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Review Article

Prospects for Children's Height in Japan and South Korea: Perspective from Food Consumption

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Abstract

In the past half century, children in Japan and South Korea grew rapidly in height by 2 cm per decade. Children in Japan ceased to grow any taller in the mid-1990s, whereas Korean peers kept growing and overtook the Japanese 3 cm in the mid-2000s and then stopped. In the 1990s, when Koreans caught-up the Japanese in height, per capita caloric supply from animal products in Korea was 150 kcal/day less than in Japan. When Korean children stopped growing in height in the mid-2000s, per capita supply of animal products was still rising. *Household Expenditure Surveys* classified by age groups of household head were decomposed to demonstrate that children and younger people in Korea started to turn away from vegetables in the early-1990s, and by the end-2010s they ate less than 10% of the vegetables eaten by those aged 50. Similarly, two decades before Japanese height stopped increasing in the early 1990s, the young people started to turn away from fresh fruit. Vegetables/fruit may be essential nutrients to support animal protein intake in human metabolism. Judging from the fact that 1st graders in primary school in Korea declined in mean height by 1.5 cm from 2008 to 2017 and that boys' height increment from 12 to 17 years of age fell drastically from 18.9 cm in 2005 to 15.5 cm in 2015, it looks as though young people in South Korea will decline in mean height by 1-2 cm in the foreseeable future.

Keywords: Body height, height increment, animal products, fruit/vegetables, South Korea, Japan

Introduction

Japan and South Korea in "temperate Asia" (Grasgruber, 2021) [1] achieved rapid and steady economic progress after WW II. Korea was two decades behind Japan, largely due to Korean War (1950-53). As standard of living improved, food consumption increased in quantity and quality, particularly with animal protein boosted remarkably. Children grew in height unprecedentedly in the two countries. Per capita caloric supply from animal products in Japan reached the peak in the end of the 1990s, whereas Korea's per capita consumption of animal protein kept increasing vigorously to the end of the 2010s. Children in Japan ceased to grow any taller in height in the early-1990s, whereas their Korean peers kept growing in height swiftly to overtake Japanese children at all school ages by 3-4 cm in the mid-2000s. Established theorem in human biology fits these cases observed in temperate Asia in the past half century.

Korean teens, however, suspended to grow any taller in height in the mid-2000s, while per capita animal protein kept increasing vigorously. This reminded the author what happened in Japan three decades ago: teens suspended to grow taller in height. When the biological behaviors closely examined, growth in height from freshmen in middle school (age 12) to seniors in high school (17) proved to be slower in Korea than in Japan since the early-2010s. Increments in height from fresh men in primary school (6) to fresh men in middle school (12) in Korea started to fall behind their Japanese peers since the mid-2010s, despite Korea did not cease to expand in per capita supply of animal-sourced products.

Data

Pertaining to secular changes in children's mean height by age, there are two public data sources: *National Nutrition Surveys* [2, 3]and *School Health Surveys* [4, 5], both in Japan and South Korea. The first covers entire age groups, from 1 to 24, 25~29, 30~39, --, and provides information on "the earlier years of life", "critical 1,000 days" (Cole,2003; Deaton,2007; Prentice et al.,2013) [6, 7, 8]. The first comprehensive *Health and Nutrition Survey* was conducted in 1998, the 2nd one in 2001, and the 3rd one in 2005 in Korea*1. Nationwide *Nutrition Survey* has been conducted every year since 1946 in Japan and valuable for identifying long-run trends by decade in the past half century. As is shown by Figures.1-2, mean height of children by age provided by *Nutrition Surveys* are not stable from year to

year, as compared to *School Health Surveys*. *School Health Surveys* depend on much larger samples than *Nutrition Surveys* but do not cover preschool ages, 0-5. As mentioned above, we are trying to examine differences in growth patterns of child height between the two countries, in the order of 0.5~3.0 cm.

Fig. 1 Conparison of mean height of Japanese boys at age 6, as reported by *School Health Surveys*[4] and *National Nutrion Surveys*[2], 1989 to 2001

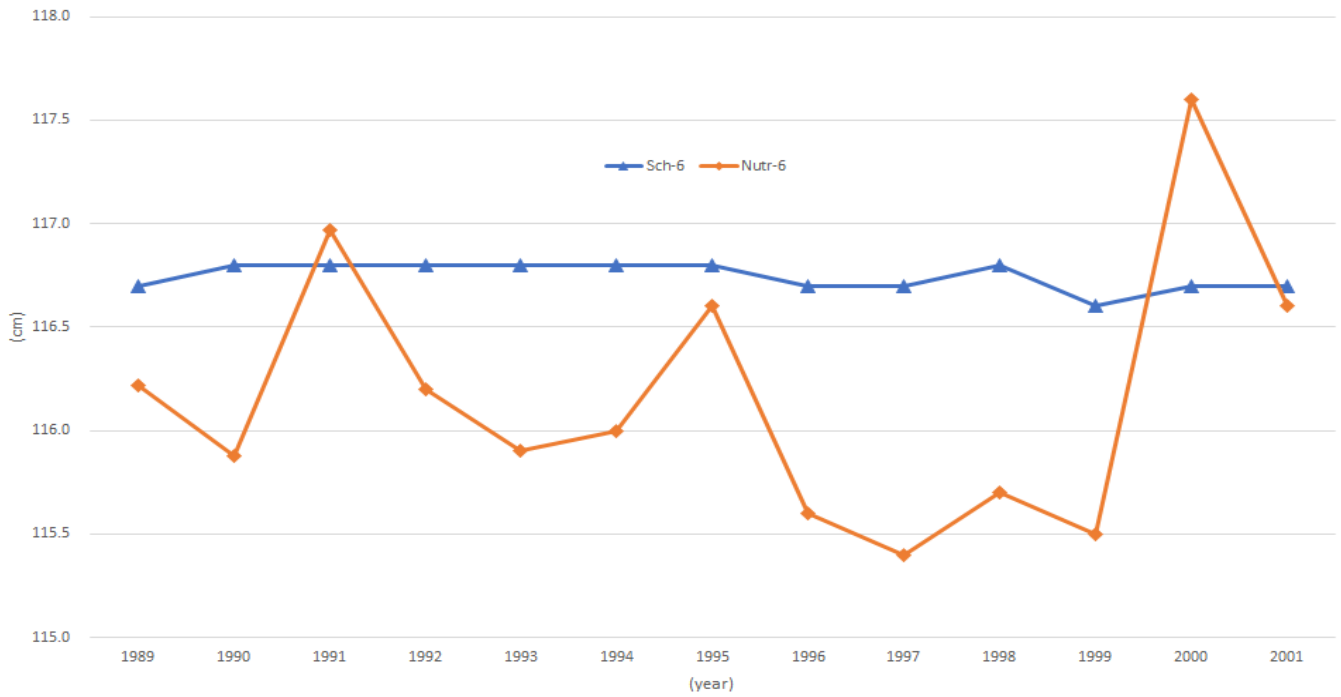
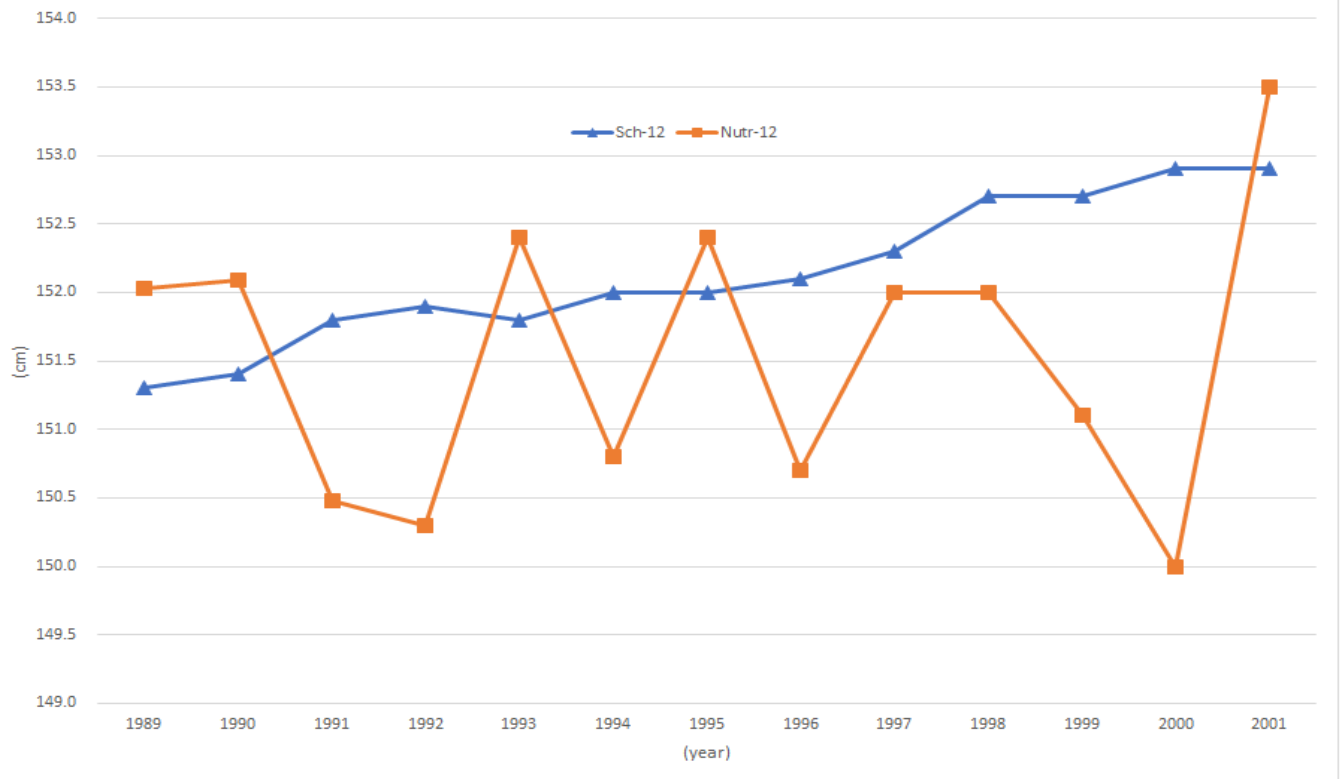


Fig. 2 Comparison of mean height of Japanese boys at age 12, as reported by *School Health Surveys*[4] and *National Nutrition Surveys*[2], 1989 to 2001



Pertaining to inputs to health, food consumption in particular, *Nutrition Surveys* are valuable data sources. South Korea has not conducted comprehensive surveys for a long time, as mentioned above. Food balance sheets provide stable supply data on per capita, annual/day basis. Supply is not equal to consumption. There lies no question that consumption cannot exceed supply. FAOSTAT [9] provides food balance sheets, by individual items, such as pork, milk, --, also by aggregated items, cereals, meat, vegetables, and broader items, animal products, grand total foods, since 1961, which covers Japan and South Korea. The two countries have prepared their own food balance sheets, generally in accordance with the international format, set by the United Nations. The author has access to *Food Balance Sheets* prepared by Ministry of Agriculture, Japanese government [10], every year from 1948 to 2019. He obtained simple tables, one or two pages, which provide per capita supply by commodity, such as rice, pork, vegetables, for South Korea, from 1960 to 1990 and detailed *Annual Reports of Food Balance Sheets*, 2002 to 2018, prepared by KREI, Republic of Korea [11], which provides detailed data, back to 1990.

Japan started normal economic progress in 1955, when recovered from the war devastations and South Korea had recovered from Korean War only in the mid-1960s. The analyses in this note cover the period a decade earlier for Japan, which is not covered by FAOSTAT. Food supply data for Japan depend on *Food Balance Sheets*, prepared by Ministry of Agriculture, whereas FAOSTAT is depended for Korean food supply.

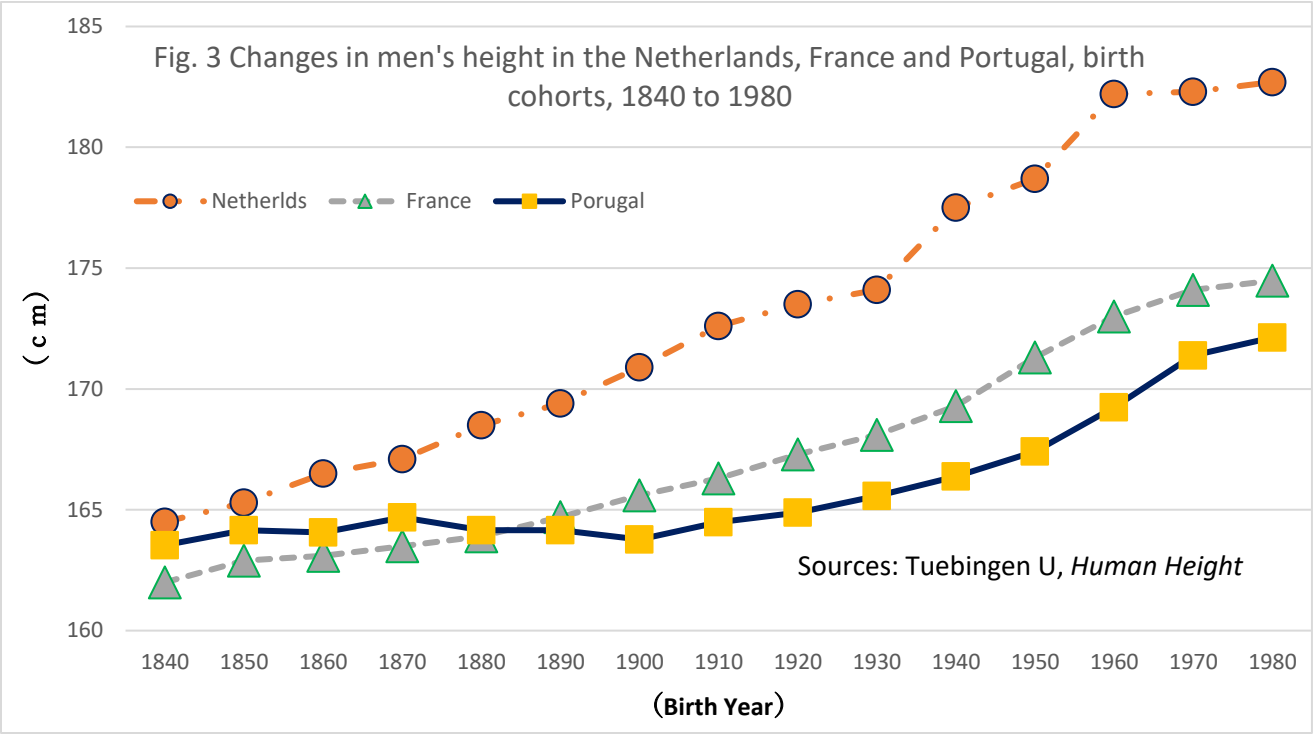
Family Income and Expenditure Surveys, Bureau of Statistics, Japan are referred very commonly in Japan [12]. The Surveys are based on 8,000 households across the country, by 6 month-rotation. *FIES* covers household expenditures on foods and eating out, by major items: rice, fish, vegetables and fruit by various varieties, and most expenditures: medical expenses, education, etc. *FIES* provides expenditures on major food items, with prices paid, by household income groups and age groups of household head, etc. used very widely for economic analyses, including demand-system econometric analyses. Republic of Korea, Statistics Korea, publishes *Household Income and Expenditure Surveys* [13], by broader categories, grains, meat, including processed meat, vegetables, only by monthly expenditures, without physical amounts and prices paid, but by age groups of household head, which contributed to identifying trends of at-home consumption by age/cohort in this research note.

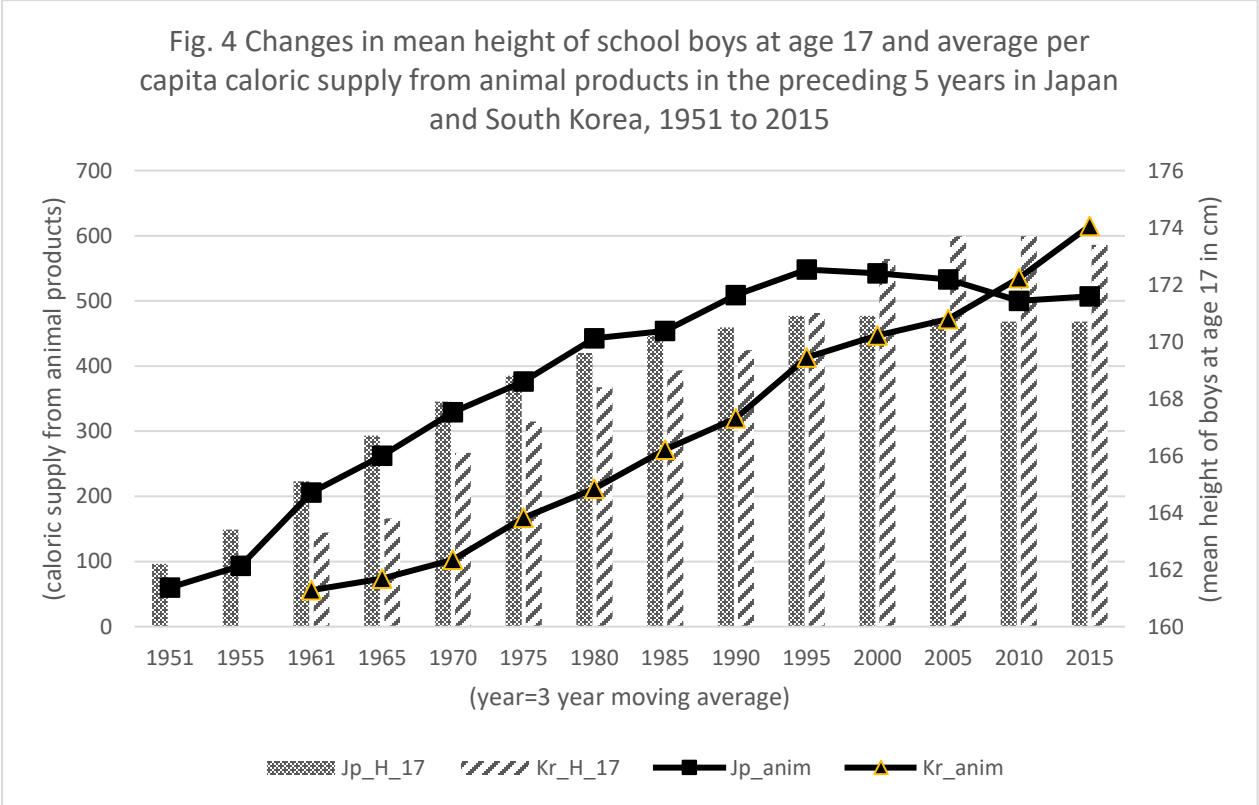
*1 Republic of Korea may have conducted much simpler nutrition surveys occasionally before the first *KNHNES* was conducted in 1998.

Secular changes in child height by age and per capita supply of animal-sourced foods over the past half century in Japan and South Korea

It is widely accepted that growth of child height is positively associated with consumption or supply of animal protein on the top of genetics (Baten and Blum, 2014; Grasgruber et al., 2016; etc.) [14, 15]. Men in the northern Europe are appreciably taller than those in the southern Europe. As shown in Figure. 3, young men in the Netherlands were almost the same in height as those in France and Portugal in the mid-19th century. In the end of the 20th century, the Dutch were 184 cm in mean height, more than 10 cm taller than the Portuguese in the end of the last century. The young workers in Taiwan were 165-6 cm, a couple cm taller than those in Korea in the 1930s, when both countries were under the Japan's colonization, whereas Korean teens were 174 cm, a couple of cm taller than their Taiwanese peers in the mid-2000s (Olds,2003; Kimura,2018; Mori,2019) [16, 17, 18]. For the author, with no anthropological background, genetics cannot be the subject for discussion in this paper.

Figure. 4 clearly demonstrate that children in Japan and South Korea rose in height in the past half century, as per capita caloric supply from animal products increased, with Korea two decades behind Japan. Japanese children ceased to grow taller in height at all ages in the early-1990s, whereas their Korean peers kept growing taller sharply to overtake Japanese children by 3-4 cm in the mid-2000s and then suspended to grow taller. One thing in common, which caught the author's attention, is that children in both countries suspended to grow taller in height, while pea capita supply of animal products still kept growing appreciably.





Needless to mention, children at age 17, senior students in high school in 2018, were born in 2001, 1 year of age in 2002, first graders in primary school (6) in 2007, fresh men in middle school (12) in 2013. No one ages from 6 to 17 in the same one year, 2018, for example.

In order to examine the height behavior of school boys in the two countries, particularly in the recent 3 decades, Figure. 5 is prepared: increments from 6 to 12, and 12 to 17, following birth cohorts in the past 3 decades. To explain the graph in rather concrete manner, fresh men in middle school in 1985, had grown by 34.4 cm from fresh men in primary school in 1979, in Japan, 1.1 cm larger than their Korean peers. Fresh men in middle school in Korea in 2005 had grown by 36.9 cm from fresh men in primary school in 1999, 1.0 cm larger than their Japanese peers. One last example: fresh men in primary school in Korea in 2012 rose to middle school fresh men in 2018 by 35.5 cm, 0.6 cm less than Japanese peers, while per capita caloric supply from animal products

in 2018(5-year average in the preceding 5 years, 2013 to 2017*2) was 592 kcal/day in Korea, 86.3 kcal larger than in Japan.

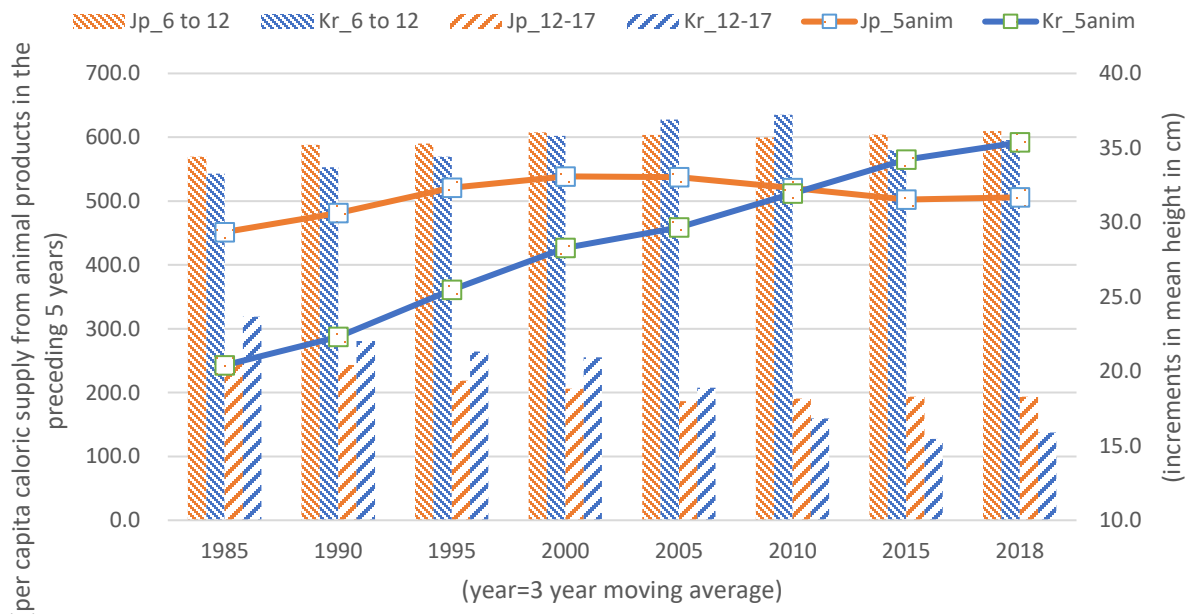
Korean school boys grew from fresh men in middle school (12) to seniors in high school (17) 2 to 3 cm faster than their Japanese peers for the period from the mid-1980s to the mid-2000s but Korean boys began to grow 2.0 cm slower or less than their Japanese peers since 2010, despite that per capita supply of animal products kept increasing toward the end of the 2010s, while Japan started to decline gradually in respect of per capita caloric supply of animal products in the mid-2000s. When glimpsing over mean height of high school senior boys from the mid-2000s to the end of 2010s, 3-year averages, Korean teens were *nearly constantly* 3.0cm taller than their Japanese peers. Carefully examined, though, by growth patterns of birth cohorts, Korean children may not have been stably taller, or faster in growth velocity than their Japanese children over the same period.

In human biology, "the earlier years of life" are key determinants of future adults' height, as mentioned earlier. Korean school boys in the earlier grades of primary school, 1st to 3rd grades of primary school, were nearly 4 cm taller than their Japanese peers in the end of the 2010s. Does this imply that Korean high school seniors will be that much taller than their Japanese peers in the end of 2020s?

As observed just above, Korean school boys started to grow slower in respect of increments from 1st graders in primary school to 1st graders in middle school and again more distinctly slower from 1st graders in middle school to senior graders in high school since the early-2010s (Figure. 5). We cannot sit on comfortably on the "the earlier years of life" theorem. The author would like to discover why Korean children became slower in growth, since the early-2010s, than their Japanese peers, despite that they took more animal-sourced food products than in Japan.

*2 Per capita supply in fiscal year, 2017, starts from April, 2017 to March, 2018).

Fig. 5 Changes in increments in mean height of boys from 6 to 12 and 12 to17, and average per capita caloric supply/day from animl products, Japan and South Korea, 1985 to 2017



Why did Korean children stop growing taller in height in the mid-2000s? — Author's hypothesis

1994 White Paper on Agriculture, Ministry of Agriculture, Japanese government called for public attention on "wakamono no kudamaonobanare" (steering away from fruit by the young) [19]. Based on *Family Income and Expenditure Surveys*, classified by age groups of household head (HH), the *White Paper* discovered that Japan's young started to consume distinctly less fruit at home than what they consumed in the 1970s, and far less than the older adults in their 50s to 60s who kept per capita consumption unchanged in the 1980s, without discussing any further implications. The author designed statistically more robust econometric model to derive per capita individual consumption of commodity items listed in *FIES*, by explicitly incorporating age structure of households classified by HH age groups (Mori and Inaba, 1997; Tanaka, Mori, and Inaba, 2004) [20, 21].

Table 1 displays changes in per capita household consumption of fruit by age groups from the beginning of the1970s to 2010 in Japan, estimated by the author. Children, 0~9 and 10~19, halved their fruit consumption at-home from 1971 to the mid-1980s and further again more than halved to the mid-1990s. Children, 0~9 and 10~19, consumed less than 10% of fruit consumed by those in their 50s and 60s, the older cohorts in the beginning of the 2000s. Virtually none of food economists and nutritionists have agreed with the author and/or some of them contended that the younger people consume fruit in the form of juice rather in fresh form (Iba,1996; etc.) [22] which is not supported by total production statistics of fruit juice, which reached its peak before the mid-1990s(Japan Federation of Soft-Drink Manufacturers Association [23].

Table1 Changes in per capta at-home consumption of fresh fruit by age groups, 1971 to 2010, Japan (kg/year)

	1971	1980	1985-86	1990	1995-96	2000	2008-10
0~9	36.3	26.5	15.2	8.9	4.7	2.3	3.0
10~19	45.6	30.5	20.1	14.9	9.4	5.7	4.7
20~29	48.3	31.5	23.4	16.8	15.1	11.8	10.5
30~39	46.1	43.8	36.6	30.4	23.6	21.8	16.4
40~49	51.0	52.6	48.5	44.9	37.2	33.4	22.6
50~59	54.4	59.9	56.6	54.0	50.5	48.5	36.4
60~	42.9	56.4	60.4	61.2	60.4	63.3	57.1
Grand-ave	45.6	41.6	36.4	33.8	31.5	31.1	28.9

Sources: derived by the author from *FIES*[12], various issues, the TMI model[21].

When the author became involved in the comparative analyses of children's height in Japan and South Korea in 2016, he began to suspect that one of reasons why children in Japan stopped to grow any taller in height in the early-1990s could be attributed to the very fact that they have "steered away" from fruit so radically. A group of researchers in the National Fruit Tree Research Institute, in collaboration with Dept. Epidemiology, Medical School, Hamamatsu University had been engaged in the Mikkabi-machi prospective cohort study, to confirm if large consumption of mandarins tends to reduce the risks of osteoporosis among women in post-menopausal, or help increase bone mineral accrual or density (Sugiura et al., Nakamura et al., 2008-2015) [24, 25, 26, 27]. They refer to the similar empirical studies in other countries, which examined bone-mineral accrual among adolescents by consumption of fruit and vegetables (McGartland et al.,2004; Vatanparast et al.,2005; Prynne, CJ, 2006; Li, J-J.et al., 2012; etc.) [28, 29, 30, 31] Even in Japan, their studies have not been widely received.

It was only two years ago, when the author obtained the Korean version of *FIES* (*Household Income and Expenditure Surveys*), Statistics Korea [13], 1990 to 2019, which are not as detailed as Japan's *FIES*: fruit, vegetables, meats, --are not itemized, such as apples, mandarins, banana, --, for example and monthly expenditures on fruit, vegetables, meats, --are published, without quantities, average prices paid. Fortunately, household expenditures by broad commodities are published by the age groups of HH, with household age compositions for every year attached, which are very helpful to foreign researchers*3.

The author tried to estimate household expenditures on "grain" (≒polished rice), "meat-all" (including processed meats), vegetables, fruit, dairies (including powdered milk for babies), by age groups of household members, 0~9, 10~14, 15~19, 20~29, --, 60~, every year from 1990 to 2019, as summarized in Tables 2-A, B, C and D, in terms of % of expenditures by households headed by those in their 50s, each year, with per capita supply in kg, derived from *Food Balance Sheet*.

The author has repeatedly stated that South Korea has supplied on per capita basis nearly twice as much vegetables as Japan since the mid-1980s and this might have contributed to the taller height of Korean teens in the 2000s, on the tacit assumption that children in South Korea eat as much vegetables as the national averages. Table 2-A very clearly demonstrates that the author was totally mistaken in assuming until very recently that children in Korea should be eating as much vegetables as grown adults, i.e., children under 20 consumed one half as much vegetables as those in their 50s in the beginning of the 1990s, one third in the early 2000s and barely one tenth in the end of the 2010s. The young in South Korea started to steer away from vegetables shortly before

the 1990s. With the close observation of at-home fruit consumption in Japan and rice consumption in South Korea since the early 1980s, the author was certain that the newer cohorts in South Korea would decrease rice consumption, not because rice was "inferior goods" and/or abnormally expensive in price but likely because the newer cohorts in South Korea proved negative in rice consumption (Mori and Stewart, 2011) [32].

Table 2: Changes in per capita household expenditures by age groups, 1990 to 2019

	A: vegetables(% of the 50's)						
age group	1990-91	1995-96	2000-01	2005-06	2010-11	2014-15	2017-19
0-9	49.8	31.4	30.5	19.4	12.6	13.6	8.5
10~14	51.8	34.5	34.1	22.5	15.3	15.1	10.1
15~19	51.6	35.1	36.5	25.9	18.9	16.8	12.9
20~29	55.2	42.1	43.8	34.5	27.7	25.5	22.4
30~39	73.3	64.7	62.3	54	48.2	50.2	45.6
40~49	96	87.8	85.5	78	72.6	73.3	68.1
50~59	100	100	100	100	100	100	100
60~	95.1	98.3	104	107	116.2	121.1	130.5
per capita	(kg/year)						
supply	131.7	156.4	154.5	149.7	143.4	145.6	142.5

	B: grain≒rice (% of the 50's)						
age group	1990-91	1995-96	2000-01	2005-06	2010-11	2014-15	2017-19
0-9	45.1	30.2	35.4	28.4	9.6	14.5	8.3
10~14	54.2	38.6	42.4	32.8	13.8	18.8	10.6
15~19	58.1	43.9	47.5	36.5	18.7	24	13.5
20~29	54.9	44.1	51.8	40.6	25.8	33	19.6
30~39	69.5	61.3	61.8	55	42.5	48.2	40.6
40~49	97.2	89	82.4	77.7	68.7	70.8	68.1
50~59	100	100	100	100	100	100	100
60~	101.8	105.7	107.4	125.2	138.2	136.9	155.5
per capita	(kg/year)						
supply	121.4	111.5	101.2	84.9	82.4	74.6	72.6

	C: meat-all(processed meats included)(% of the 50's)						
age group	1990-91	1995-96	2000-01	2005-06	2010-11	2014-15	2017-19
0-9	41.4	39.6	49.5	41.4	45.2	49.8	48
10~14	42.6	41.7	52	46.2	49.6	52.9	48.4
15~19	38.5	37	50.7	47.1	49.2	53	46
20~29	45.1	43.2	54.8	50	50.1	52.6	44.3
30~39	72.3	72.9	73.8	66.6	69.9	70.4	67.8
40~49	95.6	95.6	93.7	91.8	98.2	93.3	91.9
50~59	100	100	100	100	100	100	100
60~	92.5	98.1	96.1	98.7	88.1	87.4	92.8
per capita	(kg/year)						
supply	24.2	33.4	37.9	37.5	44	52.2	56.4

	D: fruit (% of the 50's)						
age/years	1990-91	1995-96	2000-01	2005-06	2010-01	2014-15	2018-19
0-9	52.5	42.2	45.3	52.5	41.6	35.4	30.1
10-14	54.0	42.6	46.9	52.5	39.3	35.2	30.0
15-19	53.0	42.1	47.6	52.5	37.0	33.8	28.5
20-29	60.4	52.0	56.1	53.5	42.5	39.6	31.6
30-39	74.1	71.5	71.3	71.3	70.4	65.9	58.4
40-49	90.3	87.8	87.9	83.3	87.8	85.4	83.6
50-59	100.0	100.0	100.0	100.0	100.0	100.0	100.0
60-	104.8	92.3	101.5	101.5	89.2	91.1	96.8
per capita	(kg/year)						
supply	52.1	66.5	70.8	72.5	67.3	55.1	52.5
Sources: Derived in current won from Kr *Household Expenditure Surveys*, by Mori							
by means of the TMI model [21].							
KREI, *Food Balance Sheet*, various issues, for per capita supply (A,B, and C).							
FAOSTAT, *Food Supply Sheets*, for fruit (for D).							

As the newer cohorts, born in the 1970s, turned away from rice consumption at home, the young in South Korea are estimated to eat half as much rice in the early-1990s as the older cohorts, born in the 1960s. The newer cohorts started to eat less and less rice, as the economy progressed and those children under 20 years of age are estimated to eat only one tenth of rice consumed by the older cohorts in the age of 50s and 60s in the end of the 2010s (Table 2-B). The author is surprised to find that the negative cohort effects in rice consumption in South Korea have proved more pronounced than estimated a decade ago, based on data from 1982 to 2002 (Mori and Stewart) [32]. Unlike Japan's young, however, Korean children have not steered away from fruit (Table 2-D).

Changes, or drastic decreases in vegetables by newer cohorts seem to have accompanied decreasing rice. As the newer populations ate more bread, burgers and noodles, they tended to eat less Kimchi. Japanese consumers take a few pieces of *Tsukemono*, like *Takuan*, when they eat rice (Gohan), but only a few small pieces, far less comparable to Kimchi, leader of vegetables (Figure.2; Table 3 in Lee, H-S, KJ Duffey and BM Popkin, 2012; Kim, EA et al, 2016) [33, 34]. Kimchi is not simply salty, fermented vegetables. Anyway, the newer cohorts in Korea started to consume drastically less vegetables.

*3 The author relies on the *National Census*, *Shohijittai Chousa Houkoku*(*National Consumption Surveys*) which takes place every 5 years by Bureau of Statistics, on more detailed items on greater number of samples, and other side surveys in Japan.

Conclusions

Unlike Japan's economy, which turned stagnated in the early-1990s, South Korea's economy has kept fantastic progress until the end of the 2010s. Korean children kept increasing in height, overtaking their Japanese peers in the mid-2000s but they suspended to grow any taller since then. As the economy expanded in GDP, per capita supply of animal products kept increasing but children suddenly ceased to grow taller. It was discovered by the author with careful analyses of *Household Expenditure Surveys* that children started to steer away from Kimchi≒=vegetables in the early 1990s. With very little background in human biology, the author is beginning to suspect that reasonable amounts of vegetables and/or fruit should be essential in making intakes of animal protein effective in human metabolism (Stephan Peters, 2020) [35].

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Conflicts of Interest:

The author declares no conflicts of interest.

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