Anthropometric Changes in Children Under 7 Years old in Nanjing, China from 1995 to 2015

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Abstract

Background: To date, there have been several reports about regional trends in physical growth in children of different races around the world. However, no studies on this trend have been reported in Nanjing, China. We decided to assess regional trends 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 trend for increased 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 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 regional growth in height, weight and head circumference of children in Nanjing from 1995 to 2015. The trend for increased height and weight of urban children in the second decade was obviously slower, especially in urban areas. Before 2.5 years old, negative increases in weight and height in urban children were observed. The growth of head circumference from 2005 to 2015 underwent a visibly negative regional change.

Conclusion: The increased growth due to rapid social and economic development gradually disappeared, and genetic potential might have been seen in developed areas.

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 regional trends in children's physical growth [5, 7–9]. A report approximately 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 increases in weight were 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 regional 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]. Physical inactivity in daily life is increasingly prevalent [11]. 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 [12]. 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 [12]. A similar increasing trend was found in pre-school-aged children. In Harbin, one 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 [13].

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, 13]. 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 no report regarding regional trends in children's weight, height and head circumference in Nanjing, which is the provincial capital city of Jiang Su Province in East China. Therefore, we re-analysed the NSPGDC data to examine regional 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

All participates were a part of NSPGDC from Nanjing and healthy boys and girls under 7 years age old were included. The results for body weight and height measurements were obtained in 1995, 2005 and 2015. As previously reported[7, 14], 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).

The body weight, body length/height and head circumference (HC) were measured using standardized methods by two trained investigators. The details of measurements were reported in previous papers [15]. 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 was no more than 10%. The intraobserver and interobserver measurement errors were controlled within 50 g for weight or 0.5 cm for length.

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).

IBM SPSS version 22.0 was used to analyse the data. Mean and standard deviation of weight, length/height and HC among each subgroup was calculated and depicted. GraphPad Prism version 5.0 was used to draw figures.

Results

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

Figure 1 displays the regional trends in weight and length/height in boys and girls of urban and suburban Nanjing in 1995, 2005 and 2015. The values of weights and heights of boys aged 6 to 7 years or girls in all subgroups in 2015 was higher than those of their counterparts in 2005 and 1995. In addition, 6- to 7-year-old boys and girls in urban areas were taller and heavier than suburban children. 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 differences in physical growth between urban and suburban children is becoming increasingly smaller. The details of mean values for body weight and length/height in boys and girls are shown in supplementary Tables 1–4.

Table 1
The sample sizes of the surveys (2005 and 2015)

Age	2005				2015			
	urban		sub-urban		urban		sub-urban	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Birth	166	169	168	177	207	191	-	-
1m□	197	187	134	135	218	219	213	182
2m□	177	182	101	97	212	190	152	129
3m□	184	195	142	135	215	212	211	209
4m□	196	189	153	147	208	204	109	103
5m□	190	188	139	124	189	210	176	149
6m□	214	194	158	176	218	210	214	209
8m□	207	205	154	151	211	211	210	213
10m□	194	186	154	126	211	218	215	211
12m□	204	200	165	150	204	210	209	209
15m□	190	194	181	166	207	215	187	185
18m□	188	188	185	162	210	211	210	200
21m□	187	181	145	149	208	188	206	169
2.0y□	185	191	201	204	199	189	216	209
2.5y□	183	179	232	241	191	200	211	224
3.0y□	200	200	184	179	211	223	213	214
3.5y□	189	198	246	205	208	221	221	214
4.0y□	207	203	150	165	211	212	208	210
4.5y□	194	203	228	173	210	204	217	204
5.0y□	201	198	173	161	221	210	212	211
5.5y□	197	200	202	167	203	228	207	209
6.0□7y	206	236	243	245	213	203	215	210

As Figs. 2 and 3 illustrate, an increase in weight and length/height was observed during the two decades from 1995 to 2015, especially the first decade from 1995 to 2005. Figure 2A and 2B show that the

increases 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 increases in urban boys' indexes in some age groups before 2.5 years old were negative. In addition, the growth of urban boys' weight and length/height in the second decade was significantly smaller than that of the first decade. 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. 2C-D). Figure 3 shows the relative increases in weight and length/height among urban and suburban girls, and regional trends and urban and suburban differences were similar to those of the boys. It is worth noting that the relative increases in suburban girls' weight after 4 years old were obviously larger in the second decade.

Table 2
Information of some demographic, socioeconomic, and health funds in Nan Jing from 1995 to 2015

Characteristics	**1995**	**2005**	**2015**
Total population (million)	5.22	5.96	6.53
Birth rate (‰)	8.56	7.69	10.35
Natural increase rate (‰)	2.62	2.34	4.14
GDP (billion Yuan)	58.46	245.12	972.08
Proportion in three industrial sectors (%)			
Agriculture	7.6	3.3	2.4
Industry	52.1	49.8	40.3
Services	40.3	46.9	57.3
GDP per captia (Yuan)	10887	40887	118171
Consumption per captia (Yuan)	4524	9593	43926
Health funds (billion Yuan)	-	0.998	7.254
Proportion of health funds (%)	-	3.16	6.94

Figure 4 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. For weight, the urban-suburban difference in boys and girls increased with age in all 3-year time periods, especially from 1995 and 2005 (Fig. 4A-B). After 3 years old, boys and girls had difference values in 2005 that were still larger than those in 1995, and the girls' weight differences increased in 2005 more than those of the boys. However, in 2015, the difference between urban-suburban children sharply decreased, especially in girls. A negative difference in most age groups before 3 years old existed, indicating that the weight of suburban children was higher than that of urban children.

For length/height, the differences between urban-suburban children decreased across time, especially from 2005 to 2015 (Fig. 4C-D). Similarly, negative differences in both boys and girls before 3 years old were observed in most age groups, suggesting that the height of suburban children was taller than that of urban children before 3 years old. Notably, in 6- to 7-year-olds, the mean height difference was smaller at 0.3 cm for boys and 0.1 cm for girls in 2015, 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 head circumference in boys and girls in urban and suburban Nanjing in 1995, 2005 and 2015 are shown in Supplementary Tables 5 and 6. Figure 5 presents the regional changes in head circumference for urban and suburban children. As the growth curve for mean head circumference shows, head circumference generally increased during the period 1995–2005 but decreased during 2005–2015. The same situation was observed in both boys and girls of urban and suburban areas. For example, the mean head circumferences of urban boys aged 2.5 to 3 years were 49.0 cm, 49.5 cm and 49.1 cm, respectively, in 1995, 2005 and 2015. The head circumferences were 48.1 cm, 48.6 cm and 48.2 cm for urban girls aged 2.5 to 3 years. Furthermore, we found that the increases in head circumference in different sex and area subgroups from 1995 to 2005 were almost positive in different age groups but visibly negative from 2005 to 2015.

Discussion

Our results demonstrated that there was positive regional 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 regional trend 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 increases in height and weight of urban children in the second decade were obviously lower than those in the first decade. Even in most 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 curve of mean height and weight of suburban children (0–7 years old) in 2015 was close to that of urban children. The urban–suburban difference in physical growth has been shrinking since 2015. The regional growth trend in children in our study was similar to others' reports [7, 15–17]. Zhang illustrated an increasing trend in weight and height that decelerated from 2005, especially in developed cities of China[7, 15]. These findings reflect again that rapid social and economic development has positive effects on children's physical growth, especially in economically undeveloped 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 obviously more than those of height in suburban boys and girls aged more than 3 years. 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 5.3–20.5% 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 a sharp deceleration in the trend of increased weight in the second decade, especially in urban girls, and even negative changes in weight in many age groups of urban children was observed. We thought these findings might be associated with patients 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 regional 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 [18]. 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 [19]. Therefore, this growth standard was thought to be an ideal target growth model. Compared with the WHO 2006 growth standards for 0–24 months, we observed that the weight and length values of urban and suburban children in 2005 and 2015 were both obviously more than that of children of the same age and same sex [20]. However, the weight and length of urban children (0–2 years old) in most 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 could reduce the risk of infant overweight or obesity. This effect might be shown in the research conducted in Shanghai, one 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 [21].

Conclusion

In conclusion, our results demonstrated that there was positive regional growth in height, weight and head circumference in children in Nanjing during the two decades from 1995 to 2015. However, the trend for increasing height and weight in urban children in the second decade was obviously shrinking, especially in urban areas. Before 2.5 years old, negative changes in weight and height in urban children were observed. The growth in head circumference from 2005 to 2015 underwent a visibly negative regional change. These results suggested that the increasing growth from rapid social and economic development gradually disappeared, and the genetic potential might be seen developed areas.

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.

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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.

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Not applicable.

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Figures

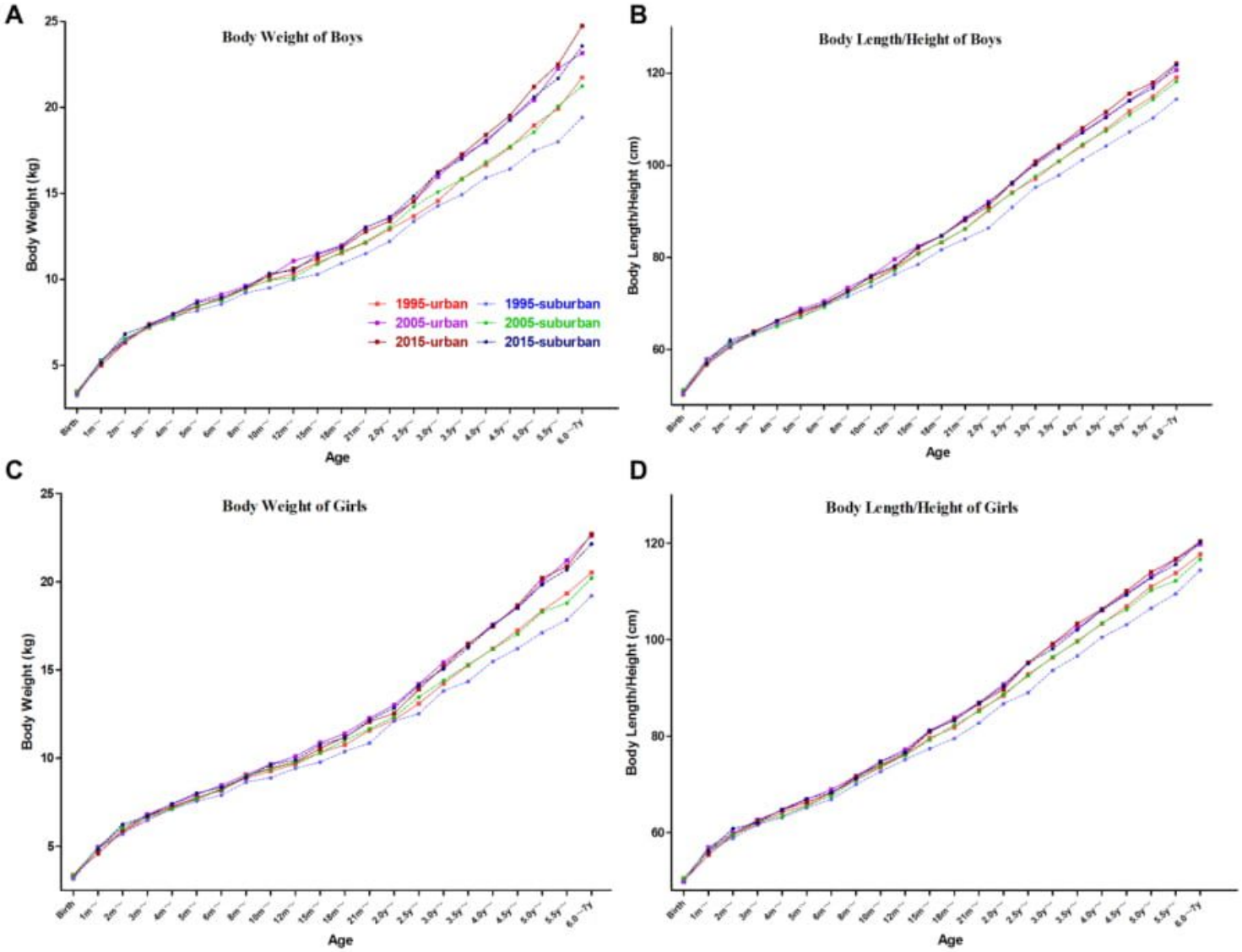

Figure 1

Regional trends in mean body weight and length/height in urban and suburban boys and girls from 1995 to 2015

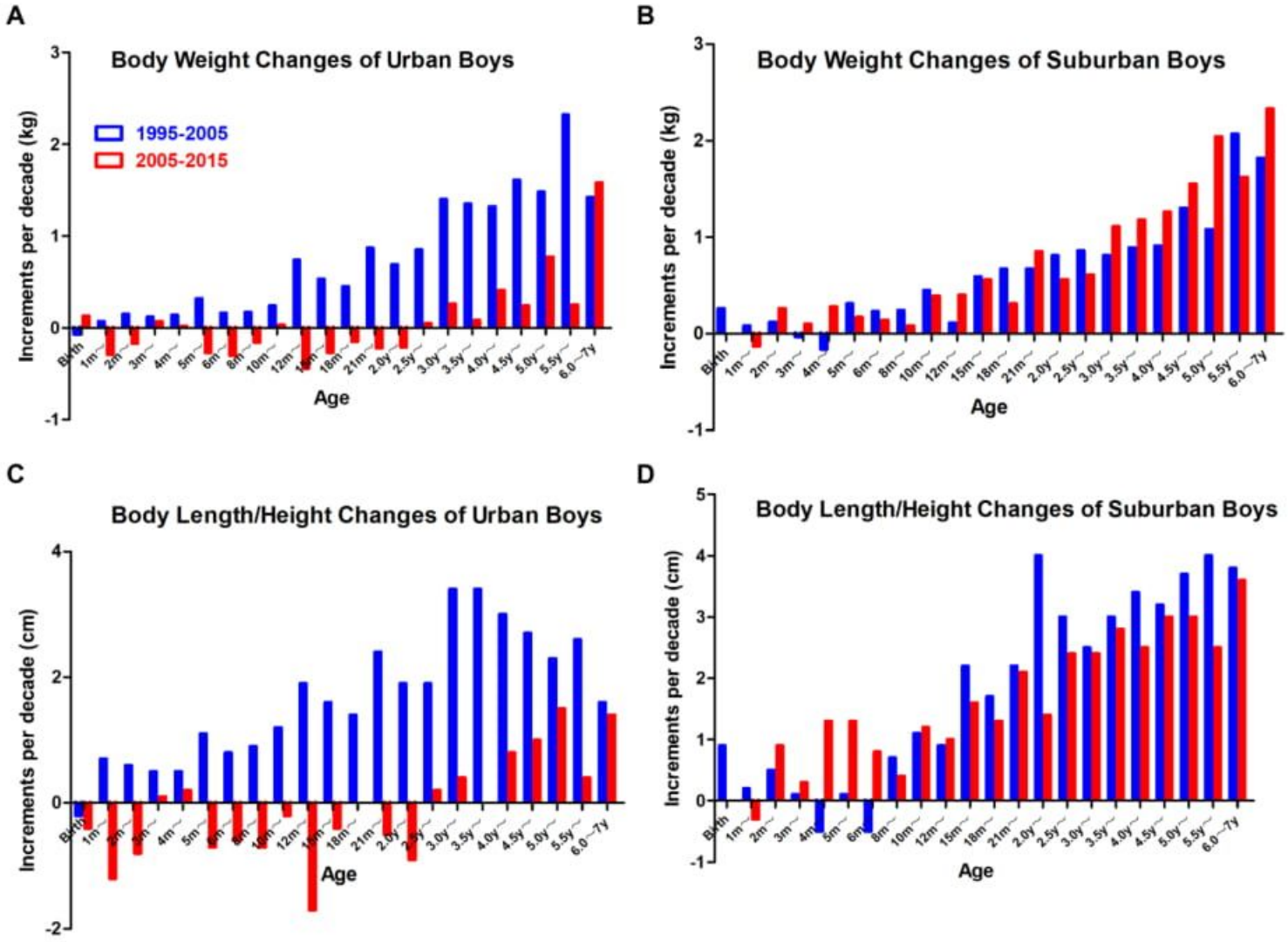

Figure 2

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

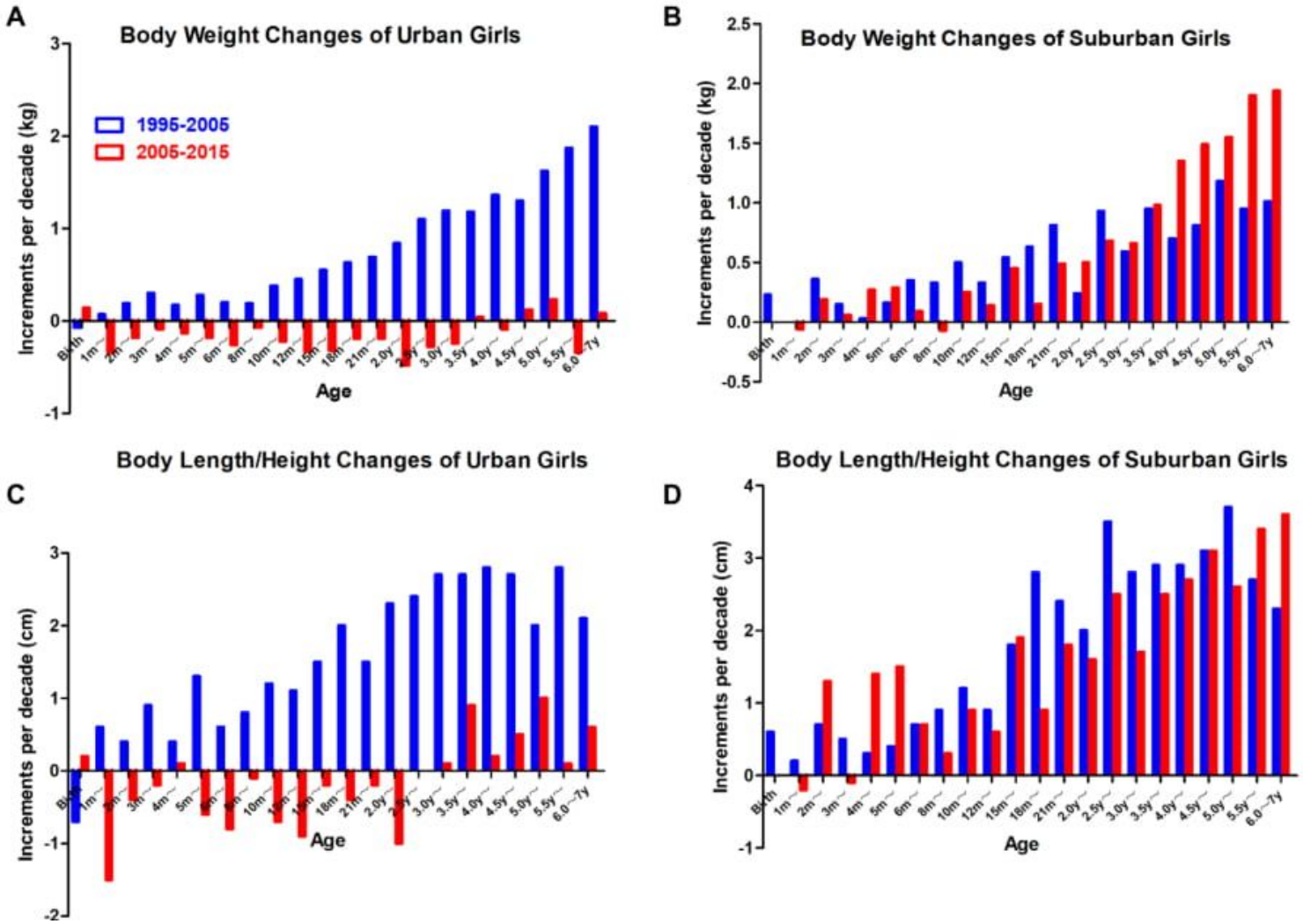

Figure 3

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

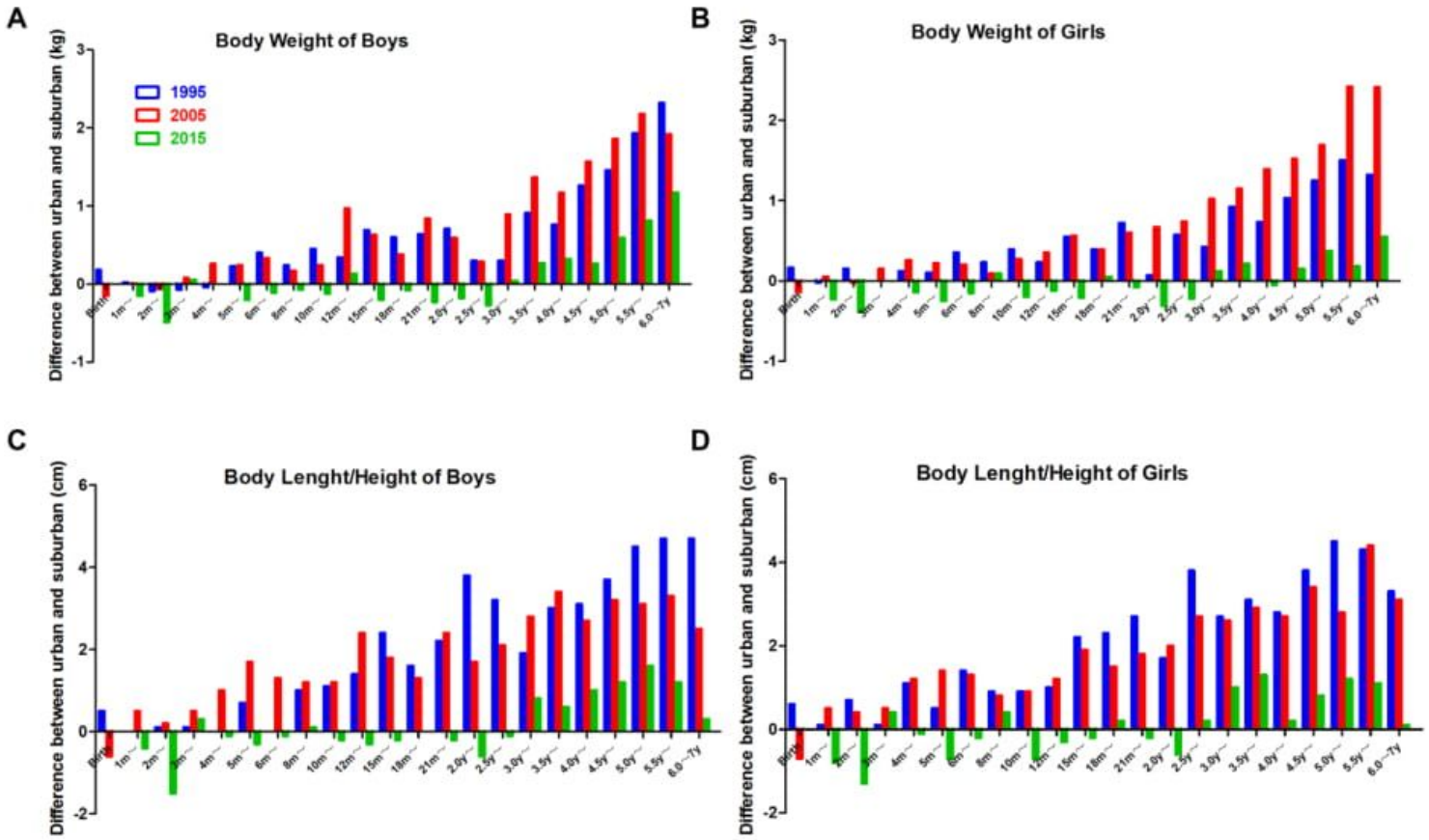

Figure 4

The urban-suburban difference in body weight and length/height of boys and girls in 1995, 2005 and 2015

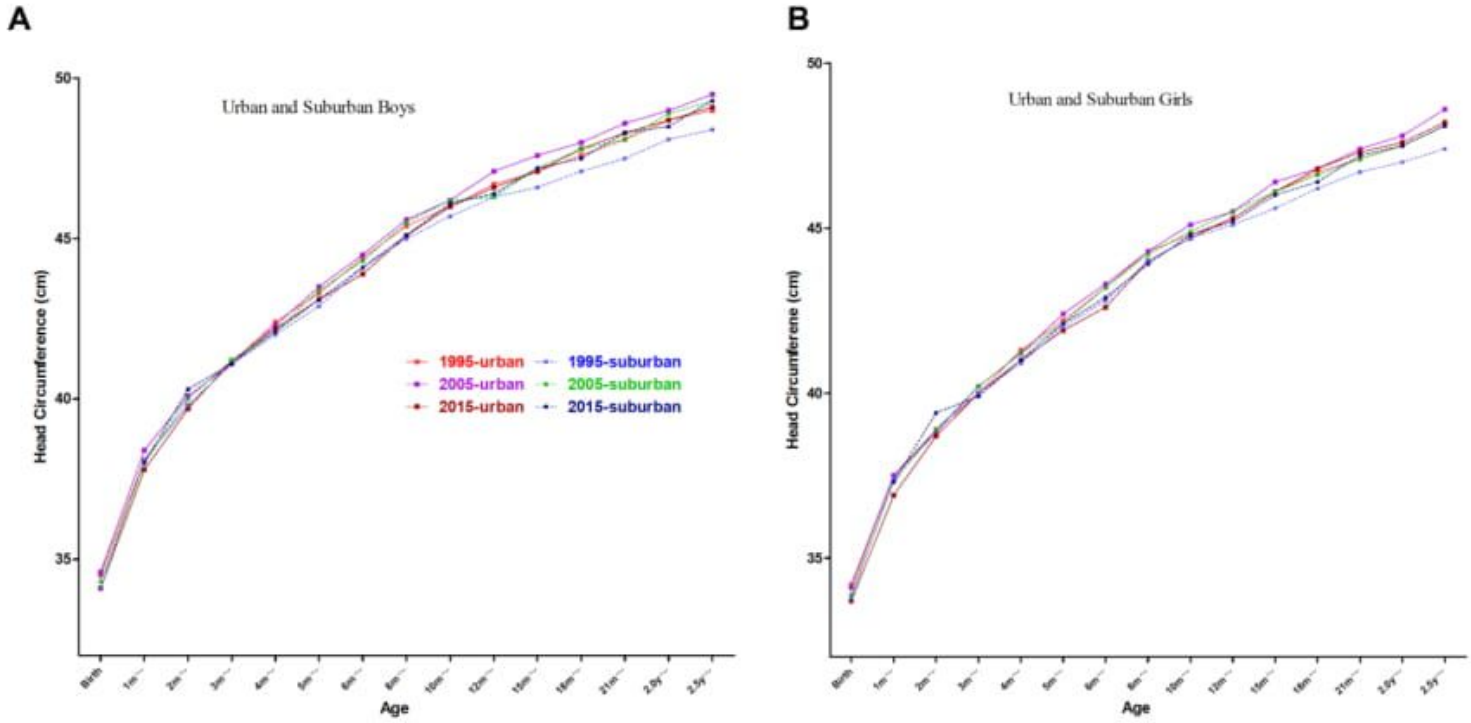

Figure 5

Regional trends in mean head circumference in urban and suburban boys and girls from 1995 to 2015

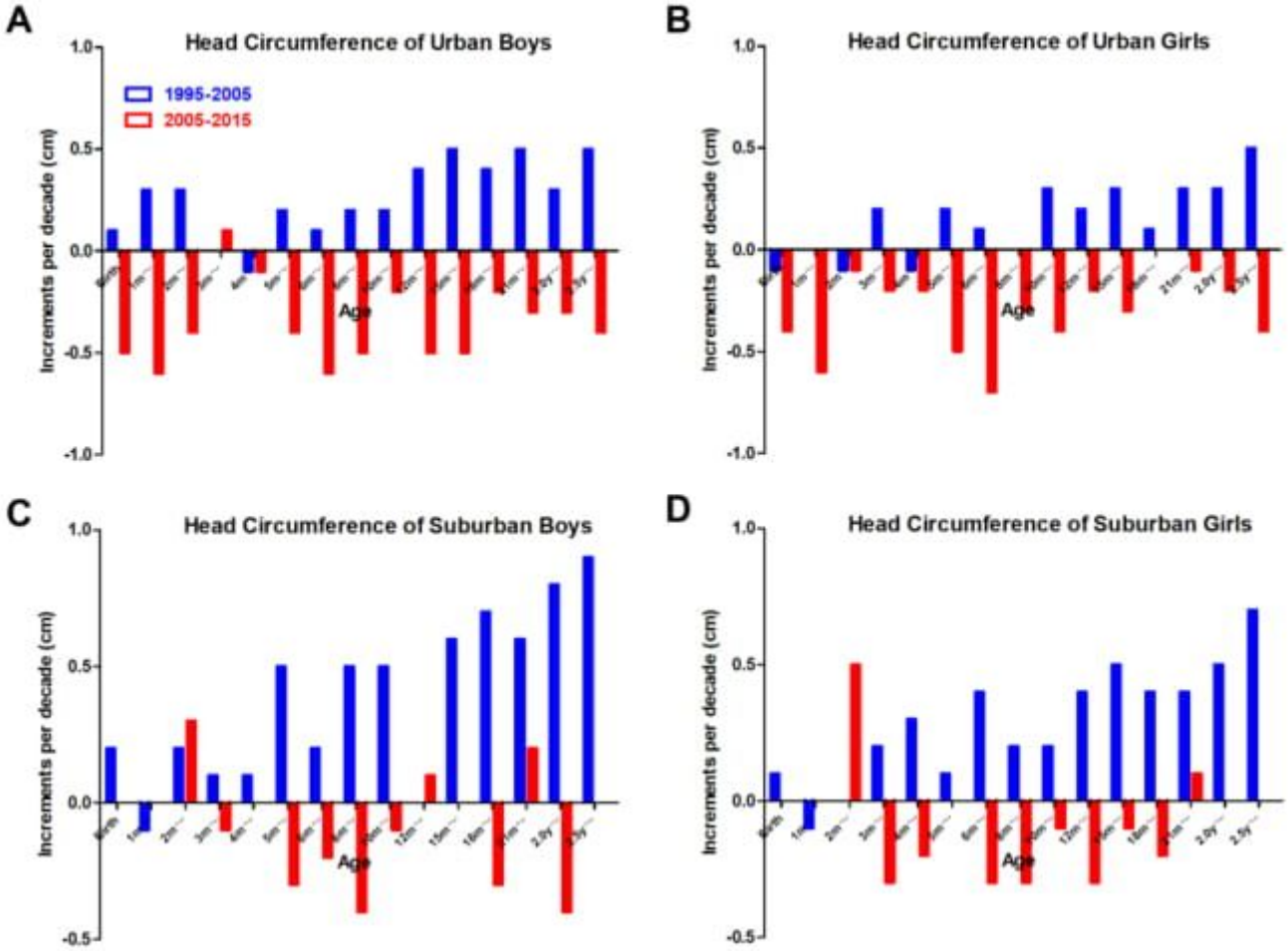

Figure 6

Increases per decade in head circumference for urban and suburban boys and girls in different stages (1995-2005 and 2005-2015)

Supplementary Files

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- Supplementarytables.xls