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Original Article

Physical fitness status of children and adolescents in Tianjin of China during past three decades: a cross-sectional study

Xinyue Zhi[1], Wei Xi[2], Lei Gao[2], Junping Huang[2], Xu Yang[2], Wei Dai[2], Yanmei Deng[2], Xin Zhang[2]

[1]*Department of Epidemiology and Biostatistics, School of Public Health, Tianjin Medical University, Tianjin, China;* [2]*Department of Maternal, Child and Adolescent Health, School of Public Health, Tianjin Medical University, Tianjin, China*

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Abstract: Background: Significant changes in the society and lifestyle have been observed in China, which influences the physical fitness status of children and adolescents. This study aimed to estimate the physical fitness status in Tianjin during the past three decades. Methods: Cross sectional survey was used in this study. The data were derived from the Chinese National Students' Physical Health Survey database (1985-2010) using stratified cluster randomized sampling method. A total of 58,006 subjects aged 7-21 were recruited. The ethics approval was obtained from the Ethics Committee of Tianjin Medical University before collecting data from the children and adolescents, and/or their parents/guardians on behalf of them. Also written informed consent was obtained before collecting data from the patients. The secular trend of the physical fitness status, Levels of height, weight, body mass index, and chest circumference in China were calculated. The increase velocity of according indexes were analyzed, gender and rural/urban difference were discussed afterwards. SPSS16.0 was used in the analysis. Results: Levels of height, weight, body mass index, and chest circumference were obviously increased in 2010 compared to those levels in 1985, especially in the 9-13 age group. It was observed that the increase in the two crosses for height velocity between two genders of rural students was disappeared and the age of seven was important for the physical development. Conclusions: The circumstance was good for the physical development of the children and adolescents. The disappearance of the two crosses for height velocity between two genders of rural students in this study might be associated with factors such as nutritional status.

Keywords: Children and adolescents, physical fitness status, cross of height growth

Introduction

Substantial changes in the society and lifestyle of China have contributed to the physical status of the population in the past decades. Improved nutrition, more convenient transportation, less interest in physical exercises, coupled with intensive level of education and employment competition have led to the present issue related to the physical well-being of children and adolescents [1-5]. China is a developing country, and Tianjin is one of the developed cities in Northern China. In the past decade, GDP in Tianjin has grown consistently by more than 10% and the city is becoming a fast growing economic zone. In terms of urban population, Tianjin is the fourth in China following Shanghai, Beijing, and Guangzhou [6-8]. Living standard and the environment in Tianjin have improved significantly during the past decades. The gap between urban and rural areas has been reduced gradually [9, 10]. This situation has provided a better environment for the growing up and development of children and adolescents [11, 12].

Long-term trend growth, as a biological standard living condition, is similar to GDP, average life expectancy, infant mortality, and other indicators in its ability to reflect social fairness. It is the combined effect of multiple factors, namely, the gene locus (target-seeking growth model), nutrition, and disease. These factors directly affect the rise of environmental factors that

Table 1. Characteristics of the population in 2010

Variables	Male (n=5191)	Female (n=5370)	Total (n=10561)	
	Mean (median)/ number (SD or %)	Mean (median)/ number (SD or %)	Mean (median)/ number (SD or %)	*P* value
Age, year	13.98 (4.38)	14.17 (4.47)	14.08 (4.43)	0.0261
Urban/rural	2600/2591	2682/2688	5282/5279	0.8922
height	160.00 (1.72)	153.13 (1.27)	156.51 (1.55)	<0.0001
weight	54.84 (0.19)	47.12 (0.13)	50.91 (0.17)	<0.0001
BMI, kg/m^2	20.78 (4.43)	19.68 (3.63)	20.22 (4.08)	<0.0001
BMI				<0.0001
Low	1772 (34.22)	2104 (39.19)	3876 (36.73)	
Normal	2282 (44.13)	2670 (49.71)	4957 (47.01)	
Overweight	766 (14.78)	463 (8.62)	1229 (11.64)	
Obesity	361 (6.97)	130 (2.38)	491 (4.72)	
Chest circumference	80.78 (12.44)	76.85 (10.28)	78.78 (11.56)	<0.0001
Spermarcheal/menarcheal age, yrs	14.42 (3.75)	12.18 (3.83)	13.28 (3.79)	<0.0001

Table 2. The variation trend of physical fitness status in the students of Tianjin from 1985 to 2010

		Male		Female	
		Urban	Rural	Urban	Rural
Height	Age of increase peak, yr	12	12	11	10
	Maximum increase, cm	10	10.9	8.1	9.6
	Increase at 7 yr, cm	5.2	8.1	4.5	7.6
	Increase between 7-18 yr, cm	6.4	8.5	4.3	6.1
	Increase between 19-22 yr, cm	3.3	4.3	2.4	3.2
Weight	Age of increase peak, yr	13	12	10	12
	Maximum increase, kg	18.1	13.2	10.4	10.2
	Increase at 7 yr, kg	6.1	5.6	4.8	5.5
	Increase between 7-18 yr, kg	13.2	9.9	7.8	6.3
	Increase between 19-22 yr, kg	8.4	8.7	3.2	1.7
Chest circumference	Age of increase peak, yr	11	11	10	12
	Maximum increase, cm	10.8	8.8	8.4	6.9
	Increase at 7 yr, cm	4.1	3.8	3.6	4.1
	Increase between 7-18 yr, cm	7.5	5.6	5.9	4.6
	Increase between 19-22 yr, cm	2.4	2.6	1.7	0.4

influence the development of related concerns such as socio-economic status. Long-term trends for growth have been disappearing gradually in developed countries. However, these might remain in existence in developing regions [4, 13-15]. Living standard and the environment in Tianjin have improved significantly during the past decades. Although the urban per capita income gap has been less than the national average, an increasing trend has been observed. The gap between urban and rural areas has been reduced gradually [9, 10], the improvement of the city provided a better environment for the growing up and development of children and adolescents. Moreover, the implementation of the National Students Intervention may have also affected the status of these sectors of the population [11, 12], but the difference between rural and urban might still exist. Thus the gender and area difference for the physical development in children and adolescent in Tianjin China were discussed in this study.

Methods

Study design

The data were derived from the Chinese National Students' Physical Health Survey database using stratified cluster randomized sampling method. A total of 58,006 subjects aged 7-21 were recruited from 6 databases: 16,746 from 1985; 6,613 from 1991; 8,798 from 1995; 5,980 from 2000; 9,675 from 2005; and 10,561 from 2010. The sample covered elementary, middle, and high schools, and universities in three districts. The data, which

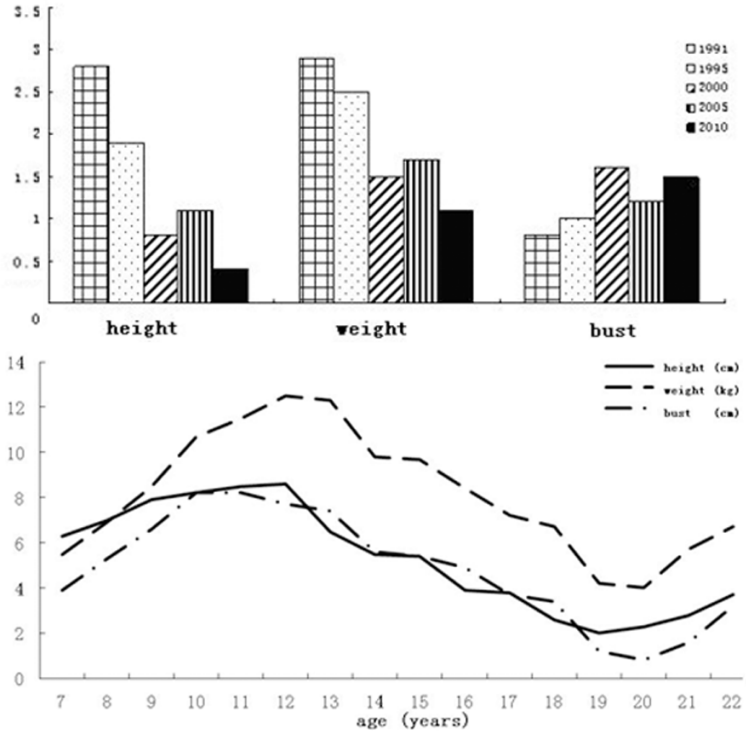

Figure 1. Height, weight and chest circumference increase during three decades in Tianjin students.

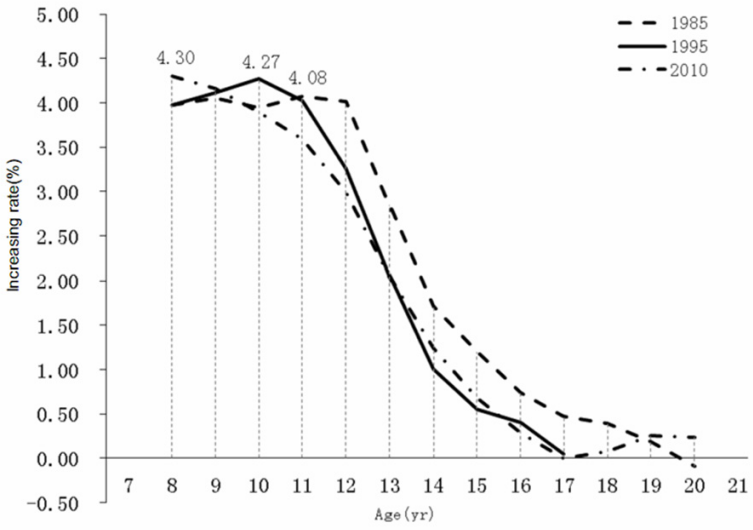

Figure 2. The variation trend for the increase rate of height among students in 1985, 1995 and 2010.

include gender, height, weight, blood pressure, and so on were collected and measured by standard criteria and method. The ethics approval was obtained from the Ethics Committee of Tianjin Medical University before collecting data from the children and adolescents, and/or their parents/guardians on behalf of them. Also written informed consent was obtained before collecting data from the patients.

Statistical analysis

SPSS 16.0 (version 16, SPSS, Inc., Chicago, IL, USA) was used for the analyses. Data were expressed as mean for the normal distributions or median if normal distribution was rejected. Chi-square or Fisher's exact test was used to compare the categorical variables. Student's t test or Wilcoxon two-sample test was applied to compare continuous variables between the two groups. Body mass index (BMI) was calculated as body weight (kg) divided by the squared body height (m^2). The difference was considered statistically significant using $P<0.05$ as basis.

Results

Characteristics of the population in the latest survey

A total of 10,561 students in the 2010 physical fitness and health survey of Chinese school students were broken down into 5,191 males and 5,370 females. Of the total, 5,282 (50.01%) were from urban Tianjin and 5,279 (49.99%) were from the rural area. The average age was 14 years. The average height of the students in 2010 was 156.51 cm (160.00 cm for males and 153.13 cm for females). The average weight was 50.91 kg (54.84 kg for males and 47.12 kg for females) and the average chest circumference was 78.78 cm (80.78 cm for males and 76.85 cm for females). Part of the students had normal

Table 3. The variation trend of height in the students from 1985 to 2010

	Index	1985	1991	1995	2000	2005	2010
Urban Male	Peak of increase (cm)	4.80	4.26	4.71	4.45	4.31	4.31
	Age of the peak (yrs)	12	10	11	8	8	8
	Level before the peak (cm)	148.5	140.2	147.9	131.6	135.8	135.0
Urban Female	Peak of increase (cm)	4.25	6.20	4.39	4.94	4.68	4.66
	Age of the peak (yrs)	10	8	10	9	8	8
	Level before the peak (cm)	138.9	128.4	141.3	136.5	133.4	133.5
Rural Male	Peak of increase (cm)	4.85	4.24	4.55	5.92	4.37	4.28
	Age of the peak (yrs)	12	9	11	12	13	12
	Level before the peak (cm)	143.7	132.6	147.5	150.8	158.2	154.6
Rural Female	Peak of increase (cm)	4.34	4.78	4.61	4.44	4.69	4.24
	Age of the peak (yrs)	10	9	9	8	9	8
	Level before the peak (cm)	134.4	131.3	136.9	128.4	135.5	132.1

body mass index (BMI) (47.01%). The average spermarcheal/menarcheal age was 13.28 (3.79) years; 12.18 (3.75) years for males and 14.42 (3.83) years for females. Males showed higher levels of height, weight, BMI, and chest circumference than females, while the spermarcheal age of males was higher than the menarcheal age of females (**Table 1**).

Physical fitness status

Gender and area differences in the increase in height, weight, and chest circumference were observed. Dramatic increase was observed in urban male students. All three indices showed similar variation trends in students older than 18 yrs. The increased velocity of height was higher in the rural area and among male students; the other two indices were higher in the urban area and among female students. We also found a dramatic increasing trend of BMI in the seven-year old age point for all indices, specifically for male students and those from the rural area (**Table 2**).

A cross was detected between the increased velocity in height and weight for rural students. The weight velocity increased steadily, whereas the height increased before the age of 9 or 10, and subsequently decreased. Among rural females, a similar cross happened between the ages of 10 years and 11 years (**Figure 1**).

Growth and development: variation trend of growth and development

The growth spurt age for height was lower during these years, that is, 11 years in 1985, 10 years in 1995, and 8 years in 2010 and the growth peaks were 4.08, 4.27, and 4.30 cm, respectively (**Figure 2**).

An obvious early trend was observed among urban male and female students. The average height of male students increased before the peak, in which higher average height was observed among rural students. In the 2010 survey, all of the urban students demonstrated a high increase rate at the age of 8 years (**Table 3**).

Two height increase crosses between urban males and females appeared at 9.5 years and 12.5 years in 1985. In 2010, the height increase cross among urban students appeared only once, at the 10-year old age point. No such cross was observed between the two genders among rural students (**Figure 3**).

Discussion

The main characteristics of the population physical fitness status

Height and weight are the main principal parameters used to assess growth. Increasing or decreasing average levels reflect the level of growth at a particular time [16]. Specifically, the level of height, weight, and chest circumference, which were observed to be more rapid in the 9 to 13 age group can also reflect growth. Similar to other studies [17], the physical fitness status of the students in Tianjin of China suggests the contribution of more environmental factors to the physical development of early

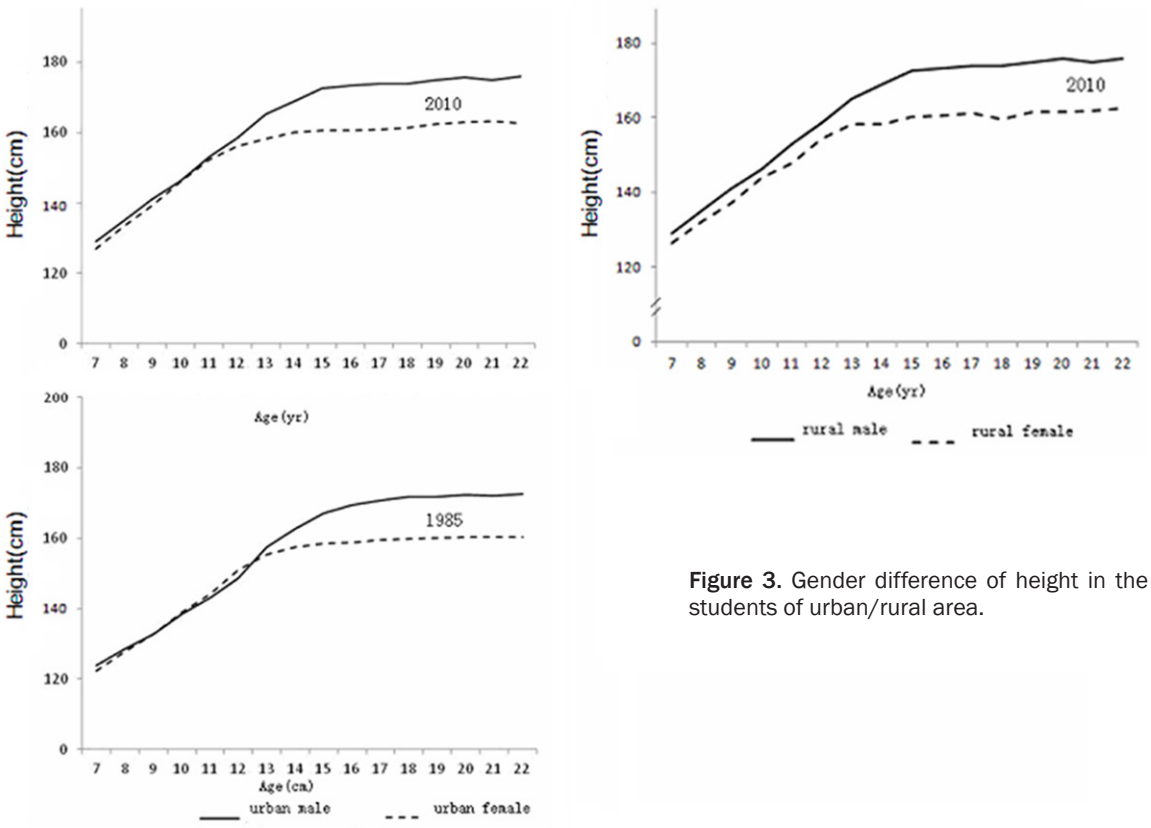

Figure 3. Gender difference of height in the students of urban/rural area.

adolescents. The gradual increases in height, weight, BMI, and chest circumference were observed according to the development of the city in the past decades.

The growth spurt and the long term trend in the population

The growth spurt age for height was lower during the years cited above in this study. Moreover, an obvious early trend was observed among urban male and female students, in which the average height before the peak increased more in male students. High average height level before the peak was also observed among rural students. In the 2010 survey, all of the urban students demonstrated high increase rate at the age of 8 years, which highlights the good nutrition and health situation in the preschool period.

Seven years old is always an important age point for physical development [15, 18-20]. In this study, an increasing age point was observed, which was higher for male students and rural area students. Studies have confirmed that better nutrition and medical care were associated with the height development trend [4, 14, 15, 18, 19, 21]. By contrast, factors such as excessive infancy nutrition obstruct height development [4, 15, 18]. In this study, the period of 7 to 22 years was the time interval where the early trend of development would be taken place; thus, more attention should be paid to this period.

Before the ages of 7 years and 9 years, males were taller and heavier than females. After females enter puberty, the rapid growth and development of the all parts of the body was observed. Their indices would be higher than those of males. Until the age of 13 years, the males would experience another rapid growth and development, whereas the females would experience a slowing down. Therefore, two crosses could be observed during the growth processes of males and females. The growth and growth spurt are related to nutritional status and energy intake [4, 18]. Disappearance of the two crosses of increasing height curve between the two genders of rural students was observed in this study. Nutrition, among other factors, might play a role [4, 18, 19, 22]. Differences in height between the two genders gradually increased after puberty, which is simi-

lar to the result of a Japanese study [23, 24]. This result might be associated with the full play of male students' growth potential provided by the improvement in the living standards [4, 25, 26] because such improvement might lead to the disappearance of the two crosses. Moreover, the reasons for the change of the cross would probably be different for the urban and rural populations in this study. The pattern of physical development of students in the rural area may be slow whereas the pattern for urban students may be fast. When compared with similar age groups in other countries, it was observed that the increasing velocity of the height in this population was more rapid than those of some European countries and Japan [13, 16, 23]. These results indicate the existence of long-term trend growth among the students in Tianjin of China, especially in the rural areas, which agrees with the observed strong increasing trend. Long-term trend of the physical development is an important change point in human development, and its feature, in relation to children and adolescents, vary based on location [27-29]. Long-term trend growth is the combined effect of multiple factors, also can be observed not only in the 7 years to 18 years age group, but also during the entire lifetime. It has been disappearing gradually in developed countries but might remain in existence in developing regions [4, 15, 30, 31]. And the continued progress in the growth of long-term trends in China will gradually reduce the gap between urban and rural areas caused by historical reasons [5, 20, 30]. In this study, the increased velocity of physical development changed significantly and showed an early trend for spurt age and gender and area differences. Accordingly, related intervention focused on the general population combined with the effect of the long-term trend growth process should be conducted to avoid the negative effects of long-term trend growth.

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Disclosure of conflict of interest

None.

Address correspondence to: Xin Zhang, Department of Maternal, Child and Adolescent Health, School of Public Health, Tianjin Medical University, Tianjin, China. Tel: +86 22 83336609; Fax: +86 22 83336603; E-mail: zhangxin@tmu.edu.cn

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