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Plateauing of Children's Height in Japan and South Korea—Unhealthy Eating Habits

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Abstract

When discussing the determinants of height, most studies have tried to identify changes in food consumption, particularly animal protein, in terms of simple per capita averages of population, without explicit attention on age/cohort identification of children in growing ages. In modern societies, where generational effects are more prevalent in individual food consumption, greater efforts to identify changes in individual consumption by age/cohort in the populations are crucial. Such analysis shows that younger generations have turned away from fruit in recent decades in Japan, while the older generations in their 50s to 60s still eat reasonable amounts of fresh fruit today. In order to determine major correlates of children's height in food consumption, either cross-sectionally or over time, explicit efforts are required to determine changes in per capita food consumption by children, as distinct from mere per capita consumption of the full population. *Family Income and Expenditure Surveys* by Japan's Statistics Agency started to provide data classified by age groups of household head (HH) in the 1970s. One can estimate per capita consumption of selected products by household members by age, with statistical precision. Statistics Korea followed suit. The author statistically refined the statement, "steering away from fruit by the young" used in the Japanese government *White Paper on Agriculture, 1994*, to surmise that radical reduction in fruit consumption by Japanese children in the 1980s-90s should be responsible for the plateauing of children's height in the 1990s. Children in South Korea started to reduce consumption of vegetables appreciably in the early 1990s and further continued this tendency to eat only about 10% of vegetables eaten by the middle aged adults in their 50s in the end of the 2010s. Children in Korea grew much faster than their Japanese peers to outgrow them by 3.0 cm in the early 2000s and then ceased to grow any taller. The drastic reduction of vegetables by the young should have something to do with the cessation of height growth, in the midst of economic expansion in South Korea.

Keywords: Height, Children, Japan, South Korea, Fruit/Vegetables, Cohort Effects

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Introduction

In the past half century, children in Japan and South Korea grew rapidly in height, as their living standards steadily improved, with South Korea two decades behind Japan due to the Korean War (1950-53). Children in Japan plateaued in height in the early-1990s, whereas Korean peers kept growing taller to overtake Japanese by 3.0 cm in mean height in the mid-2000s and then stopped growing any

taller, while the economy prospered and consumption of animal protein kept increasing (Japanese government and Republic of Korea, *School Health Surveys*).

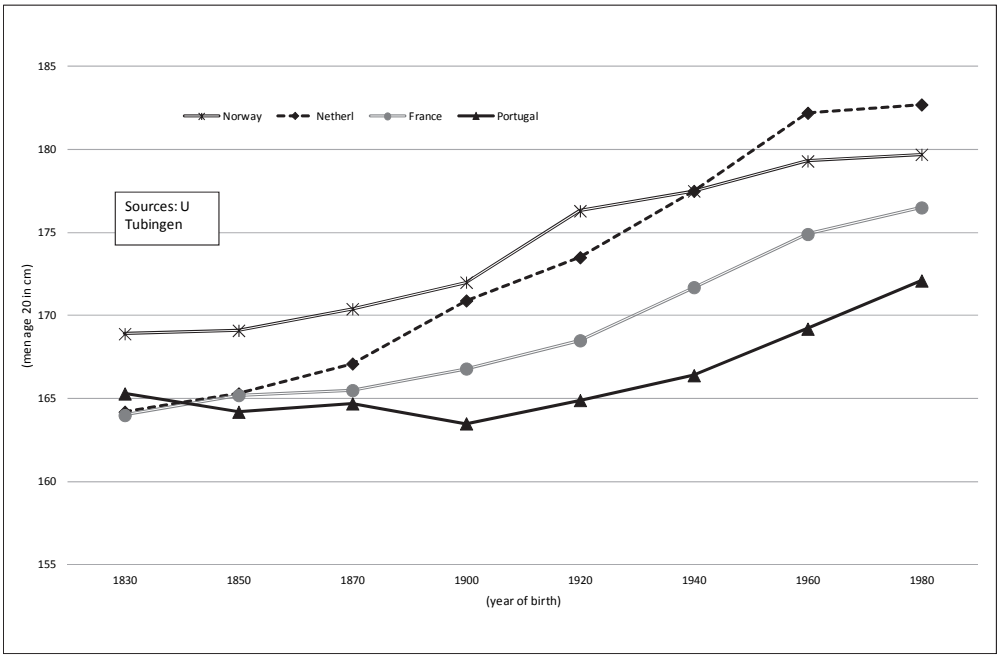
One common assumption is that the two nations have attained or depleted gene potential in height, (Kopczynski, 2016, p.56).

Asians are distinctly different from Caucasians, particularly in respect of head structure, hair color, eye color, etc. If populations in South and North Korea are "identical in gene potential" (ibid. p.57), the 3 cm differences in mean height, observed between South Korea and Japan in the 2000s, should not be attributed to "the Koreans' higher gene potential" (ibid. p. 57). Based on the objective school health survey of Korean School, Osaka, Japan, Kim, Y.S. concludes that Korean children born and raised in Japan proved statistically not bigger in stature than Japanese school children in the neighborhood, although they were distinctly taller and heavier than their peers in South Korea at the same time, reflecting differences in standard of living (*Annals of Human Biology*, 9, No. 5, 1982).

Until 7 years ago, when the author began involved in bio-economic investigation of human stature, he had been a simple believer that Seiyojin, Westerners, are tall in height, while Orientals are short, based on his personal shock to meet a group of US GIs soon after the war.

He learned that people in Northern Europe, widely conceived taller than those in Southern Europe, were 165+ cm tall in mean height (conscripts) some 100 years ago. As shown in Fig. 1, the Dutch, currently the world tallest (Mori, 2022, *FNS*), were 165 cm in mean height, the same as the French in 1870 (1850 birth cohort), and 4 cm shorter than Norwegians. In 1940 (1920 birth cohort), Norwegians were still 4

Fig. 1 Changes in mean height of young men (age 20), France, Netherlands, Norway and Portugal, by Birth Year, 1830 to 1980



cm taller than the Dutch but the differences were reversed in the latter half of the 20th century, i.e., the Dutch were 4 cm taller than the Norwegians. The "gene potential approach" should not be applied without sufficient anthropological evidence (Tubingen University).

Based on the quantitative analyses of *Family Income and Expenditure Surveys*, classified by age groups of household head (HH) by the Bureau of Statistics, Japanese government, diary-type surveys of 8,000 households across the nation, in 6 months rotation, the author estimated age/cohort tables of major food groups, rice, fish, meat, vegetables, fruit (minor product groups such as beef, pork, --, apples, oranges, as necessary) since the early 1970s (Mori ed., 2001). To fortify the argument of wakamono no kudamono-banare (steering away from fruit by the Japanese young) in Japan, *White Paper on Agriculture, 1994*, Japanese government, the author and his colleagues engaged themselves in detailed analyses of secular changes in at-home consumption of fruit and vegetables by household members by age groups, including infants. The summary tables of fruit and vegetables from the early 1970s to 2010 are transcribed in Tables 1-2.

Tanaka and the author, 2003, predicted at-home fruit consumption in 2010, 10 years ahead, based on their cohort analyses of *FIES* data from 1980 to 1999. Mori and Stewart, 2013, examined how close

Table 1 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

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-age intervals.

Table 2 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	71.8	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

Sources: The same as Table 1.

Tanaka's predictions have turned out, analyzing *FIES* data, 2000 to 2010, published in 2011-12. Mori and Stewart discovered that the cohort analysis proved very efficient in predicting future consumption, a decade or two ahead, with economic variables set-aside.

Mori hypothesized that the plateauing of Japanese children's height in the early-1990s could have been caused by the radical reduction in per capita consumption of fruit and vegetables by children in growing ages, which started in the mid-1970s. Per capita consumption of fruit has been increasing steadily in South Korea over the corresponding period and per capita consumption of vegetables has been considerably larger in Korea than in Japan (Lee, Duffey and Popkin, 2012; Mori, 2018, 2019). The author was tempted to suspect that South Koreans may have "depleted in reserves height gene potential" (Kopczynski, p. 57), when children in Korea ceased to grow taller in the mid-2000s.

Steering away from vegetables by the young in Korea

As briefly mentioned earlier, children in South Korea grew very fast in height, while their Japanese peers plateaued in the early-1990s. However, Korean children abruptly stopped growing any taller in the mid-2000s and seem to be shrinking slightly in the end of the 2010s (Mori, Cole, and Kim, 2021; Mori, 2022). Mori decomposed *Household Income and Expenditure Surveys*, classified by HH age groups, Statistics Korea, 1990 to 2019, furnished by Kim, Sanghyo, to discover that the young, particularly children in growing ages started to turn away from vegetables in at-home consumption in the early 1990s or maybe a little earlier[1] and consumed only 10% of vegetables eaten by the older cohorts in their 50s to 60s in the end of the 2020s (Table 3). Table 4 presents the results of age/ period/ cohort decomposition of Table 3 (age 0-9 group excluded), standard cohort table of household vegetable expenditures in 2010 constant Wons (≒consumption), which clearly demonstrates radically declining cohort effects in vegetable consumption in South Korea.

Table 3 Changes in per capita household expenditures on vegetable in Korea, 1990-2019

(in 2010 Wons)

	1990-91	1994-95	1999-00	2004-05	2009-10	2014-15	2018-19
0~9	15390	11021	8430	4776	2842	2701	1658
10~14	19357	14628	11055	6289	3920	3422	2154
15~19	18857	14565	11026	7017	4502	3640	2637
20~24	18006	14848	10702	7966	5090	4269	3427
25~29	22707	19571	12339	10148	6709	6473	5425
30~34	24865	23465	13498	12524	9113	9703	8316
35~39	28588	27873	16168	14875	11827	11458	10666
40~44	32685	32067	21491	17538	14538	14246	13045
45~49	35340	35472	24298	20287	17438	16421	15843
50~54	35621	38062	26779	22859	19977	19271	19203
55~59	35645	40027	29460	25112	23163	22726	22733
60~64	37251	39646	31324	26487	25949	25833	27090
65~	30076	32696	28586	23835	25233	24744	27592

Sources: Derived from *Household Expenditure Surveys*, classified by HH age groups, by the author, using the TMI model.

Table 4 Changes in individual household expenditures on vegetable decomposed into age, period and (birth) cohort effects, South Korea, by Bayesian Estimator (in 2010 won/month)

Grand Mean Effects=19484 (9.9)

age	age effects	t values
10~14	-5137	-3.1
15~19	-5670	-4.0
20~24	-6019	-5.2
25~29	-4386	-4.9
30~34	-2797	-4.2
35~39	-1025	-2.0
40~44	1150	2.2
45~49	2738	4.1
50~54	4043	4.5
55~59	5549	4.8
60~64	6910	4.9
65~69	4646	0.8

$\Sigma A_i = 0$

year	period effects	t values
1990~91	7218	7.6
1994~95	6986	10.0
1999~00	-273	-0.6
2004~05	-2794	-7.4
2009~10	-4287	-8.9
2014~15	-3689	-5.3
2018~19	-2981	-3.1

$\Sigma P_t = 0$

born	cohort effects	t values
~1921	1580	0.6
1925~29	3556	1.5
1930~34	5416	2.7
1935~39	6060	3.5
1940~44	6144	4.3
1945~49	5287	4.6
1950~54	4326	4.8
1955~59	2599	3.8
1960~64	704	1.3
1965~69	-903	-16.1
1970~74	-1806	-2.6
1975~79	-2434	-2.7
1980~84	-2973	-2.6
1985~89	-3390	-2.4
1990~94	-4546	-2.6
1995~99	-5568	-2.8
2000~04	-6613	-2.9
2005~09	-7439	-2.9

$\Sigma C_k = 0$

Notes: estimates for the older and newer cohorts are not dependable, due to the fewer observations.

Sources: Table 3, standard cohort table, was decomposed into age/ period/ cohort effects by the author, using Nakamura's Bayesian cohort model.

People in Korea are linked to Kimchi, fermented vegetables, in the minds of many people including the author. People in Japan pick Tsukemono, pickled vegetables: salted-radish (Takuan), Chinese cabbage, cucumber, eggplant, when they eat bowls of rice, but they "pick" only a few pieces. On the contrary, people in Korea *eat* Kimchi with rice. It was inconceivable for the author to imagine Koreans to turn away from vegetables (≒Kimchi) in diets, young as they are.

Expenditure Surveys, classified by HH ages, Statistics Korea, do not classify grain into rice, bread, noodles, as is the case of Japan's *FIES* but provide "grain-processed", which should include bread, noodles and instant ramen. It should be a close approximation to assume that household expenditures on "grain" in recent years may represent mainly those on polished rice. Appendix Table 1 provides expenditures on grain and grain-processed in ratios classified by HH age groups, 1990 through 2019. In the early 1990s, the younger households (HH in their 20s) spent 85.5% of total grain expenditures on "grain" and 14.5% on grain-processed, and then in the end of the 2010s, 23.8% on grain and 76.2% on grain-processed, whereas the older households spent 70% on grain (≒polished rice) in the same time. These changes may imply that the younger households have drastically decreased purchases of polished rice to be cooked at home. They consumed mostly rice as main starchy food in the early-1990s but purchased substantially less polished rice than noodles and bread, "grain-processed"[2] in the end of the

2010s, whereas the older households kept purchasing larger amount of rice than processed grain, as compared to the younger households.

Kimchi does not "get along with" bread and hamburgers, as the author was advised by his younger colleague in Seoul. As predicted by Mori and Stewart (2011) by means of cohort analysis, rice consumption by the younger generations seems to have decreased radically in the recent few decades in South Korea. Accordingly, at least in the author's intuition, consumption of Kimchi, or vegetables in the form of traditional Kimchi has drastically declined among the newer/younger cohorts. The author is not an ardent advocate of Kimchi but tends to agree with the view that Fast-Food type diets with slices of tomatoes/onions with burgers and a few slices of BBQ/grilled pork with ramen (Chinese noodle) should be "less varied" (USA TODAY,), or far from a healthy menu (Antti Kahari, 2020; Gert Stulps, 2021).

[1] *HIES* for the earlier years are currently not available to the author.

[2] The author is not certain if Bennto (deep fried pork on rice in box, for example) is included in grain-processed.

Personal Discussions

The author is the youngest son of a big family, born and grew up in an upper-middle class household in the early 1930s, when per capita daily caloric supply averaged 2,100 kcal/day. The war broke out in 1937 and domestic supply of living necessities began to be scarce. The author first experienced every-day hunger when he was in the 5th grade of primary school, which got worse year by year until a few years after the end of the war. When he entered the university (under the old school system), per capita food caloric supply averaged 1,858 kcal/day in 1951 (Table 5). He was free from every day hunger in the fall of 1952, when anyone could purchase bread or have noodles in soup without food-ration coupons, although he had to pay money out of his scholarship. He was thin/short, 51 kg/165 cm, as compared to his eldest brother, 70 kg/170 cm. Our father was 65 kg/160 cm.

The author has two sons, who were born in the mid-1960s, when per capita caloric supply was close to 2,500 kcal/day but meat and milk were 50 and 90 kcal/day, respectively. Both of them are 175 cm tall, not appreciably taller than their playmates. Their children include one boy, who was born in the late 1990s, when per capita supply of meat and milk averaged 170 and 140 kcal/day, respectively (Table 5). He is 181 cm tall and, well-built, maybe because he played baseball in high school. He is a little taller than his contemporaries but not abnormally tall. He does not eat as much meat and/or milk as people in Europe or America. As his mother cares, he eats reasonable amounts of vegetables and fruit, definitely much larger amount than ordinary Japanese peers, as demonstrated by my statistics shown earlier.

The author eats lunch at the students' cafeteria, simply because it is so close to his office. Twenty years ago, it carried bottled milk and orange juice/drinks, which have disappeared (not due to the COVID). A half dozen plates of fruit and vegetable salads were on display for the price range of $4-5, which have also disappeared. When you order "curry and rice", curry roux contains some onions and it comes with a few pieces of pickles, the only vegetables which you eat for lunch or even for the whole day.

When the author goes to the supermarket for grocery-shopping, he, as a food economist, carefully watches who buys what. Most supermarkets place the produce department (fruit and vegetables) near the entrance.

Table 5 Changes in per capita Daily Caloric Supply from Selected Foods in Japan, 1930 to1990-99

(kcal/day)

	Total	Grains	Meats	Fish	Milk	Vegetables
1930-34	2067	1501	6.8	65.2	4.4	50.4
1935-39	2059	1486	8.0	63.6	5.6	50.6
WARS						
1946	1449	1112	3.0	36.0	4.0	36.0
1947	1695	1390	4.0	37.0	4.0	38.0
1948	1851	1440	4.0	41.0	4.0	40.0
1949	1927	1483	6.0	53.0	7.0	42.0
1950	1945	1527	8.0	71.0	9.0	44.0
1951	1858	1356	11.7	50.6	9.4	68.6
1952	1995	1376	14.8	61.2	13.6	67.7
1953	1933	1323	15.6	57.1	13.6	59.3
1954	1951	1336	16.7	58.7	18.2	58.8
1955	2217	1478	16.8	83.5	19.5	72.9
1957	2270	1511	22.5	91.7	26.1	75.6
1960	2385	1429	42.2	91.8	52.9	91.9
1965	2444	1334	61.6	92.2	69.9	93.0
1970~74	2492	1209	91.3	96.4	83.0	92.2
1975~79	2545	1154	123.3	127.2	97.4	80.7
1980~89	2624	1086	143.5	131.3	112.4	81.2
1990~99	2635	1039	144.4	139.4	133.1	86.3

Sources: Minister's Secretariat, *Basic Statistics on Food Demand*, Tokyo, Norin Tokei Kyoukai, 1976. Kayo, N. *Basic Statistics for Japan Agriculture*, Tokyo, Norin-Tokei Kyoukai, 1977.

The young shoppers do not stay long in the produce department. The author is not surprised to find at the check-outs that the young people have no produce, fresh fruit vegetables in their shopping carts. A few young female shoppers have a bottle or two of vegetable juice but no fresh produce. Simply, young home-makers in these days do not feed their children either vegetables or fruit in reasonable amounts. Instead, some of them may procure bottled supplements, as needed.

When the author discovered in published statistics that the young in Korea have drastically reduced at-home consumption of vegetables, he has become confident that either fresh fruit or vegetables or both are “essential nutrients” for normal growth of children. Populations consuming larger amounts of animal protein reach higher average height than countries with less protein consumption (Grasgruber et al., 2014; 2020). However, a high consumption of animal protein alone does not result in increasing body height, if the overall consumption of consumption of calories and other essential nutrients is insufficient (Blum, 2013; Baten and Blum, 2014).

Brief Conclusion

Children grew appreciably taller in height since the mid-1950s, as the standard of living started to improve beyond the pre-war level in Japan. South Korea followed suit, two decades behind Japan due to the Korean War (1950-53). Japanese children plateaued in height in all age segments in the 1990s on,

whereas children in Korea kept growing steadily fast in height to overtake Japanese peers by 3 cm or more in the mid-2000s and then ceased to grow any taller.

In both Japan and Korea, per capita consumption of animal protein was increasing, when children stopped growing taller in mean height. The author discovered one thing in common: insufficient consumption of "essential nutrients", fruit/vegetables among the young, children in growing ages in particular. Japanese children 0~9 and 10~19 in the age bracket consumed only 5 kg/capita of fresh fruit annually, less than 10% of the volume eaten by the older adults in their 50s-60s in 2000. Likewise, children in South Korea are estimated to start to turn away from vegetables shortly before the 1990s and consumed only 10% of vegetables eaten by the older generations in their 50-60s in the end of the 2010s. Cohort effects in food consumption do not easily reveal how they have been formed (Mori and Saegusa, 2010; Okubo et al., 2016). What the researchers are anticipated to share in bio-economics should include: dependable approaches to identify changes in consumption of various food products by age groups, in place of mere per capita consumption of the national populations. Our study covers a period from the 1960s on[3].

[3] *National Nutrition Surveys*, Japanese Ministry of Health and Welfare, started to classify intakes of various food products by broad age groups only in 1996. *Korea National Health and Nutrition Examination Survey*, Korean government, was first published in 1998, followed by the 2nd issue in 2001 and the 3rd one in 2005.

Acknowledgement

John Dyck, formerly Economist, ERS/USDA, edited the manuscript lightly at the author's request.

The views expressed in the paper represents those of the author. Glancing over the manuscript, "Young Colleague from Seoul" sent his review: Conventional idea is that Westerners are taller than Asians, attributing to race and ethnicity. However, average Koreans in the 21st century are taller than French counterparts a century ago. The myth busted.

Another generally accepted hypothesis puts emphasis on the role of protein. But the theory of growth by protein do not fully grasp why people ceased to grow any taller in South Korea after certain points in time despite a cornucopia of proteins.

In this context, Professor Mori's cohort analysis which shows the importance in human growth of fruit and vegetable intakes by children, not simply by total population, can be a paradigm shifting model.

Appendix Table 1 Changes in the ratios of expenditures on "grain" in all grains including processed grains, household expenditures, S. Korea, 1990~2019

(%)

HH age	1990-91	2000-01	2010-11	2018-19
~24	85.9	74.9	45.5	21.5
25~29	85.0	76.6	42.1	26.2
30~34	84.7	76.0	42.3	33.2
35~39	85.6	75.8	45.9	39.1
40~44	86.0	77.1	47.3	40.6
45~49	86.7	78.8	50.6	44.5
50~54	87.6	81.0	57.7	49.0
55~59	88.3	84.0	63.7	59.0
60~64	89.8	83.3	69.8	64.5
65~	88.4	84.4	74.2	73.6

Sources: *Household Income and Expenditures Surveys*, various issues.

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