*	1.2***	3.1	1.2	0.4**	1.2***	1.0**	0.7*	1.8	0.7
18	0.6***	2.0***	1.3***	0.6	2.6	1.0	0.2	1.5***	0.9**	0.6	1.7	0.7
Average	3.1	1.5	2.2	2.7	6.3	2.5	2.3	1.1	1.3	2.2	4.6	1.8

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: Rates get from It (cm/decade); *t*-test: compared between start and end year as the subscript indicate, $^{*}P<0.05$, $^{**}P<0.01$, $^{***}P<0.001$.

As shown in Figure 2, in most age groups, boys and girls in Group II had higher rates of increments from 1985 to 2010 than those in Groups I and III, with average rates of 2.7 and 1.9 cm/decade, respectively. The exception was 18-year-old females in Group I. They had the highest total increment (2.3 cm) during the 25 years from 1985-2010.

The intensities of increments were different in different survey periods between the three city groups. In Group I, average rates of increment for "7- to 18-year-olds" were highest from 1985 to 1995 and gradually decreased in the subsequent survey periods. In Groups II and III, average rates of increment during the last survey period (2005-2010) were still almost as high as in the first survey period (1985-1995). This tendency was also manifested in each specific age group. The period in which 7-year-old boys and girls gained the largest increments in Group I was from 1985 to 1995; in Group II it was from 2000 to 2005; and in Group III it was from 2000 to 2005 for boys and from 2005 to 2010 for girls. The tendency was similar for 18-year-olds (Figure 3). It should be noted that 18-year-olds in Group I had little or no increases in the last survey period, though the differences were not significant. This suggests that Groups II and III, especially Group III, had great potential for growth, whereas stature increases might have been slowing down in Group I.

Sexual Disparity

Figure 4 shows stature increments by age for boys and girls. At every age, there was a higher rate of increment for boys than for girls. During the 25 years from 1985-2010, the overall average increment for boys was 1.8 cm higher than that for girls, and 18-year-old boys gained more than a 0.9 cm increment in stature over girls. This tendency occurred in every survey period, and the situation was similar among Groups I, II, and III.

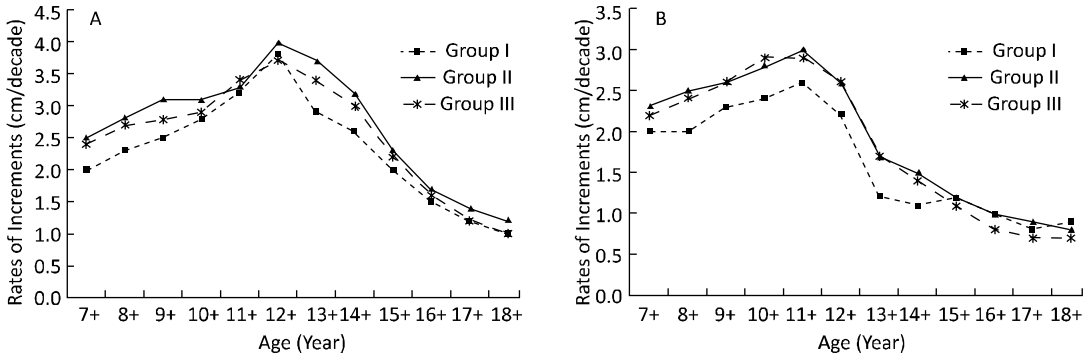

Figure 2. Rates of increments in stature of Chinese urban boys (A) and girls (B) in different city groups, 1985-2010.

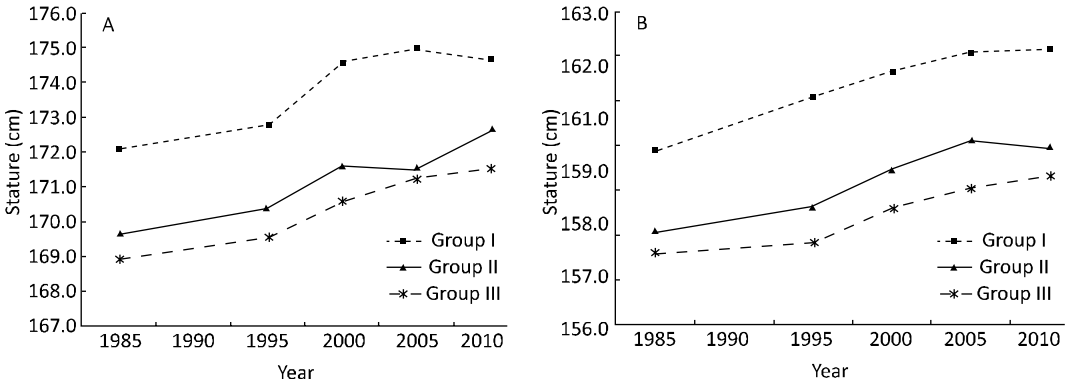

Figure 3. Secular growth changes in stature of Chinese urban boys (A) and girls (B) aged 18 years, 1985-2010.

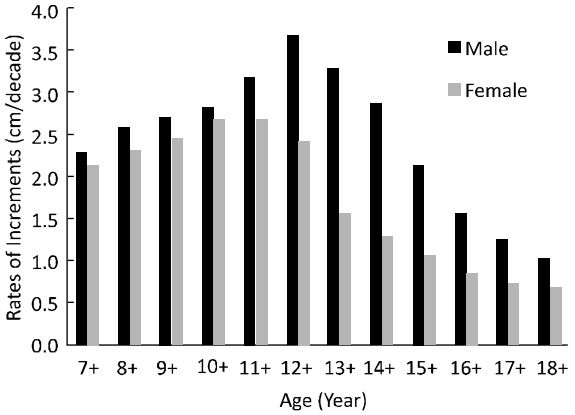

Figure 4. Increments per decade in stature of boys and girls, 1985-2010.

DISSUSION

The present study demonstrated that a strong secular change in stature occurred in urban China during the 25 years from 1985-2010. The increments were overall positive in all school-aged boys and girls in all survey periods and in all the city groups.

Overall Secular Change

The overall average rates of increment were 2.4 and 1.7 cm/decade for males and females, respectively. The largest significant increases occurred during puberty. The total increments were 9.2 cm for 12-year-old boys and 6.7 cm for 10-and 11-year-old girls, yielding rates of 3.7 and 2.7 cm/decade, respectively. Because of this trend, urban Chinese stature in boys and girls has changed greatly. The mean statures of 7-year-old boys and girls were 5.7 and 5.3 cm taller, respectively, than their same age counterparts 25 years ago. Furthermore, in 2010, the mean stature of 15-year-old boys and 14-year-old girls had reached and surpassed that of 18-year-old boys and girls in 1985. The increments confirmed our previous study reporting an overall positive trend in 16 major Chinese cities[14]. The increases were slightly higher than those found in Europe and North America reported between 1880 and 1980 with secular changes in height approximately 1.5 cm/decade in childhood, 2.5 cm/decade in adolescence and 1 cm/decade in adulthood[2,25], and were more similar to increases in other Asian countries. In South Korea[26-27], increases between 1956 and 1994 were approximately 2.1 and 2.6 cm/decade at 9 years of age, and 3.7 and 1.9 cm/decade at 15 years of age for boys and girls, respectively. Takaishi[28] reported a trend of 3.5 and 3 cm/decade in 14-year-old boys and 12-year-old girls, respectively, in Japan between 1950 and 1990. These increases were below the dramatic increases of 8 cm/decade in Japanese boys at 14 years between 1950 and 1960. This study confirmed once again that positive secular trends in growth appeared in both genders in many parts of the world with improved living standards during the last century, regardless of the country, climate, race or socioeconomic situation[29-31]. In addition, the secular trend varied with population and the period of observation.

Puberty and Sexual Dimorphism

The largest change occurred at puberty, resulting from the combined effect of secular trends of increasing height and faster developmental tempo[4]. In 1985, the menarcheal age for Chinese urban girls was 13.17 years; in 2005 it had fallen to 12.64 years with a decreasing rate of 3.2 months/decade[20,23]. The steadily increasing stature at each age, plus the forward stature curve associated with earlier maturation caused the peak in increase. Furthermore, the increase was more pronounced in boys than in girls in China, as in other populations, suggesting that growth in boys is more responsive to changes in the environment than in girls, as other studies have pointed out[32-33]. It has been argued that sexual dimorphism is "an inappropriate measure of a society's nutritional status"[34]. However, a variety of studies have found that sexual dimorphism in stature is lower in societies with inadequate levels of nutrition than in societies where people are well nourished[35-37]. Furthermore, populations with a positive secular trend in stature are accompanied by increases in sexual dimorphism[37-38]. Our study is consistent with those reports.

Adult Height

Adult height is the result of the interaction of genetic and environmental factors, and is a sensitive indicator of the nutrition of adults during their growing years[39]. The total increases in adult stature for urban boys and girls in China were 2.6 and 1.7 cm, respectively, yielding rates of 1.0 and 0.7 cm/decade. This strongly suggests that urban Chinese children and adolescents have been experiencing a gradual movement toward the genetically determined upper limit of an individual's potential for growth, as our previous study suggested[14]. Hauspie et al.[2] reviewed population surveys during the 1950s and 1990s and reported that the rate of adult height

increase varied from 0.3 to 3.0 cm/decade, with the smallest being 0.3 cm/decade in Northern Europe and approximately 1.0 cm/decade in Western Europe, and the largest being 3.0 cm/decade in Eastern Europe and Japan (1950-1960). They also showed that secular trends in adult height had slowed in most countries. Rates of adult height increments in urban China during the 25 years from 1985-2010 were similar compared with some western European countries. However, the trend in urban China was different from those countries because of the heterogeneity of socioeconomic groups, which we will discuss later. On the other hand, mean adult height of adults in China was lower than that in most European countries[40], with the mean for male adult height similar to that of the Netherlands in the 1930s and the US in the 1910s[41]. It should be noted that most data from European countries came from conscripts. Chinese data used 18-year-old height as "adult height", perhaps causing an underestimation of actual adult height since the study showed that the mean stature of 19-year-old Chinese males still increased. Compared with Japanese height data[42], mean height of urban Chinese adults was 1.2 cm shorter for males and 0.3 cm taller for females in 1985. However, in 2005, Chinese adult height had exceeded that of Japanese adults for both sexes, with 0.4 and 1.5 cm higher for males and females, respectively. Because the Japanese trend has slowed since 1985[2,42-43], the height difference between Chinese and Japanese adults is expected to continue to widen.

Stature of 7-year-olds

Interestingly, the average height of Chinese girls at 7-years-old in 2005 was still 0.7 cm shorter than that of Japanese girls of the same age. Body size at this age reflects health status in early childhood and is the physical basis for the growth spurt at puberty. Furthermore, childhood health is closely related to socioeconomic status[44]. To promote child and adult health, the gap that exists between early childhood health care in China compared with Japan should be given more attention[42].

Disparity in Secular Change in Different City Groups

In the present study, we divided all subjects into three city groups with different socioeconomic levels. Each group had a specific character and trend. Mean statures in Group I were higher than those in Group II, and statures in Group II were higher than those in Group III. This indicates that higher stature is associated with better socioeconomic status, as previous studies have argued[3]. Group II had the highest rates of increments from 1985 to 2010 for two possible reasons. First, the baseline height in Group I was relatively high in 1985, and the propensity to grow is inversely linked to the child's size[4]. Second, the extent of economic improvement in Group II cities might have been greater than that in Group III cities. Another obvious phenomenon is that overall average rates of increment in Group I decreased gradually over the survey periods, with the height of 18-year-old boys in Group I even showing negative changes in the last survey period, though the differences were not significant. This phenomenon has also been reported in other developed countries[2,45]. For example, the increase in stature for Japanese 17-year-old between 1950 and 1970 was 3.0 and 1.5 cm/decade for males and females, respectively. However, it was reduced to 1.3 and 1.1 cm/decade between 1970 and 1990, and decreased further to 0.4 and 0.2 cm/decade between 1990 and 2000[43]. Results indicated that in Group I the secular trend had slowed, and adult height seemed to slowly and stably increase, as happened in developed countries. On the contrary, in Groups II and III, the secular changes continued to increase, suggesting that populations in those areas were still achieving their genetic potential for growth of stature in the future. Children with a better socioeconomic status were taller and represented less of a secular increase than their counterparts with a worse socioeconomic status, consistent with other reports[2,46-47]. Furthermore, the stature gap between different socioeconomic groups seemed to be gradually narrowing[48-49]. On the other hand, it should be noted that the speed of economic development in cities primarily divided into three classes according to a 1985 criterion was different during the 25 years from 1985-2010. Thus, the economic status of some cities might be different at present. This suggests we should find more detailed socioeconomic data to manifest this relationship more clearly in future studies. In addition, it is important for policy makers to pay attention to the socioeconomic gaps between areas.

There are some limitations in the present study. We only had national data from 1985. Some studies have shown that secular trends in the Chinese population occurred even as early as the 1950s[14-15,18]. Lack of data before 1985 might preclude an accurate outline of Chinese secular trends and identification of time periods with the

highest increment rates. Data from 1991 were not used because they focused only on the provincial capital cities. Another limitation was that only urban subjects were studied. There have been great improvements in health care and living conditions in rural areas since 1985 and on the other hand there is inequality between urban and rural areas. Thus, our future research will focus on the rural population.

Secular changes in stature of urban Chinese individuals have occurred along with immense economic progress and consequent promotion of healthy living, nutrition and education as well as social health and welfare. This trend will almost certainly continue with the further development of the economy. However, there are disparities between socioeconomic populations. Stature in urban Chinese boys and girls will continue to increase compared with their same-age counterparts in previous years in all three socioeconomic populations. However, in coastal big cities, the increase in adult height seems to have slowed and become stable. In other big cities and moderate and small cities, adult height still has great potential to increase. The overall positive secular change indicates the necessity of establishing new growth references for Chinese children and adolescents. In addition, schools should update their facilities based on current students' growth status in an effort to deter development of diseases such as myopia and kyphosis. Furthermore, policy makers should pay more attention to living conditions and health care in moderate and small cities to ensure the narrowing of inequity in different socioeconomic populations, particularly in regard to child health care.

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