

Anthropometric changes in children under 7 years old in Nanjing, China from 1995 to 2015

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Research article

Keywords: Children, Physical growth, Long-term change

Posted Date: November 9th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-30850/v3>

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Abstract

Background: To date, there have been several reports about long-term changes in physical growth in children of different races around the world. However, limited studies on this change have been reported in Nanjing, China. We decided to assess long-term changes in body weight, length/height and head circumference in children (0-7 years old) in Nanjing over the past two decades from 1995 to 2015 and the relationship between socioeconomic development and the change of physical growth.

Methods: The results for body weight, length/height and head circumference in 0-to 7-year-old children were obtained from three repeated cross-sectional surveys that were performed by using the same methods in the same urban and suburban areas of Nanjing in 1995, 2005 and 2015. The differences in mean values between urban and suburban boys and girls and the increases per decade were compared. Socioeconomic indicators were collected and analysed.

Results: There was positive long-term growth in height and weight of children in Nanjing from 1995 to 2015, measurements increased 0.3-3.00 kg in weight and 1.0-3.8 cm in height for boys, 0.23-2.18 kg in weight and 1.3-3.6 cm in height for girls in urban areas (except children under 15 months), as well as 0.32-4.15 kg in weight and 1.1-7.4 cm in height for boys, 0.26-2.95 kg in weight and 1.2-6.3 cm in height for girls in suburban areas (except children under 8 months). Compared with the first decade, the changes of mean values in height and weight of urban children in the second decade were smaller. In contrast, the long-term change of suburban children still kept fast growth rate. Before 2.5 years old, negative increases in weight and height in urban children were observed in second decade. Urban-suburban difference of weight and height became smaller in 2015. The growth of head circumference from 1995 to 2015 underwent a small long-term change, especially of urban children.

Conclusion: The increased long-term physical growth due to rapid social and economic development would disappear, and genetic potential might have been seen.

Background

Over the past two decades, with socioeconomic development, people have improved living standards and society, and parents have provided a more privileged life to their children, including increased health management investment, greater accessibility to education and improved food supply[1, 2]. As previously reported, sustained economic growth has a substantial effect on children's long-term health [3-9]. Several researchers have shown that economic production plays a positive role in long-term trends in children's physical growth [5, 7-9]. A research about 7- to 18-year-old children and adolescents in Shandong Province reported that the mean height of 18-year-old boys increased 7.7 cm, and girls' height increased 4.7 cm over four decades, whereas the increase in weight was 7.5 kg for boys and 0.3 kg for girls [8]. Another investigation of children under 7 years old in nine cities in China also found significant increasing trends in height between 1975 and 2015, indicating long-term changes from sustained socioeconomic growth [7].

However, improved economic productivity results in changes in food intake, such as more fat, sugar and calories and lower dietary fibre [10, 11]. Physical inactivity in daily life is increasingly prevalent [12]. With national economic development, negative effects on children's physical growth have emerged. As Dong reported, from 1995 to 2014, Chinese school-aged children and adolescents have transitioned from thinness to overweight and obesity in both urban and rural areas [13]. The mean prevalence of overweight and obesity quadrupled to 20.5%. They found that higher GDP (Gross Domestic Product) per capita, a higher urbanization ratio and a lower Engel coefficient were associated with a higher prevalence of overweight and obesity [13]. A similar increasing trend was found in pre-school-aged children. In Harbin, a city in northeast China, the combined prevalence of overweight and obesity in children aged 0-6 years increased from 2.6% in 1995 to 7.6% in 2015 [14].

The National Survey on Physical Growth and Development of Children in the Nine Cities of China (NSPGDC), which is a large-scale national survey on children's growth, has been conducted since 1975 and performed every ten years at the same sites [7, 14]. Zhang and Zong et al. analysed the NSPGDC data and presented rapid changes in weight and height with socioeconomic development among children under 7 years in nine cities in China in recent decades. However, there is limited report regarding long-term change in children's weight, height and head circumference in Nanjing, which is the provincial capital city of Jiangsu Province in East China. Therefore, we re-analysed the NSPGDC data to examine long-term growth changes and urban-suburban disparities accompanied by socioeconomic development for body weight, length/height and head circumference of children aged 0-7 years in Nanjing from 1995 to 2015.

Methods

Study design and setting

All participants were a part of NSPGDC from Nanjing and healthy boys and girls under 7 years age old were included. The results for body weight, body length/height and head circumference (HC) measurements were obtained in 1995, 2005 and 2015. As previously reported[7, 15], a multistage, stratified, cluster sampling method was used in Nanjing, and several hospitals, communities and kindergartens in different urban and suburban areas were selected for collecting the anthropometric characteristics of children aged 0 to 1 month, over 1 month to less than 3 years and 3 to 7 years. Children who were twins or part of multiple births, had a gestational age at birth <37 weeks, or had a birth weight <2.5 kg were excluded. All participants had medical checks before measurement to ensure that they had no physical or mental disorders, including endocrine diseases, neurological disorders, chronic systemic disease and others. In total, the sample sizes were 17,505 in 1995, 15,995 in 2005 and 17,469 in 2015 (Table 1).

Measurement and quality control

The body weight, body length/height and HC were measured using standardized methods by two trained investigators. The details of measurements were reported in previous paper [16]. Briefly, body weight of newborns was measured by a newborn scale (accurate to 10 g) and weight of children aged 1 month to 6

years was obtained on lever scales (accurate to 50 g, in 1995 and 2005) or an electronic scale (accurate to 50 g, in 2015). Body length/height of children was measured by infant meter (<3 years old) or stadiometer (≥ 3 years old), and the result was recorded to the nearest to 0.1 cm. Children's HC was measured using a flexible, non-stretchable plastic tape, and then, the results were recorded to the nearest 0.1 cm. Before the survey, all investigators underwent rigorous professional training. All measuring equipment was uniform and calibrated daily before use. At each site, approximately 5% of all subjects were randomly selected for a repeated measurement every day, and the allowable errors between the two measurements were no more than 10%. The intraobserver and interobserver measurement errors were controlled within 50 g for weight or 0.5 cm for length.

Socioeconomic data

We collected information about demography, socio-economic status, and health investment from the statistical yearbook recorded on the official website of the Nanjing Statistics Bureau (<http://tjj.nanjing.gov.cn/>). The indexes included total population, birth rate, natural increase rate, GDP, the ratio of the three economic sectors (agriculture, industry and services), GDP per capita, income per capita in the city, income per capita in the country, consumption per capita, health funds and its ratio to total financial expenditure (Table 2).

Statistical analysis

IBM SPSS version 22.0 was used to analyse the data. The data with normal distribution were shown as mean \pm standard deviation (SD). Mean and SD of body weight, length/height and HC among each subgroup was calculated and depicted. Independent samples t-test was employed to assess the growth differences of weight, length/height and HC among different populations or periods. GraphPad Prism version 5.0 was used to draw figures.

Results

The sample sizes of sex-age and urban-suburban subgroups in 1995, 2005 and 2015 are shown in Table 1.

The details of mean values and SD for body weight and length/height of children in Nanjing are shown in Table 3-4. There was positive long-term growth in body weight and length/height of urban and suburban children from 1995 to 2015. The measurements increased 0.3-3.00 kg in weight and 1.0-3.8 cm in length/height for boys, 0.23-2.18 kg in weight and 1.3-3.6 cm in length/height for girls in urban areas (except children under 15 months), as well as 0.32-4.15 kg in weight and 1.1-7.4 cm in length/height for boys, 0.26-2.95 kg in weight and 1.2-6.3 cm in length/height for girls in suburban areas (except children under 8 months). Except urban girls, the mean values of weights and heights of children aged 6 to 7 years in 2015 were higher than those of their counterparts in 2005 and 1995.

Figure 1 shows that the long-term changes in boys' weight and length/height both in urban and suburban areas in the first decade were obviously positive. However, from 2005 to 2015, the growth changes in urban boys' indexes were slight with no statistics difference in most age groups. Besides, negative increase was shown before 2.5 years old (Fig 1A and 1C). In contrast, the suburban boys' weight and length/height in most ages from 2005 to 2015 maintained the momentum of rapid growth, especially weight (Fig 1B and 1D). Figure 2 shows the relative per-decade increments in weight and length/height among girls, and similar change characteristics were shown to those of the boys. It is worth noting that the relative increase in suburban girls' weight after 4 years old was still large in the second decade (Figure 2B). As supplementary Figure 1 showed, both suburban boys and girls had growth curves of weight and length/height in 2015 that were very close to those of urban groups, reflecting that the difference in physical growth between urban and suburban children is becoming smaller.

Table 5 displays the differences in weight and length/height between urban and suburban children in 1995, 2005 and 2015. During 1995-2005, the differences in weight and length/height were stable and sustained at high levels in most age groups. Generally, the urban-suburban difference of weight in boys and girls increased with age in 1995 and 2005. However, in 2015, the difference between urban-suburban children was slight with no statistics difference in most ages. In 2015, the 6- to 7-year-old boys and girls in urban areas were as tall as suburban counterparts, reflecting that the height of suburban boys and girls had nearly caught up to that of their urban peers by the age of 7 years.

The details about the mean values of HC in boys and girls in urban and suburban Nanjing in 1995, 2005 and 2015 are shown in Table 6. The long-term change in HC of urban children in some age groups was negative shown from 1995 to 2015, and was with no statistics difference after 10 months. However, there was a positive growth in suburban children after 15 months. The mean head circumferences of suburban children aged 2.5 to 3 years were 49.3 cm for boys, 48.1 cm for girls in 2015, were higher than these of 1995. Meanwhile, the head circumferences of urban children aged 2.5 to 3 years in 2015 were as long as counterparts of 1995. Notably, the difference of head circumferences between urban-suburban children aged 2.5 to 3 years in 2015 was not statistically significant.

Discussion

Our results demonstrated that there was positive long-term growth in height and weight of boys and girls from 1995 to 2015. As the data showed, the mean height of 6-7-year-old suburban children rapidly increased 7.4 cm for boys and 5.9 cm for girls for over 20 years, while weight increased 4.15 kg for boys and 2.95 kg for girls. We thought that this long-term growth may be credited to the rapid socioeconomic development, as the GDP per capita, household disposable income, consumption per capita and health investment in Nanjing increased over the two decades.

In our study, the growth change in height and weight of urban children in the second decade was obviously lower than that in the first decade. Even in some age groups before 2.5 years old, negative increases in weight and height were observed. However, the growth in height and weight was still

increasing rapidly in suburban areas from 2005 to 2015. Therefore, the growth curves of mean height and weight of suburban children (0-7 years old) in 2015 were close to those of urban children. The urban-suburban difference in physical growth has been shrinking in 2015. The long-term growth change in children in our study was similar to others' reports [7, 16-18]. Zhang illustrated an increasing trend in weight and height that decelerated from 2005, especially in developed cities of China[7, 16]. These findings reflect again that rapid social and economic development has positive effects on children's physical growth, especially in economically underdeveloped regions. However, the increase in growth from rapid social and economic development gradually disappeared, and genetic potential might have been seen in urban areas or developed cities.

Moreover, we noticed that the relative increases in mean weight were more than those of height in suburban boys and girls aged more than 3 years in second decade. The disproportionate increases in weight and height could lead to overweight or obesity. In the article published by Zhang [7], the relative increases in P97 of weight and weight for height of 2-7-year-old Chinese children were significantly larger than those in P3 and P50, indicating that Chinese children are changing from slender to thickset. The prevalence of overweight and obesity in children (2-7 years old) increased remarkably from 2005 to 2015. The increasing rates of overweight and obesity in suburban children first exceeded those of urban children in 2005 [7]. Another report about Chinese school-aged children and adolescents showed that the mean prevalence of overweight and obesity increased from 5.3% to 20.5% from 1995 to 2014. These results suggested that with socioeconomic improvement, overweight and obesity in children become a potential health problem. Therefore, in the future, we should pay more attention to the prevention of overweight and obesity in children's health care.

Notably, an interesting phenomenon of an obvious deceleration in the change of weight in urban children in the second decade, especially in urban girls, and even negative changes in weight in some age groups was observed. We thought these findings might be associated with parents and health care physicians focusing on overweight and obesity in children and health promotion services provided by departments of public health. From this view, we believed that if we attached enough importance to the problem of overweight and obesity in children, the benefits of socioeconomic development on long-term trends in children's physical growth would far exceed its costs.

To date, the WHO (World Health Organization) growth standard for 0-24 months in 2006 is still widely used around the world and is based on data derived from a longitudinal follow-up survey from six countries [19-21]. In investigation of the growth standards, the WHO found that the growth curve for healthy children under 2 years old using the best feeding recommendations and medical and environmental conditions was similar among different countries, reflecting that the most important determinants of child growth are not race and heredity [22, 23]. Therefore, this growth standard was thought to be an ideal target growth model. Compared with the WHO 2006 growth standards for 0-24 months [24], we observed that the mean values of weight and length of urban and suburban children in 2005 and 2015 were more than those of children of the same age and same sex (data not shown). The same result was also shown in the 5th national survey which weight and height of urban and suburban

children aged 0-2 years in China were all higher than the WHO standards [16]. However, the weight and length of urban children (0-2 years old) in some age groups in 2015 were lower than those of those counterparts in 2005, which demonstrated a tendency to gradually approach the WHO 2006 growth standard. The phenomenon suggested the genetic potential of urban children in Nanjing might be seen under the best conditions. The use of WHO 2006 growth standards in Nanjing since 2006 might reduce the risk of infant overweight or obesity. This effect had been shown in other researches[25-27], such as one conducted in Shanghai, a developed city of China, which showed that after adopting the WHO 2006 growth standards, the proportion of overweight infants (0-1 years old) in urban areas decreased [26].

Conclusion

In conclusion, our results demonstrated that there was positive long-term growth change in height and weight in children in Nanjing during the two decades from 1995 to 2015. However, the long-term change for height and weight in urban children in the second decade was obviously shrinking. Besides, the urban-suburban areas disparities were gradually shortened from 1995 to 2015. These results suggested that the positive long-term growth along with rapid social and economic development would eliminate, and the genetic potential might be seen in developed areas.

Limitation

Some limitations in the research should be considered when interpreting the results. Firstly, the detailed information of urban and suburban socioeconomic status, and family income were not available, which limited us to determine the reasons for eliminated urban- suburban difference. Secondly, with the rapid urban extension in Nanjing, the anthropometric data of children collected in 2015 in original suburban areas which were enrolled in 1995, may not reflect the physical growth level of real suburban children.

Abbreviations

GDP: Gross Domestic Product; NSPGDC: National Survey on Physical Growth and Development of Children in the Nine Cities of China; HC: head circumference; WHO: World Health Organization

Declarations

Ethics approval and consent to participate

The NSPGDC was approved by the Ethics Committee of the Capital Institute of Pediatrics, and written informed consent to participate in the study was obtained.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

This study was supported by grants from the Jiangsu Provincial Medical Youth Talent (QNRC2016098) and Medical Outstanding Youth Science Foundation of Nanjing (JQX19009). The funding had no role in the design of the study, the collection, analysis, and interpretation of data, and in writing the manuscript.

Authors' Contribution

LC and YC collected and analyzed the data. LC drafted the manuscript. MZ and LC revised the paper. MZ and MLT monitored data collection for the whole process. MLT, MZ and LC designed the study. MZ is responsible for the integrity of this study. All authors read and approved the final version.

Acknowledgements

Not applicable.

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Tables

Due to technical limitations, HTML conversion of the Tables could not be completed. Tables can be found in the Supplementary files section.

Figures

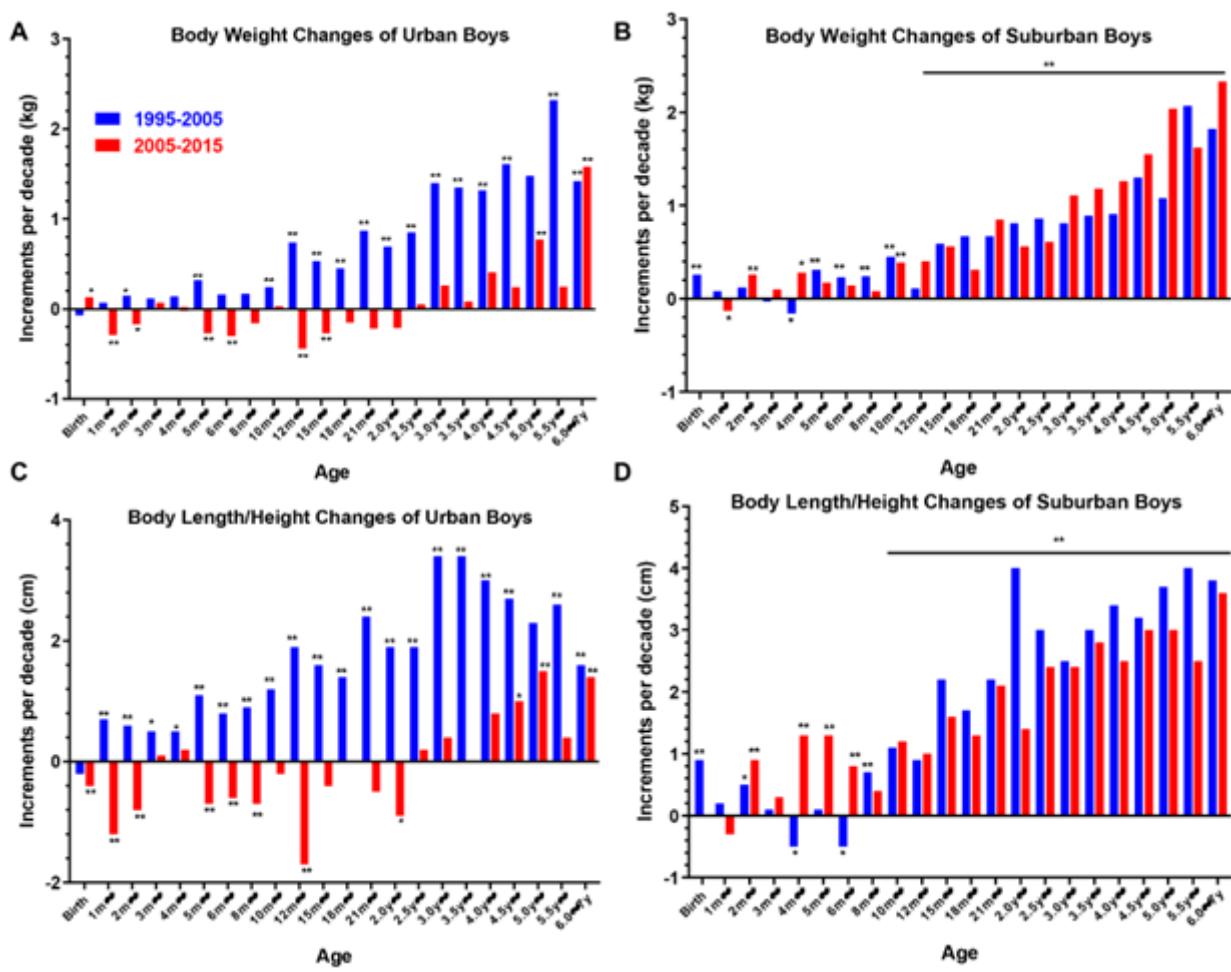


Figure 1

Increases per decade in body weight and length/height for urban and suburban boys in different stages (1995-2005 and 2005-2015)

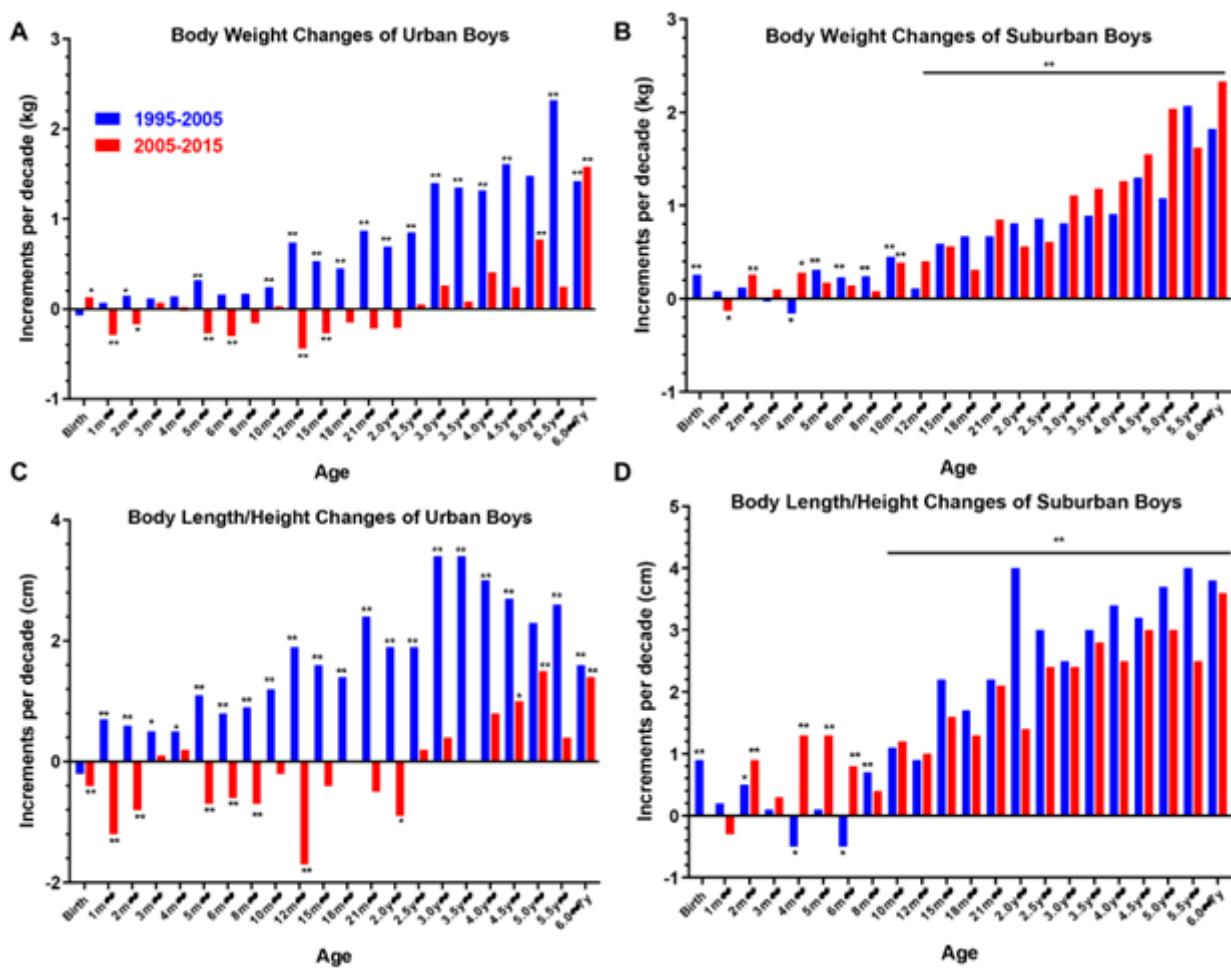


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Increases per decade in body weight and length/height for urban and suburban boys in different stages (1995-2005 and 2005-2015)

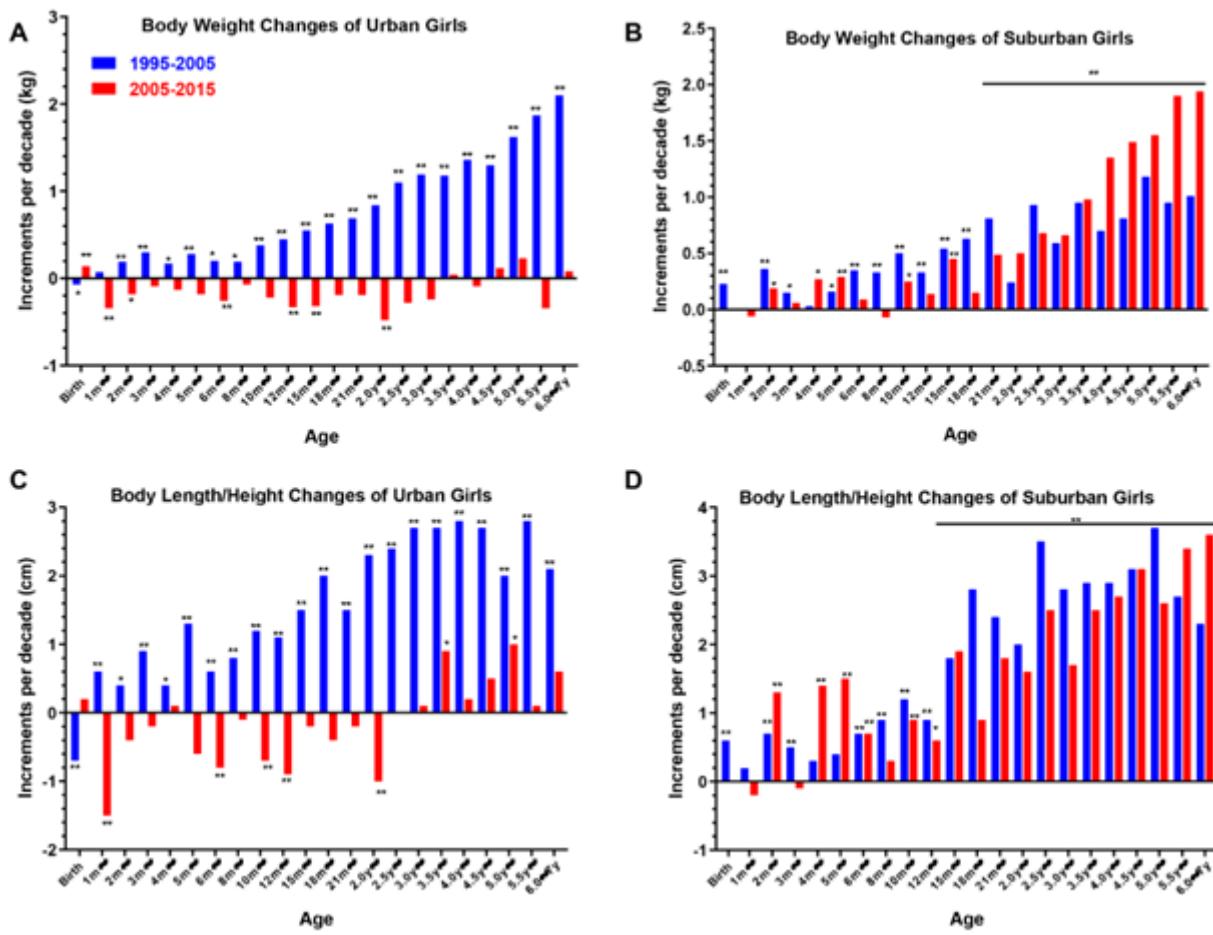


Figure 2

Increases per decade in body weight and length/height for urban and suburban girls in different stages (1995-2005 and 2005-2015)

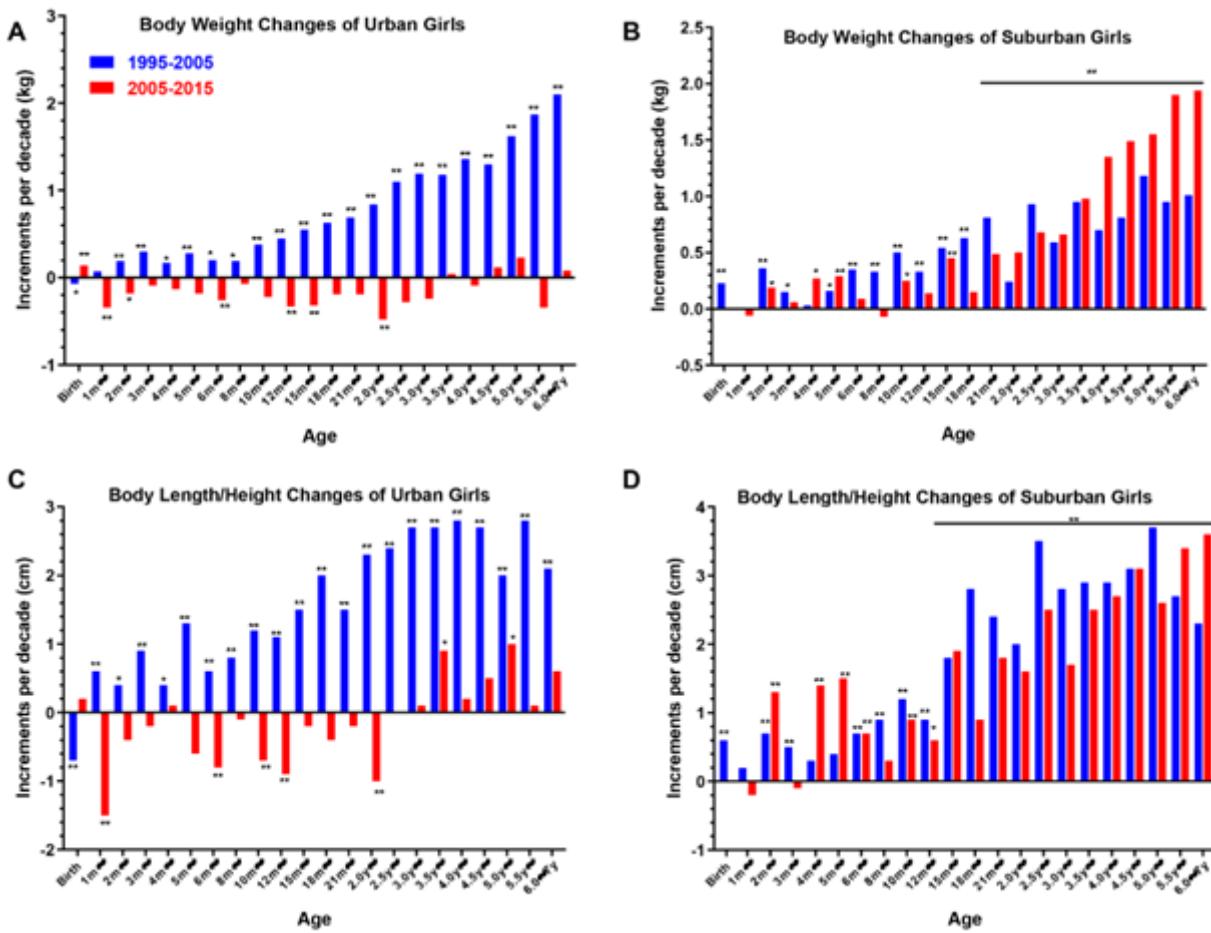


Figure 2

Increases per decade in body weight and length/height for urban and suburban girls in different stages (1995-2005 and 2005-2015)

Supplementary Files

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