Why Did Japanese Children Cease to Grow Taller in Height in the Midst of a Booming Economy in Contrast with South Korean Youth?

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Abstract

Over the past half century children's attained height in Japan and South Korea has increased dramatically. At age 17-18 years, Japanese boys were 3 cm taller than S. Korean boys in the 1960s and still slightly taller in the 1980s, but by the early 1990s their height had stabilized, whereas their S. Korean peers kept increasing in height, exceeding the Japanese by 3 cm in the mid-2000s. Economic growth was very rapid in both countries, but with S. Korea some two decades behind Japan due to the Korean War (1950-53). Per capita GDP in Japan was four times that in S. Korea in the mid-1980s and twice in the early 2000s. Over the same period food consumption increased appreciably in the two nations, with per capita net supply of animal products in Japan exceeding that in S. Korea nearly 30 % in the early-2000s.

On the other hand, per capita total caloric intake has been a few hundred calories/day greater in S. Korea than Japan since the mid-1970s. In particular, S. Koreans have consumed twice as many vegetables, excluding potatoes, as Japanese. Specifically, compared to older adults, Japanese children and young adults drastically reduced their consumption of fruit and vegetables, starting in the mid-1970s, whereas their S. Korean peers have maintained their consumption. These contrasts in food consumption patterns may have contributed to the differences in child height growth in the two countries.

Keywords:

Child height, food consumption, fruit and vegetables, Japan, South Korea

<It (stature) is a net measure that captures not only the supply of inputs to health but demands on those inputs (R. Steckel, 1995, p.1903).>

Introduction

Young people in Japan increased conspicuously in height in the last half of the twentieth century: men at age 19-21 years increased (in mean height) from 161 cm in 1949-51 to 171 cm in 1989-91 and women at age 17-19 years increased from 151 cm to 158 cm over the same period and both sexes ceased to grow any taller after the end of the 1980s.

Since 1950, Japan's economy kept growing very rapidly and steadily, despite the two worldwide oil-crises. Growth in child height, among both sexes, was very minimal (i.e., 1 cm or so) during the 1980s, when the economy enjoyed "bubble" which burst at the end of 1991. Per capita caloric supply from animal products (i.e., meats, eggs, milk, and fish) increased steadily from 377 kcal/day in the mid-1970s to 463 in the mid-1980s and eventually to 546 in the mid-1990s, while total caloric supply increased only modestly from 2,531, to 2,599, and then to 2,656 kcal/day, respectively over the same period (Japanese government, MAFF, *Food*

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Balance Sheets[*1]). A plausible explanation may be that Japanese children attained their genetic potentials in height in the early 1990s. In view of the statistical fact that children in South Korea, an ethnically similar country in North-East Asia[*2], were the same in height as their Japanese peers in the early 1990s but kept growing taller onward to overtake Japanese children, both sexes, by 3 cm in the mid-2000s, there could be other explanations (specifically in respect to differences in food consumption by growing children, in particular). S. Koreans have long consumed twice as many vegetables as Japanese on a national average and they consumed 20% more fruit than the latter in the mid-1990s. Children in Japan consumed as much vegetables and fruit as adults in the 1970s but they began to reduce their (at-home) consumption of these food products before the early 1980s. Blum states: "A high consumption of animal products alone does not result in increasing body heights, if the overall consumption of calories and other essential nutrients is insufficient" (2013, p.21). An overall supply of "essential nutrients" could have been insufficient in the food consumption of Japanese children since the mid-1980s, despite the fact that per capita net supply of milk and meats, respectively, in Japan in the mid-1980s was thrice and nearly twice more than in South Korea then.

Secular Changes in Child Height in Japan and South Korea, Using School Health Surveys

In our previous studies, the data provided in "Anthropometric Changes in Children from 1965 in Korea," *Am J Physical Anthropology*, 136 (Kim, Ji-Yeong et al., 2008) were used, which furnish child height by age from 1 to 20 years, in 1965, 1975, 1984, 1997, and 2005 in South Korea. Accordingly, the similar data in the same years, 1965, 1975, 1984, 1997, and 2005, based on the *National Nutrition Surveys*, Ministry of Health and Welfare, Japanese government, were employed.

School Health Examination Surveys, which provide stature by age from 1st graders in elementary school (6 years old[*3]) to senior students in high school (17 years old[*3]) have been conducted by the Ministry of Education every year since 1900 in Japan, except for a few years during WW II. The similar government surveys have been conducted in South Korea since 1960, to the best knowledge of the author (Kubota, 2018). The school health surveys in either country do not cover infants from 0 to 5 years of age and near-adults from 18 to 20 years of age. In the arena of human biology, the first two years of life, or 1000 days, including pregnancy, are crucial periods for future adult height (Cole, 2003; Deaton, 2007; Prentice et al., 2013; Headey, Hirvonen, and Hoddinot, 2018; etc.). Analyzing the secular changes in child height in Japan and South Korea since 1965, Cole and Mori (2017) state, "Most of the height increment seen in adults had already accrued by age 1.5 years" (p.12). In this regard, the data which lack the height development for infants from 0 to 5 years may carry some limitations. On the other hand, the school health surveys in both countries are based on very large nationwide samples conducted every year from 1960 to 2015.

Table 1 provides secular changes in mean height of school boys by age (from 6 to 17 years old) in Japan and in South Korea, by 5 year intervals from 1960 to 2010. In view of the fact that the ratios of girls enrolled in high school for higher education in the 1960s and 1970s were substantially lower in South Korea than in Japan (Kim, H.K., 2014), there is a possibility that statistics pertaining to mean height of girls in high schools in the earlier period of our investigation may not represent the entire population. That is the reason why statistics for the mean height of Korean school girls by age from 15 to 17 years during the first two decades are shadowed in Table 2.

[*1] *Food Balance Sheets*, MAFF, Japanese government, are not exactly the same in fine details as *Food Balance Sheets*, FAOSTAT, the main data sources for this comparative study of Japan and South Korea.

[*2] Kim, Y.S. (1982) states, on the basis of school children surveys of Korean children born and raised in Japan, no statistically meaningful differences were found between Japanese and Korean children in their stature including sitting height in the end of the 1970s. See Mori (2017; 2018; etc. for more information).

[*3] Depending on the month when the school surveys conducted, actual age of 1st graders in elementary school were 6 years + some months old: i. e., 6 to 7 years old.

Table 1 Secular changes in mean height of Jp and Kr school boys by age, from 1960 to 2010

mean height of Jp school boys: 3 year moving averages (cm)

age/year	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010
6	111.9	113.4	114.5	115.2	115.7	116.4	116.8	116.8	116.7	116.7	116.7
7	117.2	118.8	120.0	120.8	121.3	122.1	122.5	122.6	122.4	122.5	122.6
8	122.2	124.0	125.4	126.3	126.8	127.5	128.0	128.1	128.1	128.2	128.2
9	127.0	128.8	130.3	131.4	132.0	132.7	133.3	133.5	133.5	133.6	133.5
10	131.8	133.6	135.2	136.5	137.2	137.7	138.5	138.9	139.0	138.9	138.8
11	136.5	138.6	140.4	141.9	142.8	143.3	144.4	144.9	145.3	145.1	145.0
12	142.1	144.7	147.0	148.6	149.5	150.1	151.5	152.0	152.8	152.6	152.4
13	148.7	151.8	154.0	156.0	157.1	157.6	158.9	159.5	160.1	159.9	159.7
14	155.3	158.2	160.5	162.2	163.3	163.8	164.6	165.1	165.5	165.3	165.1
15	161.5	163.5	164.7	166.1	167.0	167.5	167.9	168.4	168.6	168.4	168.3
16	163.8	165.7	166.9	167.9	168.8	169.3	169.6	170.1	170.1	170.0	169.9
17	165.1	166.7	167.9	168.8	169.6	170.2	170.5	170.9	170.9	170.8	170.7

Notes: 1965=average(1964:1966), for example.
Sources: Japanese government, Ministry of Education, *School Health Survey*, various issues.

mean height of Kr school boys: 3 year moving averages (cm)

age/year	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010
6	111.0	111.9	112.9	114.1	116.4	116.7	117.7	119.0	120.2	121.0	121.8
7	114.9	115.2	117.6	119.7	121.6	122.5	123.0	124.7	125.9	126.8	127.7
8	119.0	119.3	121.5	123.8	126.6	127.5	128.3	130.0	131.2	132.2	133.2
9	123.5	123.4	126.0	128.6	131.4	133.7	133.3	135.0	136.5	137.9	138.5
10	128.0	127.5	130.3	133.2	135.6	137.2	138.3	140.0	141.9	143.1	143.9
11	131.6	131.4	134.5	137.4	140.7	142.1	143.7	145.7	147.9	149.4	150.4
12	140.3	141.8	143.7	144.4	146.3	148.2	149.7	152.0	154.8	156.9	158.0
13	144.5	145.3	148.1	150.4	152.7	154.8	156.0	159.0	161.8	163.6	164.4
14	149.5	150.1	152.3	155.9	159.4	161.0	162.3	164.7	167.0	168.3	169.0
15	155.6	159.0	160.9	163.7	164.4	165.5	166.3	168.3	170.5	171.6	171.8
16	161.2	161.9	163.9	165.6	167.0	167.9	168.3	170.3	172.1	172.8	173.1
17	163.3	163.8	166.1	167.2	168.4	169.4	169.7	171.0	172.9	173.7	173.7

Sources: Republic of Korea, Ministry of Education, *School Health Survey*, various issues.

differences in mean height of school boys between Jp and Kr, 1960 to 2010: using 3 year moving averages (cm)

age/year	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010
6	0.9	1.5	1.6	1.1	-0.7	-0.3	-0.9	-2.2	-3.5	-4.3	-5.1
7	2.3	3.6	2.5	1.0	-0.2	-0.4	-0.5	-2.1	-3.5	-4.2	-5.2
8	3.2	4.7	3.9	2.5	0.2	0.1	-0.3	-1.9	-3.1	-4.0	-5.0
9	3.6	5.4	4.4	2.8	0.6	-1.0	0.0	-1.5	-3.0	-4.3	-4.9
10	3.8	6.1	5.0	3.4	1.5	0.5	0.2	-1.1	-2.9	-4.2	-5.1
11	4.9	7.1	6.0	4.6	2.1	1.2	0.7	-0.8	-2.6	-4.3	-5.3
12	1.8	2.9	3.2	4.2	3.2	1.9	1.8	0.0	-2.0	-4.3	-5.6
13	4.2	6.5	5.9	5.6	4.5	2.9	2.9	0.5	-1.7	-3.7	-4.7
14	5.9	8.1	8.2	6.3	3.8	2.8	2.2	0.5	-1.5	-3.0	-3.8
15	5.9	4.6	3.8	2.4	2.6	2.1	1.6	0.1	-2.0	-3.2	-3.5
16	2.7	3.8	3.0	2.3	1.8	1.4	1.3	-0.3	-2.0	-2.8	-3.2
17	1.8	2.9	1.8	1.6	1.2	0.8	0.8	-0.1	-2.1	-2.9	-3.0

Sources: compiled by the author.

Table 2 Secular changes in mean height of Jp and Kr school girls by age, 1960 to 2010

mean height of Jp school girls by age: 3 year moving averages (cm)

age/year	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010
6	110.8	112.5	113.6	114.5	114.9	115.7	116.0	116.0	115.8	115.8	115.7
7	116.1	117.8	119.2	120.0	120.6	121.4	121.8	121.8	121.7	121.7	121.7
8	121.3	123.0	124.5	125.7	126.1	126.9	127.4	127.6	127.5	127.5	127.4
9	126.5	128.4	130.0	131.3	131.8	132.6	133.1	133.5	133.5	133.5	133.5
10	132.2	134.1	136.1	137.7	138.2	138.8	139.5	140.2	140.3	140.2	140.2
11	138.4	140.5	142.7	144.2	145.0	145.5	146.2	146.8	147.1	146.9	146.8
12	144.2	146.4	148.3	149.7	150.4	150.9	151.5	151.9	152.2	152.0	151.9
13	148.5	150.3	152.1	153.2	154.1	154.4	154.7	155.1	155.1	155.2	155.0
14	150.9	152.5	154.0	154.9	155.9	156.3	156.5	156.7	156.8	156.7	156.6
15	152.9	154.1	155.1	155.7	156.5	157.0	157.2	157.3	157.3	157.3	157.2
16	153.4	154.6	155.5	156.2	156.8	157.4	157.6	157.8	157.7	157.8	157.7
17	153.9	154.8	155.7	156.3	156.9	157.6	157.9	158.1	158.1	158.0	158.0

Notes: The same as Table 1.
Sources: the same as Table 1.

mean height of Kr school girls by age: 3 year moving averages (cm)

age/year	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010
6	110.4	110.7	111.8	113.0	115.1	115.8	116.7	118.0	118.8	119.7	120.6
7	114.7	114.4	115.4	117.9	120.3	121.4	122.0	123.3	124.7	125.4	126.3
8	118.9	118.6	120.2	122.5	125.8	126.5	127.7	128.7	130.1	131.2	132.1
9	122.9	123.3	124.8	127.6	130.6	131.9	132.7	134.7	135.9	137.5	138.2
10	126.3	127.0	129.7	133.0	136.7	137.4	139.0	141.0	142.4	143.9	144.7
11	131.7	131.1	133.4	138.4	142.1	144.0	145.0	147.0	149.1	150.5	151.1
12	142.0	141.9	144.2	146.5	148.6	149.5	149.3	152.7	154.2	155.3	155.7
13	145.6	145.3	148.3	150.3	152.5	153.5	153.7	155.7	157.3	157.9	158.1
14	149.9	147.8	150.8	152.9	154.9	155.4	156.0	157.7	158.9	159.4	159.6
15	153.6	154.3	154.2	155.5	156.1	156.5	157.0	158.0	159.6	160.3	160.4
16	155.0	155.3	156.2	156.0	156.7	157.2	158.0	159.0	160.1	160.7	160.7
17	155.8	157.2	157.3	156.2	157.3	157.2	158.0	159.3	160.6	161.1	161.0

Sources: the same as Table 1.

differences in mean height of school girls between Jp and Kr, 1960 to 2010: using 3 year moving averages (cm)

age/year	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010
6	0.4	1.8	1.7	1.5	-0.2	-0.1	-0.6	-2.0	-2.9	-3.9	-4.8
7	1.4	3.5	3.8	2.2	0.3	0.0	-0.2	-1.6	-3.0	-3.8	-4.7
8	2.5	4.4	4.3	3.2	0.3	0.4	-0.3	-1.1	-2.6	-3.7	-4.7
9	3.7	5.1	5.2	3.7	1.2	0.7	0.5	-1.2	-2.4	-4.0	-4.7
10	5.9	7.1	6.4	4.7	1.5	1.4	0.5	-0.8	-2.1	-3.8	-4.5
11	6.7	9.3	9.3	5.8	2.8	1.5	1.2	-0.2	-2.0	-3.6	-4.3
12	2.2	4.5	4.1	3.1	1.8	1.4	2.2	-0.8	-2.0	-3.2	-3.8
13	2.8	5.0	3.8	2.9	1.5	0.9	1.1	-0.6	-2.1	-2.7	-3.1
14	1.0	4.7	3.2	2.1	1.0	0.9	0.5	-1.0	-2.1	-2.7	-3.0
15	-0.8	-0.2	0.9	0.2	0.4	0.4	0.2	-0.7	-2.3	-3.0	-3.3
16	-1.5	-0.8	-0.7	0.2	0.1	0.3	-0.4	-1.2	-2.4	-2.9	-3.0
17	-1.9	-2.3	-1.6	0.1	-0.3	0.5	-0.1	-1.3	-2.5	-3.1	-3.1

Sources: compiled by the author.

We start to analyze school boys, mainly because Table 1 provides full statistics for the entire age groups from 6 to 17 years from 1960 to 2010. Despite the large sample sizes of the school surveys, statistics pertaining to mean height by age groups fluctuate from year to year, particularly in South Korea, possibly because statistics published in the survey reports depict mean height of school children only in Seoul in some years and averages of a few major districts in other years and also the months when the surveys were conducted may have varied from year to year. In order to smooth the annual fluctuations, we employed 3 year moving averages for all age groups: for example, mean height of 10 years old boys in 1970 represents simple average of those in 1969, 1970, and 1971 in Table 1.

With possible statistical errors disregarded, at age 16-17 years, school boys in Japan were 3 cm taller than S. Korean boys in the 1960s and still slightly, say, 1 cm taller in the 1980s. Japanese boys ceased to grow any taller in the early 1990s and onward, whereas S. Korean boys kept growing in height onward to overtake their Japanese peers by 3 cm in the mid-2000s and ceased to grow any taller since then.

In wide-scale international comparisons, per capita national income is found strongly related to adult height, both in time-series and cross-sectional analyses (Steckel,1995; Silventoinen, 2003; J. Hatton, 2013; Grasgruber et al., 2014; 2016; etc.). After the end of WW II, the economic growth was very fast and steady in the two countries, with South Korea some two decades behind Japan due to the Korean War (1950-53). Per capita GDP (in 2010 U.S. dollars) rose from $8,608 in 1960, to $25,489 in 1980, and eventually $42,170 in 2000 in Japan, whereas that in South Korea also increased steadily, but considerably behind Japan, i.e., $944, $3,700, and $15,104, respectively over the corresponding period (FRED/St. Louis Fed). If purchasing parity, particularly in food prices, is considered, per capita income alone can't explain the differences in height growth patterns of school boys between the two countries. Intuitively quick, easy answers could be that the Koreans, ethnically, should have higher genetic potentials in height than the Japanese. The author, however, wants to explore other explanations, with the recognition of apparent differences in food consumption patterns between the two countries (Mori, 2016; Mori, 2017; Mori, 2018; etc.). Bluntly put, Koreans eat considerably more foods, in respect of total caloric intakes, and particularly substantially more vegetables of greater variety than Japanese. Specifically, young people, including children have reduced their consumption of fruits and vegetables drastically since the early 1980s in Japan, in apparent contrast with their Korean peers. This might have caused "insufficient consumption of essential nutrients" (Blum) in the food diet among Japanese youth, including expecting young women.

Based on the statistics pertaining to mean height of children from 1 to 20 years of age, mentioned above, Mori suspected that Korean children, in accordance with their ethnic traits, tend to grow faster during their late adolescence years than their Japanese peers (Mori, 2016; 2017; etc.). Cole and Mori, based on the same data, analyzed by SITAR, concluded that most of the increment in height seen in adults had already accrued by age 1.5 years, either in Japan or South Korea, as mentioned earlier. A child born in 1960, for example, aged to 11 years old in 1971 and 20 years old in 1980. To determine child growth curve, it is preferable to take the cohort aspects into consideration. When the growth velocity in height from the 1st graders in elementary school to senior students in high school, by birth cohorts, from 1960 to 2010 determined, it proved that the magnitude of growth in height from 6 to 17 years has been nearly constant at 55 cm, almost the same for both Japanese and Korean school boys, over the entire period under this investigation (Fig.1).

To reprise Cole and Mori, most of the height increment seen in senior boys in high school had already accrued by 1st graders in elementary school, age 6 years.

Based on the data provided in Table 1, mean heights of male 1st graders in elementary school in Japan and South Korea from 1960 to 2010 are compared to prepare Fig. 2, which clearly demonstrates that at age 6 years, Japanese boys were 112 cm in 1960 and grew steadily to 115 cm in 1975, 1 cm taller than Korean boys, grew more slowly to 117 cm in 1990 and then leveled off afterward, whereas Korean boys grew more sharply from 111.0 cm in 1960 to 117.7 cm, 1 cm taller than Japanese boys in 1990, and then kept growing afterward to 122 cm, 5 cm taller than Japanese boys in 2010.

Fig 1. Changes in height growth velocity from 6 to 17 yr old, by cohorts, Jp and Kr school boys, from 1960 to 2010

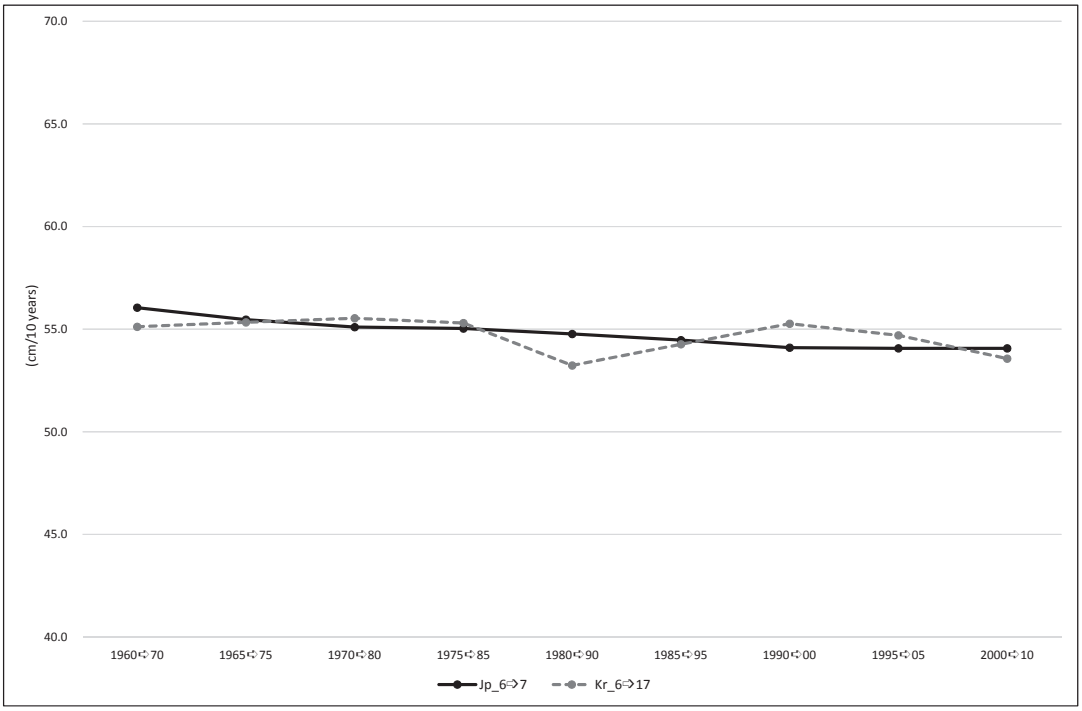


Fig. 2 Changes in mean height of 1st graders in elementary school, Jp and Kr boys, 1960 to 2000

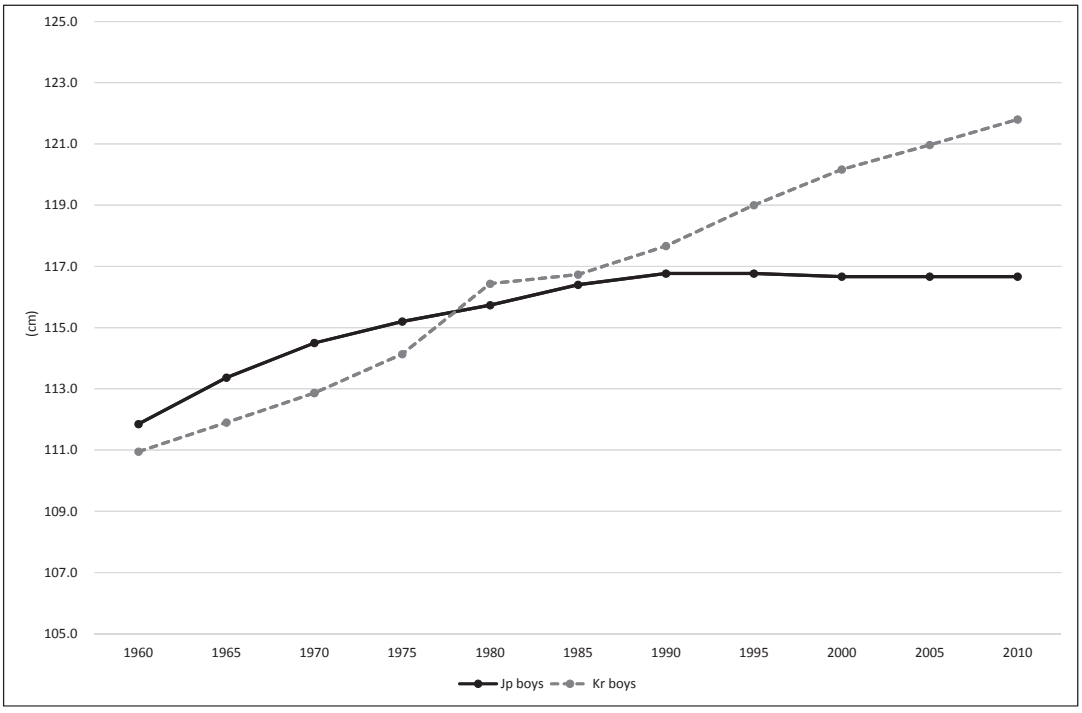


Fig. 3 Changes in growth velocity from 6 to 14 years old, by cohorts, Jp and Kr school girls, 1960-2010

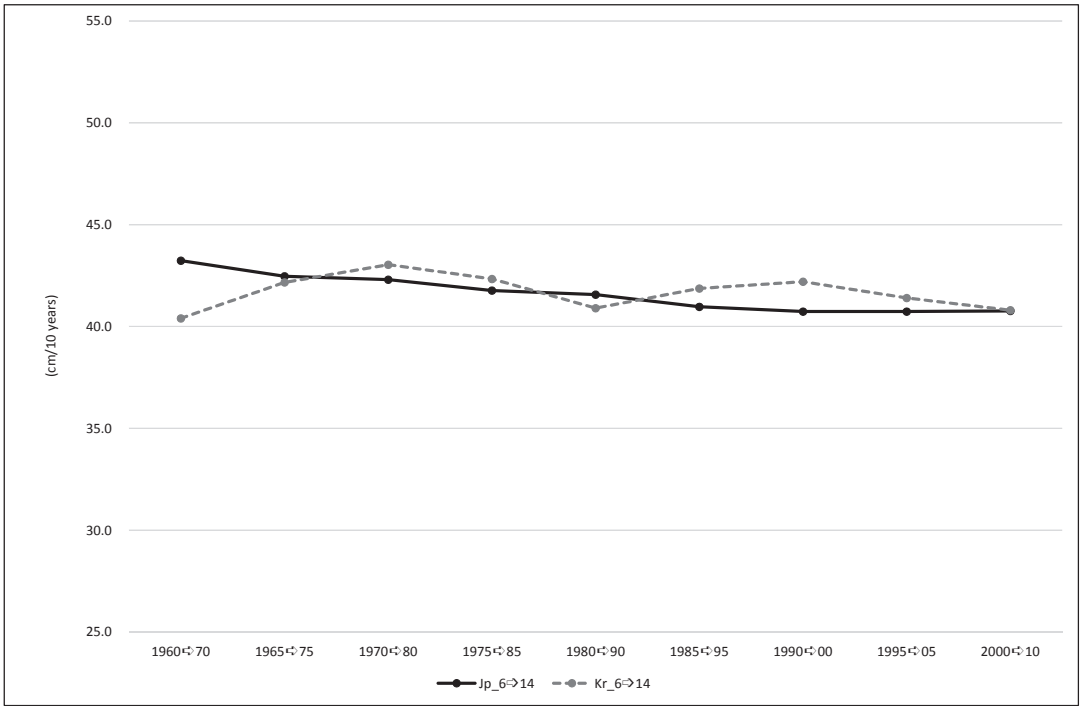
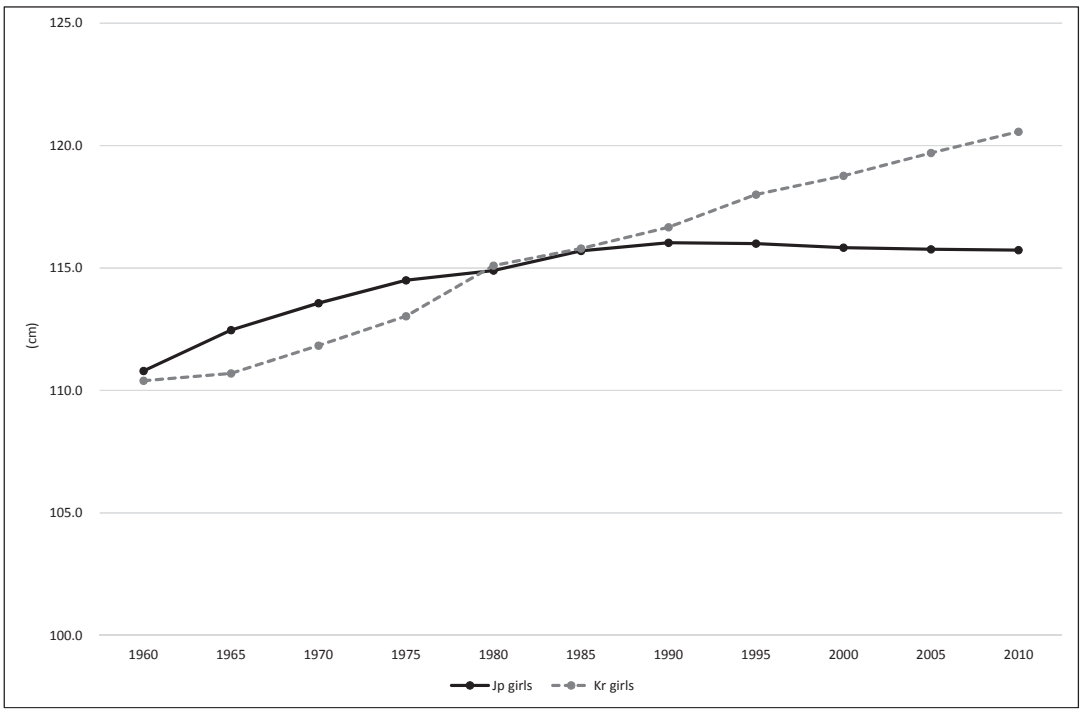


Fig. 4 Changes in mean height of 1st graders in elementary school, Jp and Kr girls, 1960 to 2010



In the case of school girls at age 13-14 years (i.e., 2nd and 3rd graders in junior high school), Japanese children were 3-4 cm taller than Korean girls in the 1960s and the 1970s and still slightly taller in the 1980s but they ceased to grow any taller in height in the early 1990s, whereas their Korean peers kept increasing in height, exceeding the Japanese by nearly 3 cm in the mid-2000s (Table 2). In the same fashion as boys (Fig.1), the growth velocity in height from the 1st graders in elementary school to 3rd graders in junior high school, by birth cohorts, from 1960 to 2010 was determined as shown in Fig. 3. Except for the first decade, the 1960s—when Japanese girls grew faster by nearly 3 cm than S. Korean girls in mean height—girls in the two countries grew almost at the same speed, 41-42 cm per decade from the mid-1960s onward. During the first two decades, the 1960s and 1970s, at age 6 years, Japanese girls were 2 cm taller than S. Korean girls, but they became the same in height at 115-6 cm in the 1980s. Mean height of Japanese girls in the 1st grade in elementary school had stabilized in the early 1990s at 116 cm, whereas S. Korean girls kept increasing in height to overtake Japanese girls by 4 cm in the mid-2000s (Fig. 4).

With possible differences in genetics between the two nations set aside, the author will try to explore the underlying environmental factors, particularly in respect of food supply, "inputs to health" (Steckel) which may have given rise to distinct differences in secular changes in child height development in past half century since 1960 between Japan and South Korea as presented above.

Changes in Overall Food Supply in the Past Half Century in Japan and South Korea

A nationwide nutrition survey was initiated shortly after the end of WW II and has been conducted regularly every year. However, food intakes by major products by age groups weren't published until 1995 and onward in Japan. The *Korean National Health and Nutrition Survey* was conducted in 1998, followed by the 2nd one in 2001, and the 3rd one in 2005 in South Korea. FAO, the United Nations, has been publishing food supply in terms of per capita supply (kg/year) and per capita caloric supply (kcal/day) under broad food categories and selected products by country every year since 1961 to present (2013) in *Food Balance Sheets*, FAOSTAT. For the sake of internationally consistent comparison, we will rely on FAOSTAT for the basic information on changes in food supply (≒consumption) in the two countries since 1961, complimented by other statistics such as *Family Income and Expenditure Surveys* (FIES) and *National Nutrition Surveys*.

Food supply was severely limited during the war years (WW II) and the subsequent few years after the war

Table 3 Changes in per capita caloric intakes, from vegetal and animal products: Japan and South Korea, 1961 to 2010

(kcal/day)

	Grand Total		Vegetal Products		Animal Products	
	Jp	Kr	Jp	Kr	Jp	Kr
1961	2525	2141	2274	2085	251	56
1965	2620	2367	2289	2293	331	74
1970	2737	2816	2314	2712	423	103
1975	2716	3106	2252	2939	464	167
1980	2798	3025	2261	2812	537	212
1985	2861	2951	2281	2679	580	272
1990	2948	2956	2332	2636	616	320
1995	2920	3022	2294	2609	626	413
2000	2899	3094	2296	2647	604	447
2005	2829	3102	2242	2630	586	472
2010	2685	3281	2135	2746	550	535

Sources: FAOSTAT, *Food Balance Sheets*, various issues.

in Japan and South Korea[*4] as well. Japan's economy recovered to the pre-war level in 1955 (*White Paper on Economy, 1956*). South Korea's economy was devastated due to the Korean War, 1950-53 and only started to rapidly and remarkably develop after the early 1960s (Frank Jr. et al., *Economic Growth in South Korea since WW II*, 1975). Along with the rapid economic progress, food consumption improved appreciably in total caloric supply in both countries, although there were no official statistics, such as *Food Balance Sheets*, available prior to 1961 for South Korea, to the best knowledge of the author.

Per capita GDP (in 2010 U.S. Dollars) in Japan remarkably increased from $8,608 in 1960, to $18,435 in 1970, $25,489 in 1980, $37,906 in 1990, and eventually to $42,170 in 2000, whereas that in South Korea also increased remarkably, but considerably behind Japan, i.e., $944, $1,815, $3,700, $8,465, and eventually to $15,104, respectively over the corresponding period (FRED/St. Louis Fed). It should be noted that per capita income in South Korea was nearly one tenth that in Japan in the 1960s through the mid-1970s. Per capita food supply (≒ net intake) was 2,141 and 2,367 kcal (in terms of daily caloric supply) in 1961 and 1965, respectively in S. Korea, appreciably lower than in Japan, which recorded 2,525 and 2,620 kcal, respectively in the corresponding years. S. Korea, however, overtook Japan by 80 kcal in respect of daily caloric intake as early as in 1970 and kept consuming a few hundred kcal more than in Japan from the mid-1970s and onward (Table 3).

South Koreans have consumed considerably more calories since 1970 than Japanese, predominantly from "vegetal products" (FAOSTAT), mainly cereals, whereas the Japanese consumed 423 kcal per day from animal products in 1970 (as compared to 103 kcal consumed by the Koreans in the same year) and the former took 626 kcal from animal products, 213 kcal more than S. Koreans in 1995 (Table 3). Changes in net supply of selected food products in terms of kg/capita/year from 1961 to 2010 in both countries are provided in Table 4, based on the same data sources, *Food Balance Sheets*, FAOSTAT.

It has been widely recognized in human biology that "high quality protein" from meat and milk is positively correlated to development of child height (Hoppe et al., 2006; Beer, 2012; Blum, 2013; Grassgruber et al., 2014; 2016; etc.). Following the remarkable increases of adult height in South Korea in recent decades, Schwendiek and Jun attributed the steady increase of adult height in recent years in S. Korea to rapid increases in per capita consumption of meat and milk in the Korean diets (p.169 and p.170, respectively, 2010). As is shown in Table 4, per capita supply of meat + eggs in S. Korea in 1985 was 25.5 kg/year, half that of Japan in the same year, and particularly that of milk, 25.8 kg/year, was one third that of Japan. Per capita milk consumption in S. Korea increased very rapidly since then to 54.0 kg/year in 2000, yet still two thirds that of Japan in the same year[*5]. Steady increases in net supply of meat and milk signify substantial improvements in food consumption, either in South Korea or Japan. It does not seem, however, statistically well-founded enough to explain why children in S. Korea kept increasing in height during the last two decades under investigation, to overtake Japanese children by 3 cm or more in the mid-2000s, principally by comparing per capita consumption of these animal sourced food products. Grasgruber et al. predict on the basis of "nutrition + socioeconomic variables" that male height in Japan and S. Korea in the mid-2000 would be 174.5 and 173.1 cm, respectively, as opposed to observed values at 172.1 and 174.3 cm, respectively (Table 5 and Fig. 12, p. 193, 2016).

Equally important may be the statistical facts that South Koreans have been eating substantially more cereals than Japanese since the early 1970s and they also have been steadily increasing their consumption

[*4] Korea was under Japan's colonization, prior to the end of war. The food supply condition was considered no better than in Japan at that time.

[*5] Per capita supply of milk, excluding butter, as reported in FAOSTAT, seems to be unreasonably under-calculated for Republic of Korea, particularly after the mid-1980s, for unidentifiable reasons. The author recalculated per capita supply (kg/capita/year) of milk by dividing total domestic supply quantity in 1,000 tonnes, as provided in FAOSTAT, by total population of the country, for the corresponding years.

Table 4 Changes in per capita net supply of selcetd product groups in Japan and South Korea, 1961 to 2010

(kg/year)

Cereals	Japan	S. Korea	**Meat+Egg**	Japan	S. Korea
1961	157.8	176.8	1961	16.8	5.5
1965	153.3	184.6	1965	24.6	7.1
1970	144.3	217.8	1970	34.1	9.2
1975	142.4	235.3	1975	39.2	11.8
1980	134.2	199.3	1980	46.7	19.7
1985	133.3	190.7	1985	50.8	25.5
1990	129.5	168.6	1990	57.3	33.7
1995	122.9	168.5	1995	63.9	47.6
2000	120.4	160.3	2000	64.8	57.3
2005	115.1	146.1	2005	65.9	59.9
2010	111.2	149.0	2010	66.7	70.1
Vegetable	Japan	S. Korea	**Milk**[*1]	Japan	S. Korea
1961	96.8	75.7	1961	26.2	0.7
1965	119.6	82.3	1965	40.7	3.4
1970	126.8	104.0	1970	53.5	3.8
1975	121.3	147.7	1975	53.6	5.3
1980	122.6	197.9	1980	73.7	12.9
1985	119.5	181.7	1985	79.1	25.8
1990	116.7	200.6	1990	81.8	42.1
1995	116.6	222.3	1995	86.2	48.8
2000	112.8	235.7	2000	84.0	54.0
2005	107.8	215.8	2005	79.9	54.9
2010	98.9	196.5	2010	74.0	52.8
Fruit	Japan	S. Korea	**Fish**	Japan	S. Korea
1961	29.7	5.2	1961	50.7	13.2
1965	39.0	9.8	1965	51.6	17.6
1970	53.9	12.3	1970	60.2	18.4
1975	61.9	14.6	1975	66.6	39.0
1980	55.6	23.2	1980	65.0	41.3
1985	51.9	35.2	1985	69.7	47.3
1990	50.2	47.0	1990	71.4	46.4
1995	53.2	69.6	1995	71.1	50.1
2000	51.4	69.6	2000	67.3	46.9
2005	60.3	76.1	2005	60.4	53.8
2010	49.1	67.6	2010	52.6	56.7

Sources: FAOSTAT, *Food Balance Sheets*, various years.
Note: *1 Derived by total domestic supply/population, provided in FAOSTAT for both countries.

Table 5 Changes in per capita at-home consumption of fresh fruit by age groups, 1971 to 2010 in Japan

(kg/year)

age/year	1971	1980	1985-86	1990	1995-96	2000	2010
0-9 yo	36.3	26.5	15.2	8.9	4.7	2.3	2.4
10-19	45.6	30.5	20.1	14.9	9.4	5.7	4.4
20-29	48.3	31.5	23.4	16.8	15.1	11.8	9.8
30-39	46.1	43.8	36.6	30.4	23.6	21.8	14.8
40-49	51.0	52.6	48.5	44.9	37.2	33.4	20.5
50-59	54.4	59.9	56.6	54.0	50.5	48.5	32.1
60-69	44.5	58.5	61.1	62.0	58.7	60.7	53.3
70+	41.2	54.2	59.6	60.3	62.1	65.8	58.8
Grand ave.	45.6	41.6	36.4	33.8	31.5	31.1	27.7

Sources: derived from FIES by the author, using the TMI model.
Notes: Estimated by 5 year age intervals first, which were simply averaged into 10 year intervals.

of vegetables since the mid-1970s, whereas Japanese have slightly decreased their vegetable consumption since the early 1970s. The Japanese ate about half as much vegetables as the Koreans on average in the 1990s. Some fifty years ago, South Koreans did not eat much fruits, i.e., per capita supply (≒consumption) of fruits was meager at 9.8 and 12.3 kg/year in 1965 and 1970, respectively, nearly one fifth that of the average Japanese in the same years. Per capita supply of fruits in S. Korea, however, sharply increased since then to 35.2 kg, two thirds the level in Japan in 1985 and further expanded to 69.6 kg in the-mid 1990s, exceeding Japan by 30%, whereas per capita fruit consumption in Japan gradually declined to 49.1 kg in 2010, as compared to 67.6 kg in S. Korea in the same year. Steady improvements in the Korean diets are vividly described in "South Korea's entry to the global food economy: shifts in consumption of food between 1998 to 2009" (Lee, Duffey, and Popkin, 2012) and "Analysis of Kimchi, vegetables and fruit consumption trends among Korean adults: data from the *Korean Health and Nutrition Examination Survey*" (Kim, E-K et al., 2016).

Steering away from Fruit and Vegetables by Japanese Youth may Be Responsible for Child Height Stagnation

As briefly mentioned in the previous section, per capita fruit consumption has gradually declined since the mid-1970s in Japan in terms of net supply of fruit, which includes fruit juice imported in frozen-condensed form for various purposes other than juice, partially such as for brewing wine. Per capita at-home consumption of fresh fruits, which may account for approximately 70-80 % of total fresh fruit consumption (Mori et al., 2009) declined from 49.7 kg in 1975, the peak year, to 31.5 kg in the mid-1990s and further to 27.7 kg in 2010 (Table 5). The *1994 White Paper on Agriculture*, Ministry of Agriculture, Japanese government drew public attention to the widespread tendencies of *wakamono no kudamon-banare* (steering away from fruit by youth) by displaying a chart which provides changes in per capita household purchases of fresh fruit, classified by age groups of the head of households (*Family Income and Expenditure Surveys*). The author estimated changes in per capita at-home consumption of fresh fruit by age groups of individual household members from 1971 to 2010 (Table 5), using the TMI model (Mori and Inaba, 1997; Tanaka, Mori, and Inaba, 2004). With some twenty years of experience in estimating per capita at-home consumption of various food products by age groups of household members from FIES, the author has reasonable confidence in the estimated values provided in Tables 5 through 8, which provide changes in per capita at-home consumption of fresh fruit and other products by age groups of family members from 1971 to 2010 (Lewis,

Mori, and Gorman, 2001; Mori, Clason et al., 2009; Mori and Stewart, 2011; etc.).

In the early 1970s, Japanese children ate on average approximately 45 kg of fresh fruit at home, the same as the grand average of 45.6 kg. They, however, began to reduce their fruit consumption drastically since then to 30 kg in 1980 and further to 10-15 kg in the early 1990s, whereas the older household members in their 50s and 60s kept their fruit consumption at fairly high levels above 50 kg over the corresponding period (Table 5). Per capita at home consumption of fresh fruit by Japanese children dropped to approximately 5.0 kg per year on average in the early 2000s, less than one tenth of those in their 50s through 70s at that time. Japanese children are estimated to eat fruit at home less than one fourth the level of national average per capita net supply of fruit in 1990 and barely one tenth the level in 2000, respectively.

While not to the extent of fresh fruit consumption discussed in the above paragraphs, though, per capita at-home consumption of fresh vegetables by Japanese children steadily declined from approximately 60 kg/year in the early 1970s to less than 40 kg in 1990, and further down to some 25 kg in the early 2000s (Table 6), one tenth the level of average per capita net supply of vegetables in South Korea then (Table 4).[*6]

The government of South Korea conducted a very comprehensive health and nutrition survey (KNHANES) in 1998, followed by a second one in 2001, and then in 2005, 2007, and every year since then. Japan's *National Nutrition Survey* started to publish food intakes under broad food groups by age groups from children to the elderly in 1995, with quite large SDs, particularly in the case of fruit, including confectionaries containing fruits. In view of the statistical fact that Japanese children ceased to grow in height in the mid-1980s, while Korean children kept growing taller after the early 1990s, neither Japan's *National Nutrition Surveys* nor Korean counterparts can directly serve in explaining the differences in growth patterns in child height.

Table 9, based on the cross-sectional panel data, provides changes in per capita daily intakes of fruits and vegetables by age groups, including infants to the elderly group in South Korea. Unlike the Japan's FIES, which covers the entire 12 months of consumption, KNHAES is based on one day-24 hour recall surveys across the nation, which tend to vary by the month when the survey was conducted. Despite these limitations, it is clearly demonstrated in Table 9 that children in S. Korea consume as much vegetables and fruit as those

Table 6 Changes in per capita at-home consumption of fresh vegetables by age groups, 1971 to 2010 in Japan

(kg/year)

age/year	1971	1980	1985-86	1990	1995-96	2000	2010
0-9 yo	44.8	33.7	27.3	23.0	20.2	18.3	17.5
10-19	62.2	51.1	44.7	38.8	36.0	30.0	30.6
20-29	67.8	56.1	52.5	45.5	46.2	40.8	37.6
30-39	68.5	65.6	60.2	54.3	52.3	49.8	45.7
40-49	77.4	80.3	78.2	71.7	67.3	62.0	54.7
50-59	89.0	90.5	91.9	84.0	83.7	82.3	66.2
60-69	87.5	93.3	99.0	91.2	91.0	94.0	80.8
70+	71.0	80.0	89.4	80.1	81.3	86.9	81.5
Grand ave.	67.1	63.6	62.4	58.3	59.0	57.2	55.4

Sources: the same as Table 5.
Notes: the same as Table 5.

[*6] In Japan, per capita at-home consumption of meat by youth increased appreciably from the early 1970s to the early 1980s and stayed fairly constant at a relatively high level since then and that of milk also kept unchanged to the early 2000s, whereas those in the older ages increased consistently and considerably their at-home consumption of both meat and milk since the early 1970s (Tables 7-8).

Table 7 Changes in per capita at-home consumption of meats by age groups, 1971 to 2010 in Japan

(kg/year)

age/year	1971	1980	1990	2000	2010
0-9 yo	8.9	10.5	9.9	10.7	11.7
10-19	12.0	17.2	16.6	17.4	17.8
20-29	11.0	14.5	14.1	15.6	15.7
30-39	10.8	14.9	14.3	15.5	17.1
40-49	10.3	16.0	17.2	18.9	20.0
50-59	9.9	14.3	15.4	18.8	19.8
60-69	9.1	12.6	12.6	16.0	19.0
70+	7.7	9.2	9.0	12.1	13.9
Grand ave.	10.6	14.7	15.1	15.5	17.1

Sources: the same as Table 5.
Notes: meats include ham and other processed meats;.estimated by 5 year age intervals first and simply averaged into 10 year intervals.

Table 8 Changes in per capita at-home consumption of milk by age groups, 1971 to 2010 in Japan

(l/year)

age/year	1971	1980	1990	2000	2010
0-9 yo	28.6	28.9	30.5	26.4	18.1
10-19	23.7	25.6	29.3	26.9	19.8
20-29	26.7	28.3	27.5	22.9	18.8
30-39	19.1	24.5	31.7	30.9	24.1
40-49	11.7	20.2	32.7	36.8	29.8
50-59	10.5	22.0	32.4	35.5	31.2
60-69	16.4	23.6	36.7	39.6	33.4
70+	16.8	23.6	35.4	43.2	35.7
Grand ave.	20.6	24.9	31.7	32.8	27.6

Sources: the same as Table 5.
Notes: the same as Tsble 5.

individuals in their 20s through 60s. Those in their 20s in the early 2000s were in their adolescence in the early 1990s, suggesting the amount of vegetables and fruit these generations used to eat at that time, in the presence of robust cohort effects in food consumption (Mori and Saegusa, 2010; Mori, Inaba, and Dyck, 2016; etc).

Blum states that a high consumption of animal proteins alone does not result in increasing body height, if the overall consumption of calories and other essential nutrients is insufficient, as cited above. The author suspects or hypothesizes that some “essential nutrients” should be contained in not only vegetables but also in fruit, which is regarded in Japan as non-essential for child growth, being called *mizukashi* (watery confectionary, or jelly desert, etc.).

According to the longitudinal cohort studies of the Mikkabi-machi residents for the past ten years, by the National Fruit Tree Research Institute, Japanese government, in collaboration with the Hamamatsu University School of Medicine, quite high positive correlations exist between large intakes of fruit, mandarins in

Table 9 Per capita daily intakes of fruits and vegetables by age groups in South Korea, 1998 and 2001

(1) 1-6 years old infants (gm/day)

Food groups	1998		2001	
	g	SE	g	SE
Fruits	167.9	10.0	179.6	9.1
Vegetables	81.6	4.1	85.1	3.8

(2) 7-14 years old children (gr/day)

Food groups	1998		2001	
	g	SE	g	SE
Fruits	201.9	10.4	197.7	9.7
Vegetables	190.6	7.0	183.1	4.6

(3) 15-19 years old adolescents (gr/day)

Food groups	1998		2001	
	g	SE	g	SE
Fruits	192.2	13.7	169.6	13.1
Vegetables	227.8	6.0	234.2	7.1

(4) 20-29 years old adults (gr/day)

Food groups	1998		2001	
	g	SE	g	SE
Fruits	220.4	11.4	208.6	12.1
Vegetables	299.8	6.8	297.0	6.7

(5) 30-39 years old adults (gr/day)

Food groups	1998		2001	
	g	SE	g	SE
Fruits	228.8	9.8	227.0	10.4
Vegetables	345.5	6.5	361.7	7.1

(6) 40-49 years old adults (gr/day)

Food groups	1998		2001	
	g	SE	g	SE
Fruits	202.9	8.5	222.4	12.4
Vegetables	360.6	9.4	369.1	7.8

(7) 50-59 years old adults (gr/day)

Food groups	1998		2001	
	g	SE	g	SE
Fruits	189.7	11.2	235.4	12.6
Vegetables	337.5	7.9	349.1	8.8

(8) 60-69 years old adults (gr/day)

Food groups	1998		2001	
	g	SE	g	SE
Fruits	158.6	11.6	210.2	14.1
Vegetables	306.6	8.4	355.9	10.1

Sources: Junghyun Park, Dept. Nutrition, Gachon University (courtesy): original sources, KNHANES.

particular, and the bone mineral densities among their cohort study subjects, mainly post-menopausal females (Sugiura et al. 2008; 2012; 2015; Nakamura et al. 2016; etc.). Other empirical studies overseas, including Ireland, Canada, and China, also report positive correlations between the intakes of fruit and vegetables and bone mineral accrual/densities among the subjects of adolescents (McGartland et al., 2004; Whiting and Vatanparast et al., 2004; Vatanparast, Baxter-Jones et al., 2005; Prynne et al., 2006; Li, J-J et al., 2012; etc.). No empirical studies have discovered that a higher bone mineral accrual among children in their adolescence would lead to greater velocity in height growth.

The author, however, has long suspected that the radical decreases in fruit consumption among Japanese children since the end of the 1970s have been abnormally drastic from the international perspectives and in comparison with South Korea for this study, exerting unhealthy impacts on their stature—in Steckel's words, "the supply of (nutritional) inputs to health" in Japan in the past some 30 years has been deplorably inadequate, or "insufficient".

The younger, or newer generations today will be in their middle age in the mid-21st century and will very likely retain their eating habits then (Mori, Inaba, and Dyck, 2016).

Inadequate inputs to health will be retained for the entire population in not so distant future years.

Summary

Based on *School Health Examination Surveys* conducted by government agencies extensively since 1900 in Japan and since 1960 in South Korea, respectively, children in both countries increased appreciably in height since 1960 (i.e., boys at the age of near-maturity, 17-18 years old, in Japan steadily increased in (mean) height from 165.1 cm in 1960 to 168.8 cm in 1975, 170.2 cm in 1985, 170.9 cm in 1995, and levelled off at 170.8 cm in the mid-2000s, whereas their Korean peers increased more sharply from 163.3 cm in 1960, to 167.2, 169.4, 171.0 and 173.7 cm, respectively over the corresponding period. Japanese boys were 2-3 cm taller in the 1960s and the early 1970s but taller but barely taller by 1-1.5 cm in the mid-1980s, eventually 3.0 cm shorter in the mid-2000s than their South Korean peers.

The economy in the two countries made remarkably rapid progress since the end of WW II, with the South Korean economy lagging some two decades behind Japan due to the Korean War (1950-53). As the economy grew rapidly, food consumption improved conspicuously in quantity and quality in both countries, with some distinct differences in the pattern of food intakes. Per capita meat consumption sharply increased, accompanied by consistent declines in cereal consumption, with per capita total caloric intakes slightly falling in Japan, whereas per capita meat consumption increased modestly but cereal consumption steadily increased until two decades ago, with total caloric intakes gradually rising in South Korea. The other crucial differences are that the Koreans have eaten substantially more vegetables, almost twice as much as the Japanese since 1980 or so and that their fruit consumption has soared very rapidly since the 1960s to surpass that of the Japanese by nearly 30% by the end of the 1990s in terms of per capita net supply (FAOSTAT). As presented in the foregoing section, Japanese children have drastically reduced their at-home consumption of fresh fruit since the mid-1970s, whereas their Korean peers are presumed to have increased their fruit consumption in accordance with national averages. The same phenomena apply to the case of vegetables.

Is consumption of fruit and vegetables positively correlated with the development of a child's height, as is commonly conceived with milk and meats? Will children grow taller in height if they eat more fruit and vegetables? The author is not ready to answer directly: "yes". What he is certain about, however, is the statistical fact that children in Japan eat very little fruit and vegetables lately, as compared to their S. Korean peers. This may have had negative, if not identifiable, impacts on the stature development of Japanese children, despite the statistically discernible fact that per capita consumption of meat, eggs and milk in Japan was somewhat greater than in Korea even in the early 2000s. The comparative investigations of secular changes in child height and food consumption in Japan and South Korea over the past half century deserve further investigations through various approaches.

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