

Economic growth and height of youth: a panel data analysis on 27 provinces in China, 1985–2014

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Abstract

Background: This study aimed to empirically examine the influence of China's macroeconomic development on the height of Chinese youth in the past 30 years, using provincial panel data collected from more than one million children. **Methods:** Panel data from seven longitudinal surveys (1985, 1991, 1995, 2000, 2005, 2010, and 2014) of the Chinese National Surveys on Students' Constitution and Health, including students aged 7–22 years from 27 provinces, were utilized for data analysis. Fixed-effects models were used to estimate the association between economic growth and height. **Results:** For every 1% increase in per capita disposable income (PCDI), the average height of students significantly increased by approximately 0.009%. Stated another way, this implies that a doubling of income is associated with 0.9% increase in height, which is significant for height. The coefficient of PCDI in the last decade is higher than that of in the early two decades. The average height of boys was approximately 3.9% higher than that of girls. The average height difference between high and low ages in the sample was 1.9%. The impact of policies on students' height was extremely small and may have little practical significance. **Conclusion:** China's economic growth has a significant positive effect on the height of urban Chinese students without stagnation.

Background

Although height is highly heritable, it is also closely related to environmental factors such as socioeconomic status, nutrition and exposure to infections, and those factors depending on macro-economy development[1–3]. Studies have focus on the influence of economic development and social changes on height. The data of 364,538 women, aged between 25 and 49 years, from 54 low- to middle-income countries between 1994 and 2008 were collected and analyzed. A positive association between wealth and height in 96% (52/54) of the countries was found—and fourteen countries in Africa experienced a decrease in height, where nutritional and environmental circumstances were worse than those of other countries[4]. Results also revealed that urban children in most low- and middle-income countries who received better education, health care, and infrastructure construction were taller and heavier than their rural counterparts[5–7]. Moreover, the average height of students living in large urban centers was higher than that of students living in small urban centers in Poland [8]. These results indicated that the macro-economy has a non-negligible impact on the height of residents.

Changes in the macro-economy also exerted a significant influence on children's height[9–14]. An attenuation of growth was suggested during the Great Depression, where growth was moderate, i.e., 1–2 cm, after the mid–20th century for White and Black Americans[12]. Findings revealed that macroeconomic development has an impact on height. However, determining the extent of the influence of macro-economy on height remain an interesting research focus.

The dramatic increase in height in Europe during the late 19th century was closely associated with the industrial revolution[15, 16]. This effect can be attributed to the general improvement of living standards, improved nutrition and health care, reduced child mortality, and urbanization [11]. Meanwhile, China has implemented its reform and opening up policy since the end of the 20th century. Similarly, China's economy has developed by leaps and bounds over the past 30 years, so, it is worth studying whether the rapid development of China's economy in recent decades would bring changes in the height of youth. In addition, most studies on the association between macroeconomic factors and height are cross-sectional studies[4, 7, 12, 14], whereas longitudinal studies are limited. Therefore, the present study aims to empirically evaluate how powerful the impact of China's macroeconomic development on the height of Chinese youth is, using provincial panel data collected from more than one million children in the past 30 years.

Method

Data

Height data

Data were derived from the report of 1985, 1991, 1995, 2000, 2005, 2010, and 2014 Chinese National Surveys on Students' Constitution and Health[17–23]. The CNSSCH is a series of surveys conducted by the Ministries of Education, Health, Science and Technology, the State Ethnic Affairs Commission, and the State Sports General Administration of the People's Republic of China. This study included only subjects of Han ethnicity, who account for 92% of the total Chinese population. The respondents came from 27 out of 31 provinces of China, excluding Hainan and Chongqing, both of which were founded after 1985. Qinghai and the Tibet autonomous region were also excluded because the former missed the 1995 survey, whereas the latter did not participate in nearly all surveys. Each province had equal sample sizes from three socioeconomic classes (i.e., "upper," "moderate," and "low") at the regional level. The participants were students aged 7–22 years from primary to college levels, who were selected from the same areas in each province from 1985–2014. Respondents were selected by stratified cluster sampling from certain classes, and the clusters were randomly selected from each grade in selected schools. Table 1 presents the sample sizes at each examination period. Metal column height measuring stands (200 cm with a 0.1-cm precision) were used to measure each respondent's stature without shoes on.

Socioeconomic data

The data of per capita disposable income (PCDI) were derived from the respective statistical yearbooks of China's provinces (1985, 1991, 1995, 2000, 2005, 2010, and 2014) and the statistical database of the Chinese economic network [24].

Variables

To overcome heteroscedasticity and enhance the stationarity of data, we took the logarithm of all variables[25]. The dependent variable, $\ln height$, is the log of the student's height. The core independent variable, $\ln PCDI$, represents the indicators of the economy. The control variables are sex, age, and policy. Gender and policy are dummy variables. Three vital policies, regulations, and opinions on strengthening students' physical fitness, which were issued by the Central Government and the Ministry of Education, were selected. They are named P90, P97, and P07, which refer to the regulations on school sports as issued by the State Education Committee of the People's Republic of China on 12 March 1990. The implementation plan for the physical education examination for junior high school graduates was issued by the State Education Commission on 16 November 1997. Opinions on advocating teenagers to participate in sports and reinforce physical fitness were issued by the Central Committee of the Communist Party of China and State Council on 7 May, 2007.

Estimation approach

Panel econometric model was employed to estimate the association between students' height and $\ln PCDI$ and other factors, using height as the dependent variable and $\ln PCDI$ as a key independent variable. To reduce endogeneity, several control variables were introduced. To overcome heteroscedasticity and enhance the stationarity of data, we took the logarithm of all variables. Stata12.0 software was used to conduct the static model empirical analysis.

$$\ln y_{it} = \alpha_i + \beta_1 \ln PCDI_{it} + \beta_2 \text{sex} + \beta_3 \text{age} + \beta_4 P90 + \beta_5 P97 + \beta_6 P07 + \varepsilon_{it}$$

where $\ln y_{it}$ is log of the height status in province i at time t , $\ln PCDI$ is the log of the economic level of province i , sex, age, P90, P97 and P07 are control variables that are expected to relate height, sex is dummy variable, age is a numerical variable consisting of 7 to 22. P90, P97 and P07 refer to the regulations which are dummy variables, and ε_{it} is the error term. Equation used the fixed effect regression which controls for time-invariant characteristics, such as climatic conditions and unmeasured cultural factors, and any time-varying differences common to all provinces.

Results

Trends in height

The average height of male and female students increased steadily from 1985–2014 without any tendency to plateau (Figures 1 and 2, respectively). The research focuses on 7-, 13-, 16-, and 19-year-old students as first-grade ages in the primary, junior high school, senior high school, and university levels, respectively. Among all ages, the increment in the height of males was largely pronounced at puberty (at 13 years old), with an increase of 9.3 cm in three decades. In contrast, among all ages, the increment of the height in females was largely pronounced at childhood (at 7 years old), with an increase of 5.87 cm in three decades. The second largest increment of height in males was 6.46 cm at 7 years old relative to 4.66 cm in females at 13 years old.

Trends in PCDI

Figure 2 presents the socioeconomic changes in China between 1985 and 2014. As can be seen, urban PCDI increased from 739 to 28,843 yuan during this period.

Empirical analysis

On the basis of the natural logarithm of each variable, the robust command was used to correct the standard error with white heteroscedasticity, so as to make the result more robust. All following regressions eliminated the outliers.

Table 2 presents the estimated results of the fixed effects models which is the test of the association between China's economic growth and the height of urban students after controlling for other variables, such as gender, age, and policy. A significant positive coefficient of 0.009 was found in this model. Given the log–log specification, this coefficient represented the elasticity of height with respect to PCDI: an increase of 1% in PCDI occurred with an increase in average height by approximately 0.009%. This indicated that, for every 1% increase in PCDI, the average height of youth in China increased by approximately 0.009% given that other factors remain unchanged. Stated another way, this implies that a doubling of income is associated with 0.9% increase in height, which is significant for height. This finding reveals that economic growth may exert a promoting effect on students' height. The coefficient of sex is 0.039, which is highly significant at the statistical level of 1%. The coefficient can be explained as the average height of the male sample, which is approximately 3.9% higher than the average height of the female sample. The coefficient of age is 0.019, which passes the significance level of 1%. This coefficient can be interpreted as the average height difference between adjacent ages of the sample students at 1.9%. The impact of policies in 1990 and 1997 on students' height was negative and highly significant. However, the coefficient value is extremely small and may have little practical significance.

As shown in Figure 1, 2005 is the turning point not only of China's macro-economy, but also of a new round of healthy economic growth. Therefore, to further explore trends of association between PCDI and students' height, the model was estimated during two periods, namely, 1985–2005 and 2005–2014, as shown in Columns (3) and (4), respectively. The coefficient of $\ln PCDI$ in Column (3) is 0.009, which is highly significant at the 1% statistical level. This finding may indicate that the economic growth from 1985–2005 has a significant promoting effect on the height of Chinese youth.

As shown in Column (4), the elasticity of students' height is 0.011, which is highly significant. The coefficient is higher than that of in the early two decades. This finding may indicate that the Chinese economy has had additional positive effects on the height growth of children and adolescents from 2005 to 2014. In summary, the results show that the positive effect of the Chinese economy on students' height may gradually increase without any tendency to plateau.

Discussion

Using provincial-level 5-year interval panel data of 27 provinces from 1985–2014, the current study reveals that economic growth has a significant positive effect on the height growth of youth. Data also show a linear relationship between economic growth and height of youth, suggesting an average height increase with continued increase in PCDI without any stagnation. Moreover, the study also indicates that the effect of economic growth on students' height in the past ten years is greater than that in the previous 20 years. In fact, numerous studies reported a positive association between economic status and healthy output in both developed and developing countries [4, 6, 7]. Increase in height growth entered a period of rapid growth in the past 30 years.[26–28]. From 1995–2005, the height increments of urban male and female students aged 7–18 years in China were 2.0 and 1.3 cm, respectively[27]. From 2005–2014, the height increments of the urban male and female aged 7–18 in China were 2.0 and 1.7 cm, respectively[26].

Several reasons may explain the mechanism of economic influence on the height of children and adolescents. First, China's economy experienced unprecedented growth in the past 30 years. The country's rapid economic development has also brought about tremendous changes in the dietary structure and habits of the Chinese people[29]. In 1993, the rationing system was abolished, open markets became dominant, and a modern food system began to take shape[30], which improved crop and poultry productivity[31] and dramatically enriched the diet of the Chinese people. Entering the 21st century, China's economy achieved a new round of development. With the improvement of living standard and of health consciousness, people gradually prioritized healthy foods, such as milk, fish, and shrimp [32]. These are rich in high-grade protein and calcium essential for bone development [33]. The increase in high-quality protein and calcium intake, which is vital to bone development, significantly increased Chinese children's average height. Moreover, China's expenditure on healthcare significantly increased over the last 30 years, which accelerated the development of public health in the country. The health of youth definitely benefited from the regular examination of physical development, iron deficiency anemia, and other common diseases. Physical assessments for the prevention and treatment of malnutrition, acalcerosis in children, and obesity were also conducted regularly[34]. The implementation of public health projects in China enhanced Chinese residents' health awareness and health knowledge and encouraged them to develop healthy habits[35, 36]. In addition, driven by the rapid economic development, the Chinese people's educational level has significantly improved as well. A number of studies showed that parents' social economic status, including education level, has a significantly positive influence on the height of children and adolescents [37–39].

Limitations and strengths

Concerning the methodological issues, our estimations maybe have endogeneity issues, such as omitted variable problems. Another limitation is that our study focuses only on urban youth. Future studies should pay increased attention to rural youth and make a comparison between the two populations to gain a deeper analysis of the physical conditions of the Chinese youth.

Despite these limitations, the panel data in this paper included time series and cross-section data, which were collected across 30 years from 27 provinces in China from over one million students. In addition, the panel model can longitudinally analyze the trend of the association between economy and height, and evaluate how powerful the impact of macro-economy on height of youth is. This perspective can provide a comprehensive and targeted analysis and is a critical step as China moves toward its goal of Healthy China 2030[40].

Conclusion

In summary, this study provides evidence for the association between macro-economic growth and height of Chinese youth. China's economic growth has shown positive influence on the height of Chinese youth without any trend of stagnation

Abbreviations

PCDI: Per Capita Disposable Income; CNSSCH: Chinese National Surveys on Students' Constitution and Health; P90: Regulations on school sports as issued by the State Education Committee of the People's Republic of China on 12 March 1990; P97: The implementation plan for the physical education examination for junior high school graduates issued by the State Education Commission on 16 November 1997; P07: Opinions on advocating teenagers to participate in sports and reinforce physical fitness issued by the Central Committee of the Communist Party of China and State Council on 7 May, 2007.

Declarations

Acknowledgments

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Authors' contributions

All authors read and approved the final manuscript. KY, XG, and XW designed the study, collected the data, participated in statistical analysis, and drafted the manuscript. XG played a role in data collection and data analysis.

Availability of data and materials

The data support this study came from the reports of Chinese National Surveys on Students' Constitution and Health which was conducted by the by the Ministry of Education, Ministry of Science and Technology, National Health Commission, National Ethnic Affairs Commission, and the State Sports General Administration of the People's Republic of China. The raw data is confidential and not publicly available. Data may be shared with researchers obtaining permissions from the Ministry of Education of the People's Republic of China.

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Ethics approval and consent to participate

Data were retrieved from the reports of Chinese National Surveys on Students Constitution and Health (CNSSCH). The CNSSCH was conducted by the by the Ministry of Education, Ministry of Science and Technology, National Health Commission, National Ethnic Affairs Commission, and the State Sports General Administration of the People's Republic of China. The authors did not collect the raw data but only do the data analysis. This study was approved by the Ethics Committee of College of Education in Zhejiang University.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not Applicable

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Tables

Table 1. Sample Sizes at Each Examination Period in CNSSCHA (Aged 7–22years), 1985–2014

	Male							Female						
	1985	1991	1995	2000	2005	2010	2014	1985	1991	1995	2000	2005	2010	2014
7	8560	2933	4401	3051	4935	4486	4464	8559	2925	4400	4512	4860	4481	4480
8	8561	2999	4398	4446	4934	4485	4489	8561	2977	4406	4533	4862	4469	4487
9	8557	2959	4397	4546	4945	4481	4478	8561	2951	4402	4494	4892	4490	4490
10	8557	2932	4390	4571	4916	4490	4485	8559	2942	4402	4657	4932	4487	4488
11	8561	2965	4396	4587	5051	4500	4487	8559	2935	4413	4498	4894	4496	4474
12	8558	2957	4398	4524	4917	4483	4479	8557	2875	4397	4518	4785	4484	4477
13	8558	2906	4394	4523	4914	4487	4487	8558	2933	4395	4530	4925	4487	4495
14	8560	2948	4403	4546	4852	4489	4487	8561	2931	4383	4513	4859	4494	4485
15	8556	2952	4403	4561	4979	4489	4482	8556	2924	4394	4516	4935	4482	4489
16	8559	2936	4343	4551	4892	4476	4481	8557	2911	4396	4519	4916	4454	4493
17	8532	2936	4395	4507	4919	4488	4494	8537	2910	4403	4524	4857	4485	4490
18	8324	2968	4335	4549	4979	4476	4289	8159	2933	4365	4632	5047	4435	4289
19	5516	2937	2850	3302	3777	2971	2973	5551	2988	2863	3449	3938	2996	2997
20	5593	2953	2876	3181	3741	2975	2970	5580	2968	2880	3306	3905	2982	2988
21	5592	2770	2875	3187	3744	2972	2989	5462	2751	2879	2958	3752	2986	2987
22	4332	2955	2829	2718	3327	2915	2865	3335	2685	2737	2555	3390	2917	2881
Total	123,476	47,006	64,083	65,350	73,822	65,663	65,399	122,212	46,539	64,115	66,714	73,749	65,625	65,490

Table 2 Econometric Estimates of the Association between PCDI and Height

	(1)	(2)	(3)	(4)
	Inheight	Inheight	Inheight	Inheight
lnPCDI	0.009*** (50.67)	0.009*** (44.36)	0.009*** (43.98)	0.011*** (15.85)
sex		0.039*** (12.20)	0.037*** (11.67)	0.043*** (13.46)
age		0.019*** (48.29)	0.019*** (49.55)	0.017*** (44.83)
p90		-0.003*** (-12.64)	-0.003*** (-12.51)	
p97		-0.002*** (-5.49)	-0.002*** (-5.35)	
p07		0.000 (1.11)		
_cons	4.955*** (1094.14)	4.667*** (709.13)	4.661*** (712.92)	4.661*** (482.88)
R2	0.60	0.60	0.49	0.23
P	0.000	0.000	0.000	0.000
N	6047	6047	4319	1728

t statistics in parentheses

The White(1980) robust regression

=* p<0.1

** p<0.05

*** p<0.01"

Figures

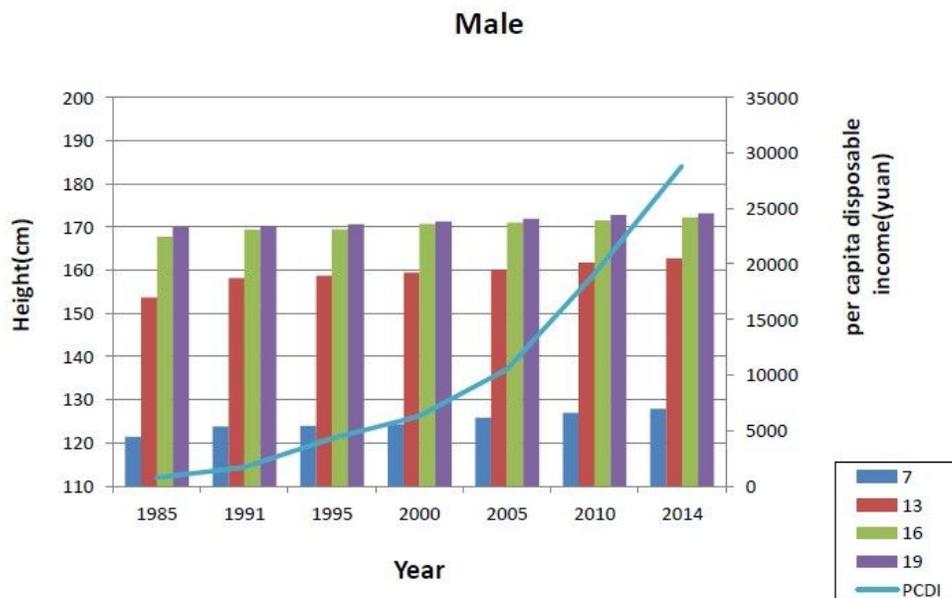


Figure 1

Trends in Height and PCDI in Males

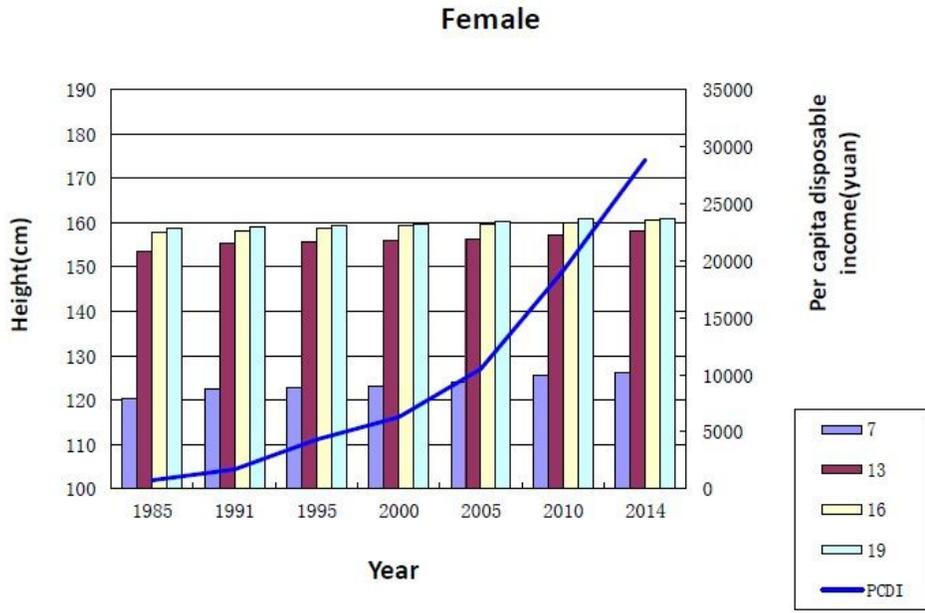


Figure 2

Trends in Height and PCDI in Females