

# Anthropometric Changes in Children and Adolescents From 1965 to 2005 in Korea

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**KEY WORDS** anthropometric profiles; Korean children and adolescents; secular growth changes

**ABSTRACT** The aim of this study was to assess the secular growth changes in Korean children and adolescents during the last four decades. In 2005, 68,790 boys and 62,557 girls were recruited for this study across the nation in 2005. Anthropometric data (weight, height, etc.) were measured. We compared the results of previous nationwide growth studies with this study. The results of this survey indicate that the growth and developmental status of Korean children and adolescents has been

changed substantially compared with those in 1965, 1975, 1984, and 1997. The data presented in this study show a distinct secular increase in growth in body height and weight of Korean children and adolescents spanning this period. A nationwide survey every 5 years would be beneficial to establish a reference standard for the growth of children and adolescents according to the socioeconomic, environmental, and nutritional changes. *Am J Phys Anthropol* 136:230–236, 2008. ©2008 Wiley-Liss, Inc.

The term “secular trend” is used to describe a slow, continuous change in growth and development over successive generations in the same regions (Ulijaszek et al., 1998). Secular changes are best documented by body height and weight and weight-for-height (Hauspie et al., 1997). Height is the physical attribute that is currently being analyzed most frequently (Vignerová et al., 2006). Although the mechanisms underlying a secular trend in growth measures are not fully understood, previous studies suggest that environmental and nutritional improvements are important causes of the secular increase (Malina, 1979, 1990; Taranger, 1983; Susanne, 1985; Van Wieringen, 1986; Tanner, 1992). Genetic components also play a role in growth regulation, even though few studies have demonstrated that genetic factors have a major effect on the extent of growth. Secular changes in growth and maturation have been observed in many countries during the last two centuries (Van Wieringen, 1986; Eveleth and Tanner, 1990; Malina, 1990; Hauspie et al., 1996), and studies of many countries have revealed a gradual increase in the mean height of adults, as well as children and adolescents (Vignerová et al., 2006). During the course of the past two centuries in many industrialized countries, striking increases in the mean stature and an earlier sexual maturation, usually called positive secular growth change, have been observed (Hauspie et al., 1996). Nevertheless, recent studies show that secular trends in growth and maturation are more pronounced in less advantaged groups of a population, such as those living in rural areas or from lower socioeconomic backgrounds, compared with more advantaged groups (Hauspie et al., 1996, 1997). Studies carried out in developing countries, especially in the last two decades, reveal a sharp and significant secular trend in growth (Zellner et al., 2004). The results of two anthropometric studies undertaken in Turkey in 1993 and 2003 revealed that Turkish children

between the ages of 7 and 15 consistently demonstrated positive secular growth trends. In all the age groups, both Turkish boys and girls in a 2003 survey were taller and heavier than their peers from the 1993 survey (Simsek et al., 2005). Further, longitudinal studies are still needed to interpret the relationship between the socioeconomic status and anthropometric growth in developing countries. Unlike developing countries, the rate of secular growth change has gradually diminished in developed nations, including in Western European countries, Japan, and North America (Simsek et al., 2005), which means that societal improvements cannot fully explain secular trends in some populations in spite of continued improvements in quality of life and health (Ducros, 1980; Henneberg and van den Berg, 1990; Hauspie et al., 1997; Henneberg, 1997; Pretty et al., 1998; Tracer et al., 1998). According to Zellner and Jaeger in a study published in 2004, a leveling off in the height trends of German school children is consistent with a wide range of studies from other European countries, which also indicate a slowing down or recent halt of the secular changes in the height of schoolchildren at

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the end of the 20th century (Zellner et al., 2004). Diminishing secular increases in developed countries may indicate that the adult stature has almost reached a plateau (Hauspie et al., 1997).

The southern part of the Korean peninsula has experienced one of the most rapid economic growth developments since the Korean War in the 1950s. It has been suggested that Korean children and adolescents have showed positive secular changes in anthropometric profiles that are associated with significant improvements in the standards of health care, hygiene, nutrition, socioeconomic status, social welfare, and education during the last four decades. However, few studies are available to support this suggestion. In 1965, 1975, 1984, and 1997, nationwide cross-sectional growth studies were performed, showing that Korean children and adolescents had become taller and heavier than children in previous generations. In this research, we expected to observe distinct positive secular changes in anthropometric profiles of Korean children and adolescents resulted from the rapid socioeconomic development.

In this study, we present growth data for height and weight from the fifth nationwide growth study in 2005 and compare the results of all five nationwide growth studies to assess secular growth changes in Korean children and adolescents during the last four decades. We also compare the results from Korean surveys with Japanese data to analyze the different growth patterns of children in developing and developed countries.

## METHODS

The first nationwide cross-sectional anthropometric survey in Korea was carried out during the summer months of 1965 and included 16,213 boys and 16,612 girls (Moon and Yun, 1978). The second nationwide study was conducted in June of 1975 and consisted of 40,149 boys and 37,865 girls (Moon and Yun, 1978). The third study, conducted from April to October of 1984, included 61,780 boys and 59,393 girls (Shim and Ko, 1986). There have been limitations in analyzing and interpreting the historical data, because the studies that were conducted in 1965, 1975, and 1984 recorded only the means and sample sizes. We gathered these data from previous publications. The fourth survey was conducted from January 1997 to August 1998 and included 57,449 boys and 51,965 girls. In the fifth study, 68,790 boys and 62,557 girls aged between 0 and 20 years were recruited across the nation. Data collection for the fifth survey took place from April 2005 to March 2006. Quality control of the data from the fourth and fifth surveys was done with the cooperation of all the organizations involved in these studies, such as the Korea Center for Disease Control and Prevention, the Korean Society of Pediatrics, and the Medical School of Kyunghee University. Staffs from the Korea Center for Disease Control and Prevention were sent to the schools where surveys were conducted to check whether trained researchers were measuring the children in an appropriate way. The Korean Society of Pediatrics supervised the part of the surveys that was conducted at the hospitals for infants. Academic personnel, including medical professors, junior doctors in the residency of preventive medicine, and other researchers such as statisticians at the Medical School of Kyunghee University, performed quality control for the data. They received all the data from hospi-

tals and schools, eliminated outliers from the dataset, and analyzed the data statistically.

Exclusion criteria were provided for each study. Details about the exclusion criteria applied to the first three studies have been published previously (Moon and Yun, 1978; Shim and Ko, 1986). Infants with a birth weight <2,500 g were excluded from the fourth and fifth studies. Children whose disorders were diagnosed as a growth hormone deficiency, growth related disorder, or other chronic debilitating conditions were also excluded from the sample of the last two surveys. Children who were twins or had non-Korean parents were not included in these surveys.

The sample was stratified according to age, sex, and province. Infants aged from 0 to 2 were measured at well-baby clinics in 26 university hospitals. From the age of 2 to 20, subjects were measured at daycare centers, kindergartens, elementary schools, middle schools, high schools, and universities.

The ages of all the children were assessed from the hospital and school registers based on birth certificates. In the first year of life, babies were divided by 1-month intervals. From the age of 1 to 2, infants were categorized at intervals of 3 months. Preschool children aged 2–7 were divided by 6-month intervals. For the ages of 7–20, the intervals were 1 year.

The trained researchers measured the stature and weight of the subjects while they were in light clothing and no shoes. The height of infants up to 2 years of age was measured to 0.1-cm sensitivity in the supine position. The international standard measuring instrument SECA 210 (Germany) was used. From the age of 2, standing height was measured to the nearest 0.1 cm using the standard measuring instrument (SECA 225, Germany). Infants aged 0–2 were weighed on calibrated baby scales. The weights of older children and adolescents were measured using calibrated mechanical step-scales. Weight was recorded to the nearest 0.1-kg.

Descriptive statistics were utilized to interpret the age and gender-specific means of the height and weight. SAS (Statistical Analysis System, SAS) version 9.1 was used to perform statistical analysis. Curves were created using Microsoft Office Excel 2003.

## RESULTS

The mean heights of boys and girls revealed by surveys performed in 1965, 1975, 1984, 1997, and 2005 are represented in Tables 1 and 2. These tables also include a summary of the differences between the mean heights of the 1965 survey and the remaining surveys. A comparison among these five national surveys shows a positive secular trend in the mean heights for Korean boys (Table 1) and girls (Table 2) aged 0–20 years. The most remarkable changes are apparent during the growth spurt period of puberty. As for boys, the greatest difference in mean height was evident at the age of 13 (143.4 cm, 1965; 162.0 cm, 2005). Thirteen-year-old boys have grown an average of 18.6 cm taller during the last four decades. The most significant height change in boys from 1965 to 1984 happened at the age of 14 (143.4 cm, 1965; 159.2 cm, 1984). Between 1965 and 1975, the greatest height change in boys was only 5.2 cm, which was found at the age of 7 (Table 1). Between 1965 and 2005, the mean height of 12-year-old girls increased by 15.5 cm, which is the most remarkable difference in mean height in girls (138.7 cm, 1965; 154.2 cm, 2005).

TABLE 1. Mean height of boys (cm) and changes relative to 1965

Age (year)	Year of the survey										
	1965 <sup>a</sup>			1975 <sup>a</sup>		1984 <sup>a</sup>		1997		2005	
	Mean	Mean	Difference	Mean	Difference	Mean $\pm$ SD <sup>b</sup>	Difference	Mean $\pm$ SD <sup>b</sup>	Difference		
0	50.4	51.1	0.7	51.4	1.0	50.8 $\pm$ 2.6	0.4	51.5 $\pm$ 3.0	1.1		
1	74.8	75.8	1.0	77.8	3.0	77.8 $\pm$ 3.1	3.0	78.9 $\pm$ 3.5	4.1		
2	82.7	85.5	2.8	87.9	5.2	87.7 $\pm$ 4.3	5.0	90.4 $\pm$ 4.2	7.7		
3	89.0	91.9	2.9	94.6	5.6	95.7 $\pm$ 4.4	6.7	98.2 $\pm$ 4.3	9.2		
4	95.5	97.9	2.4	101.8	6.3	103.5 $\pm$ 4.6	8.0	104.7 $\pm$ 4.4	9.2		
5	100.6	105.0	4.4	108.4	7.8	109.6 $\pm$ 4.7	9.0	111.0 $\pm$ 4.7	10.4		
6	106.7	110.6	3.9	113.9	7.2	115.8 $\pm$ 4.8	9.1	117.0 $\pm$ 4.7	10.3		
7	112.5	117.7	5.2	120.4	7.9	122.4 $\pm$ 5.7	9.9	124.9 $\pm$ 5.4	12.4		
8	118.1	122.6	4.5	125.6	7.5	127.5 $\pm$ 6.1	9.4	130.6 $\pm$ 5.4	12.5		
9	123.7	127.3	3.6	130.5	6.8	132.9 $\pm$ 6.0	9.2	136.1 $\pm$ 5.8	12.4		
10	128.3	131.9	3.6	135.2	6.9	137.8 $\pm$ 6.4	9.5	141.3 $\pm$ 6.2	13.0		
11	132.6	136.0	3.4	140.3	7.7	143.5 $\pm$ 7.1	10.9	147.5 $\pm$ 6.9	14.9		
12	136.7	140.0	3.3	144.9	8.2	149.3 $\pm$ 7.8	12.6	154.3 $\pm$ 7.9	17.6		
13	143.4	147.5	4.1	152.6	9.2	155.3 $\pm$ 8.4	11.9	162.0 $\pm$ 7.7	18.6		
14	149.4	153.6	4.2	159.2	9.8	162.7 $\pm$ 7.1	13.3	167.2 $\pm$ 6.8	17.8		
15	156.2	158.2	2.0	164.0	7.8	167.8 $\pm$ 6.5	11.6	170.6 $\pm$ 6.1	14.4		
16	162.5	164.1	1.6	167.2	4.7	171.1 $\pm$ 5.8	8.6	172.2 $\pm$ 5.6	9.7		
17	165.9	166.4	0.5	168.3	2.4	172.2 $\pm$ 5.9	6.3	173.1 $\pm$ 5.7	7.2		
18	167.8	167.3	-0.5	168.9	1.1	172.5 $\pm$ 6.0	4.7	174.2 $\pm$ 5.6	6.4		
19	168.7	168.1	-0.6	169.9	1.2	173.2 $\pm$ 5.7	4.5	174.5 $\pm$ 5.7	5.8		
20	168.9	168.7	-0.2	170.2	1.3	173.4 $\pm$ 5.7	4.5	174.2 $\pm$ 5.6	5.3		

<sup>a</sup> Standard deviations for the first three studies are not available.

<sup>b</sup> SD, standard deviation.

TABLE 2. Mean height of girls (cm) and changes relative to 1965

Age (year)	Year of the survey										
	1965 <sup>a</sup>			1975 <sup>a</sup>		1984 <sup>a</sup>		1997		2005	
	Mean	Mean	Difference	Mean	Difference	Mean $\pm$ SD <sup>b</sup>	Difference	Mean $\pm$ SD <sup>b</sup>	Difference		
0	50.0	50.8	0.8	50.5	0.5	50.1 $\pm$ 2.5	0.1	50.9 $\pm$ 2.8	0.9		
1	72.8	74.8	2.0	76.2	3.4	76.9 $\pm$ 3.5	4.1	77.6 $\pm$ 3.7	4.8		
2	81.5	84.6	3.1	86.9	5.4	87.0 $\pm$ 4.1	5.5	89.0 $\pm$ 4.2	7.5		
3	87.7	90.2	2.5	92.9	5.2	94.2 $\pm$ 4.4	6.5	97.0 $\pm$ 4.3	9.3		
4	94.0	97.1	3.1	100.9	6.9	102.1 $\pm$ 4.5	8.1	103.4 $\pm$ 4.3	9.4		
5	100.2	103.7	3.5	108.1	7.9	108.6 $\pm$ 4.7	8.4	109.9 $\pm$ 4.5	9.7		
6	106.5	109.2	2.7	113.4	6.9	114.7 $\pm$ 4.7	8.2	116.0 $\pm$ 4.9	9.5		
7	112.0	116.9	4.9	119.4	7.4	121.1 $\pm$ 6.1	9.1	123.7 $\pm$ 5.4	11.7		
8	117.3	121.6	4.3	124.9	7.6	126.0 $\pm$ 6.1	8.7	129.6 $\pm$ 5.7	12.3		
9	122.0	126.5	4.5	130.1	8.1	132.2 $\pm$ 6.4	10.2	135.5 $\pm$ 6.1	13.5		
10	128.6	131.8	3.2	135.5	6.9	137.7 $\pm$ 7.0	9.1	142.3 $\pm$ 6.7	13.7		
11	133.5	137.5	4.0	141.8	8.3	144.2 $\pm$ 7.6	10.7	148.6 $\pm$ 6.7	15.1		
12	138.7	142.0	3.3	147.8	9.1	150.9 $\pm$ 7.2	12.2	154.2 $\pm$ 6.1	15.5		
13	144.8	148.1	3.3	152.1	7.3	155.0 $\pm$ 6.1	10.2	157.5 $\pm$ 5.4	12.7		
14	149.0	152.0	3.0	154.9	5.9	157.8 $\pm$ 5.5	8.8	159.0 $\pm$ 5.3	10.0		
15	152.9	154.0	1.1	155.8	2.9	159.0 $\pm$ 5.2	6.1	159.7 $\pm$ 5.4	6.8		
16	154.7	155.6	0.9	156.7	2.0	160.0 $\pm$ 5.2	5.3	160.4 $\pm$ 5.2	5.7		
17	155.5	156.3	0.8	156.6	1.1	160.4 $\pm$ 5.2	4.9	160.2 $\pm$ 5.0	4.7		
18	155.7	156.6	0.9	157.3	1.6	160.5 $\pm$ 5.2	4.8	161.3 $\pm$ 5.1	5.6		
19	155.7	157.0	1.3	157.2	1.5	160.1 $\pm$ 5.0	4.4	161.6 $\pm$ 5.3	5.9		
20	155.9	157.1	1.2	157.6	1.7	160.4 $\pm$ 5.0	4.5	161.3 $\pm$ 5.1	5.4		

<sup>a</sup> Standard deviations for the first three studies are not available.

<sup>b</sup> SD, standard deviation.

Girls aged 12 years old had grown taller by 12.2 cm between 1965 and 1997 (138.7 cm, 1965; 150.9 cm, 1997). Between 1965 and 1975, the greatest height change in girls was 4.9 cm, which was found at the age of 7 (Table 2). The mean heights of boys and girls have also changed at the age of 17 (boys, 165.9 cm in 1965 and 173.1 cm in 2005; girls, 155.5 cm and 160.2 cm, respectively). An increase in the mean height is found in other age groups too.

Tables 3 and 4 describe the positive secular trend in the mean weights for Korean boys (Table 3) and girls (Table 4) aged 0–20 years old. Between 1965 and 2005, for boys, we found that the greatest relative increase in weight occurred at 14 years of age (39.7 kg, 1965; 60.9 kg, 2005). Boys at any age group did not gain more than 3 kg between 1965 and 1975. The most remarkable increase in weight for boys was 7.7 kg at the age of 14 from 1965 to 1984 (39.7 kg, 1965; 47.4 kg, 1984)

TABLE 3. Mean weight of boys (kg) and changes relative to 1965

Age (year)	Year of the survey										
	1965 <sup>a</sup>			1975 <sup>a</sup>		1984 <sup>a</sup>		1997		2005	
	Mean	Mean	Difference	Mean	Difference	Mean ± SD <sup>b</sup>	Difference	Mean ± SD <sup>b</sup>	Difference		
0	3.2	3.3	0.1	3.4	0.2	3.4 ± 0.5	0.2	3.5 ± 0.6	0.3		
1	8.9	9.6	0.7	10.3	1.4	10.4 ± 1.2	1.5	10.7 ± 1.3	1.8		
2	10.8	11.8	1.0	12.6	1.8	12.9 ± 1.8	2.1	13.5 ± 1.7	2.7		
3	12.7	13.3	0.6	14.4	1.7	15.1 ± 1.9	2.4	15.6 ± 1.9	2.9		
4	14.6	14.9	0.3	16.0	1.4	17.0 ± 2.1	2.4	17.5 ± 2.2	2.9		
5	16.0	16.7	0.7	18.0	2.0	19.0 ± 2.4	3.0	19.9 ± 3.1	3.9		
6	16.7	18.5	1.8	19.7	3.0	21.4 ± 3.1	4.7	22.4 ± 3.7	5.7		
7	19.1	20.6	1.5	22.3	3.2	24.7 ± 4.3	5.6	26.8 ± 5.4	7.7		
8	20.4	22.7	2.3	24.2	3.8	27.6 ± 5.4	7.2	30.4 ± 6.2	10.0		
9	23.0	24.9	1.9	26.7	3.7	31.0 ± 6.4	8.0	34.5 ± 7.5	11.5		
10	25.4	27.4	2.0	29.5	4.1	34.5 ± 7.5	9.1	38.8 ± 8.8	13.4		
11	28.8	29.7	0.9	32.4	3.6	38.6 ± 8.6	9.8	43.9 ± 10.2	15.1		
12	31.7	32.2	0.5	35.5	3.8	42.8 ± 9.4	11.1	49.5 ± 11.3	17.8		
13	34.7	37.4	2.7	41.5	6.8	47.2 ± 9.9	12.5	55.8 ± 12.3	21.1		
14	39.7	42.1	2.4	47.4	7.7	53.9 ± 10.3	14.2	60.9 ± 12.8	21.2		
15	44.9	46.1	1.2	52.2	7.3	58.5 ± 10.4	13.6	64.9 ± 12.7	20.0		
16	50.7	52.5	1.8	56.2	5.5	61.2 ± 9.5	10.5	66.9 ± 11.8	16.2		
17	54.5	55.8	1.3	58.2	3.7	63.2 ± 9.8	8.7	68.7 ± 12.2	14.2		
18	57.0	57.1	0.1	59.8	2.8	63.8 ± 9.1	6.8	69.6 ± 10.9	12.6		
19	58.1	58.0	-0.1	60.2	2.1	66.0 ± 8.8	7.9	70.6 ± 10.9	12.5		
20	58.2	59.3	1.1	61.9	3.7	66.6 ± 8.5	8.4	71.0 ± 10.5	12.8		

<sup>a</sup> Standard deviations for the first three studies are not available.

<sup>b</sup> SD, Standard deviation.

TABLE 4. Mean weight of girls (kg) and changes relative to 1965

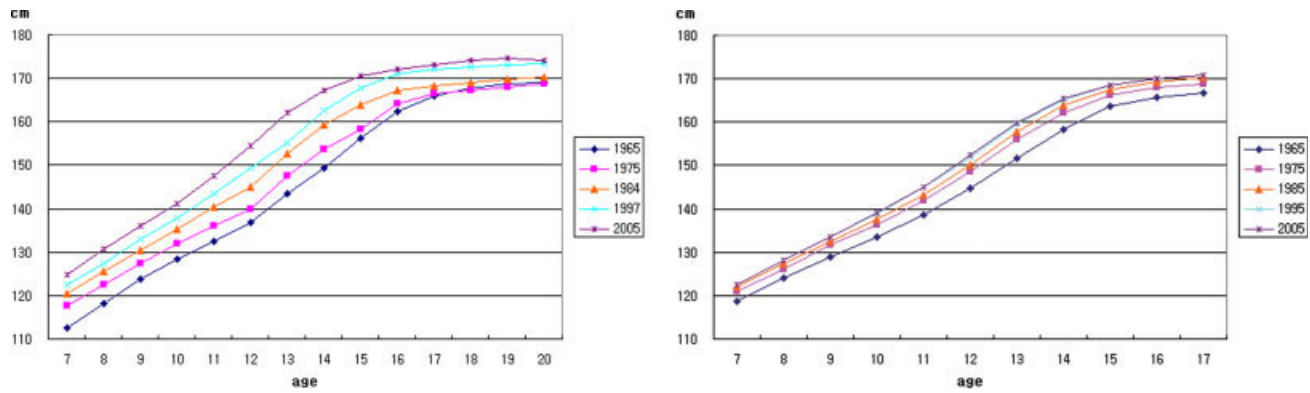
Age (year)	Year of the survey										
	1965 <sup>a</sup>			1975 <sup>a</sup>		1984 <sup>a</sup>		1997		2005	
	Mean	Mean	Difference	Mean	Difference	Mean ± SD <sup>b</sup>	Difference	Mean ± SD <sup>b</sup>	Difference		
0	3.2	3.3	0.1	3.2	0.0	3.3 ± 0.5	0.1	3.4 ± 0.5	0.2		
1	8.3	9.1	0.8	9.5	1.2	10.0 ± 1.2	1.7	10.1 ± 1.4	1.8		
2	10.3	11.5	1.2	12.0	1.7	12.5 ± 1.5	2.2	12.8 ± 1.6	2.5		
3	12.3	12.8	0.5	13.6	1.3	14.2 ± 1.8	1.9	15.1 ± 1.9	2.8		
4	13.9	14.3	0.4	15.7	1.8	16.4 ± 2.1	2.5	16.9 ± 2.2	3.0		
5	15.5	16.1	0.6	17.3	1.8	18.4 ± 2.2	2.9	19.2 ± 2.8	3.7		
6	17.5	17.9	0.4	19.1	1.6	20.7 ± 2.8	3.2	21.5 ± 3.4	4.0		
7	19.1	20.0	0.9	21.2	2.1	23.6 ± 3.8	4.5	25.4 ± 4.8	6.3		
8	20.9	22.0	1.1	23.5	2.6	26.2 ± 4.9	5.3	29.0 ± 5.9	8.1		
9	23.4	24.2	0.8	26.1	2.7	30.0 ± 6.1	6.6	32.7 ± 6.5	9.3		
10	25.2	27.0	1.8	29.2	4.0	33.6 ± 7.0	8.4	37.5 ± 7.7	12.3		
11	29.1	30.5	1.4	33.6	4.5	37.8 ± 8.3	8.7	42.5 ± 9.1	13.4		
12	32.9	33.6	0.7	38.2	5.3	43.1 ± 8.6	10.2	47.3 ± 9.3	14.4		
13	36.2	38.7	2.5	43.1	6.9	47.0 ± 8.3	10.8	50.9 ± 8.9	14.7		
14	39.8	43.5	3.7	46.8	7.0	50.7 ± 8.0	10.9	53.2 ± 8.8	13.4		
15	44.5	46.7	2.2	49.6	5.1	52.5 ± 7.8	8.0	55.2 ± 9.3	10.7		
16	47.6	49.1	1.5	51.2	3.6	54.4 ± 7.7	6.8	55.7 ± 8.7	8.1		
17	49.6	50.6	1.0	51.8	2.2	54.6 ± 7.2	5.0	56.0 ± 9.0	6.4		
18	50.3	50.8	0.5	51.9	1.6	54.7 ± 6.7	4.4	55.4 ± 7.9	5.1		
19	51.1	51.2	0.1	51.5	0.4	54.9 ± 6.2	3.8	55.7 ± 7.8	4.6		
20	51.5	52.0	0.5	51.8	0.3	55.7 ± 5.4	4.2	55.6 ± 8.7	4.1		

<sup>a</sup> Standard deviations for the first three studies are not available.

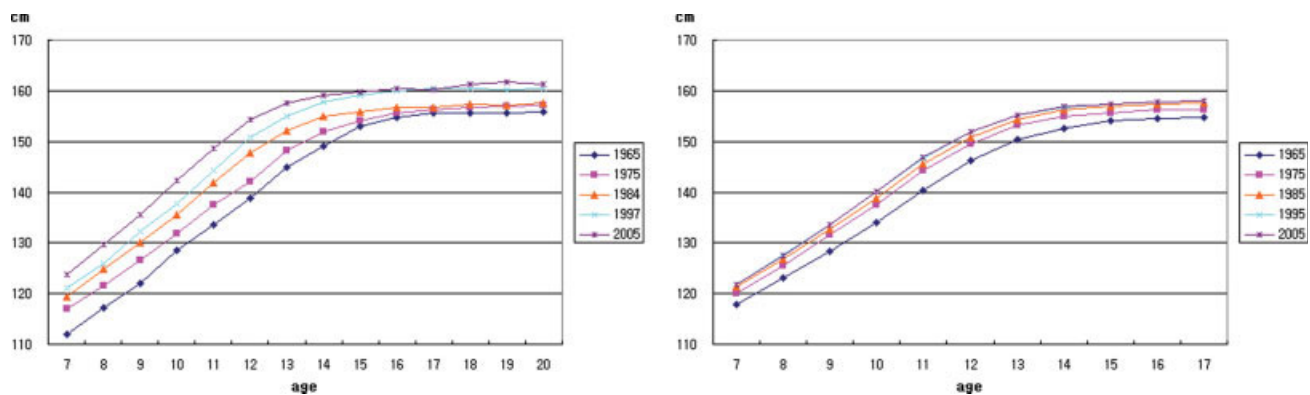
<sup>b</sup> SD, Standard deviation.

(Table 3). The most significant change in mean weight in girls (an increase of 14.7 kg) occurred at the age of 13 during the last 40 years (36.2 kg, 1965; 50.9 kg, 2005). The greatest weight change in girls from 1965 to 1984 happened at the age of 14 (39.8 kg, 1965; 46.8 kg, 1985) (Table 4). During the last four decades, the mean weight of 20-year-old boys increased by 12.8 kg, whereas that of girls increased by 4.1 kg. During the last 40 years, the weight of girls has changed less than that of boys.

During the past 40 years, the mean height of the Korean population shows more variation than that of the Japanese population (Figs. 1 and 2) (Japanese Ministry of Education, Culture, Sports, Science and Technology, 2007). Japanese children have undergone more stable and slower secular changes in growth development than Korean children have during the last 40 years. A comparison of the heights of Korean children younger than 13 years old in 2005 with those of children in 1965 shows that present-day Korean children reach similar



**Fig. 1.** The comparison of mean height between Korean and Japanese boys during the last four decades. (A) Korean boys and (B) Japanese boys. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com).]



**Fig. 2.** The comparison of mean height between Korean and Japanese girls during the last four decades. (A) Korean girls and (B) Japanese girls. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com).]

heights 3 years earlier. However, current Japanese children attain similar heights at only 1 year earlier compared with Japanese children in 1965 (Figs. 1 and 2).

## DISCUSSION

The data presented in this study show a distinct secular increase in body height and weight of Korean children and adolescents during the past four decades. The growth and developmental status of Korean children and adolescents have changed substantially compared with those in 1965, 1975, 1984, and 1997. This study provides valuable findings about secular trends in growth, because all the data analyzed in this research were from five nationwide cross-sectional anthropometric surveys involving subjects recruited across the whole nation.

Anthropometrical studies of conscripts and schoolboys show that an increase in the height of 17-year-old boys commenced in the 19th century (Lintsi and Kaarna, 2006). It has commonly been understood that secular changes in growth result from the combined effect of changes in overall body size at all ages and changes in the period of time needed for the completion of growth (Hauspie et al., 1997). Usually, a positive secular growth change is accompanied by an advance in sexual maturation (Fredriks et al., 2000). If the largest gain in height or weight over the period examined occurs around pubertal age, this reflects earlier puberty and thus a shortening of the growth period (Loesch et al., 2000). In this

study, there has been a trend toward increased height among Korean boys and girls aged 0–20 years old since the 1965 data were collected. Height is determined in part by genetics and in part by childhood living conditions, including nutrition, housing conditions, the occurrence of diseases, and strenuous work at young ages (Nyström-Peck and Lundberg, 1995). Persistent international differences in the mean height across birth cohorts demonstrate continuing differences in childhood living conditions between countries (Cavelaars et al., 2000; Komlos and Kriwy, 2002; Krawczynski et al., 2003; Gyenis and Joubert, 2004; Sander, 2004). In Korea, between 1965 and 2005 significant improvements were observed in the socioeconomic conditions and health of the population. Evaluation of socioeconomic and health indicators in the southern part of the Korean peninsula during last four decades is represented in Table 5 (Korea National Statistical Office Internet, 2007). The period between 1965 and 1984 is characterized by a positive trend in the difference of the mean height of Korean children and adolescents of all ages, more significantly for boys aged 0–11 years and girls aged 0–14 years. After 1984, the increase in mean height of boys older than 11 years old and girls older than 14 years old exceeded the changes in height taking place between 1965 and 1984 (see Fig. 3). This change means that there has been an increase in the average height of the Korean population from one generation to another. This increase in the mean height in infants and younger children (0- to 11-year-old boys

TABLE 5. Selected indicators of socioeconomic status and health, South Korea—from Korea National Statistical Office

Indicator	1970	1975	1984	1997	2005
Life expectancy at birth (years)	61.9	63.8	67.8	74.3	78.6
Infant mortality rate per 1,000 live births	57.5	38.0	23.0 <sup>a</sup>	13.2 <sup>b</sup>	3.8
GNI per capita (US \$)	254	602	2,257	11,176	16,291

<sup>a</sup> Infant mortality rate for 1984 was not available. Instead, the number for 1985 was represented.  
<sup>b</sup> Infant mortality rate for 1997 was not available. Instead, the number for 1995 was represented.

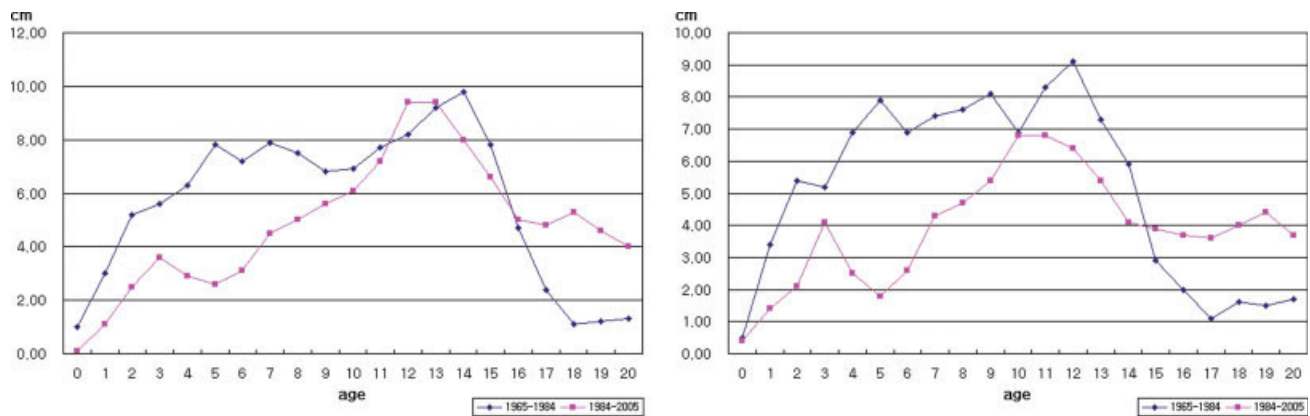


Fig. 3. Secular differences in mean height between the first two decades, the last two decades, and total 40 years. (A) Boys and (B) Girls. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com).]

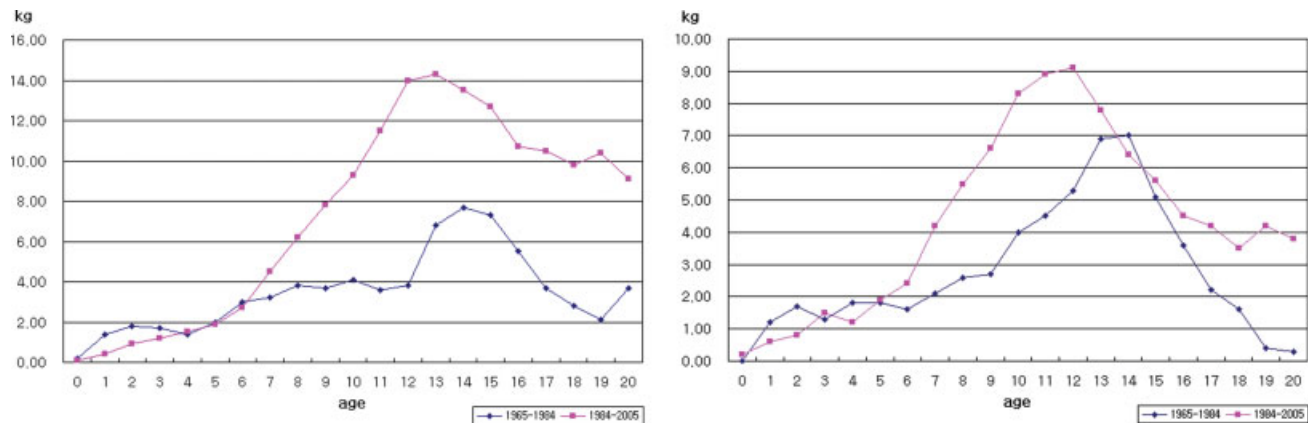


Fig. 4. Secular differences in mean weight between the first two decades, the last two decades, and total 40 years. (A) Boys and (B) Girls. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com).]

and 0- to 14-year-old-girls) occurred more drastically during the period between 1965 and 1984, which experienced a very rapid development in the Korean economy and living conditions after the Korean War. It is generally assumed that an improvement in the quantity and quality of food is the most important cause of secular growth change (Fredriks et al., 2000). After 1984, in Korea, the general wealth of the population has increased considerably, and significantly more children had easy access to food. Easier access to infant health care and the institution of a vaccination program also affected secular growth change in a positive way during this period. In many studies, the differences in somatic development between children from various social backgrounds were evaluated (Drachler et al., 2002; Langn ase et al., 2002; Armstrong et al., 2003). Socioeconomic sta-

tus and the quality of health care and nutrition are regarded as factors, which, in combination with genotype, have the strongest impact on the growth and development of an individual (Vigneroova et al., 2006). Such improvements in the socioeconomic and sociohygienic conditions and the public health status of the Korean population occurred more remarkably between 1965 and 1984 than the period between 1984 and 2005. This may explain why the positive secular trend in height has diminished in Korean infants and younger children after 1984. A secular trend in the mean weight of Korean children and adolescents during the past four decades is different from that of the height in pattern. The increase during the last two decades (1984–2005) in the mean weight of boys older than 7 years and girls older than 5 years exceeded the changes in weight that occurred

between 1965 and 1984 (see Fig. 4). A pattern of secular trend in the Korean children's weight shows a sharp increase between 1984 and 2005. Unlike the pattern for stature, the secular trend of increased weight occurred mostly during the last two decades (Figs. 3 and 4).

### CONCLUSIONS

In conclusion, a significant secular increase in height and weight measurements were found in Korean infants, children, and adolescents aged 0–20 years during the last four decades. In all the age groups, both boys and girls in the 2005 survey were taller and heavier than their peers from the 1965 study. This secular trend may have important implications for other developing countries with many changes in socioeconomic conditions. The comparison between Korean and Japanese data in this research also supports the effect of rapid socioeconomic changes in less developed nations on the secular growth trend of children. The positive secular changes of children observed in developing countries (in this research, Korea) are more distinct than those in developed world (in this research, Japan), and this supports the necessity of regular nationwide growth survey for children, especially, in less developed areas. The positive secular change in both the height and weight of Korean children underscores the need for an update in growth standards. Regular research studies of anthropometrical characteristics are an essential and relatively inexpensive component of the follow-up analysis, allowing for the examination of the health of a population of children and adolescents (Vignerová et al., 2006). Thus a nationwide survey every 5 years would be beneficial to such analysis by establishing a reference standard for the growth of children and adolescents according to the socioeconomic, environmental, and nutritional changes.

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