

# Stature: Key Determinants of Positive Height Trends— The Cases of Japan and South Korea

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## Abstract

Human stature is determined largely by genetics. It is, however, hampered by various adverse effects during the early years of life, such as malnutrition and diseases. In comparing the growth patterns of children in the neighboring two countries, Japan and South Korea, this paper suggests that intakes of vegetables and fruit, particularly oranges, not necessarily meat and milk, during the adolescence period should be beneficial to stature growth of children. The insight was furnished by the findings of the longitudinal cohort studies of residents of Mikkabi-machi by the Fruit Tree Science Institute in conjunction with Hamamatsu School of Medicine that intakes of fruit, particularly mandarins, proved effective in lowering risks of bone loss and osteoporosis in post-menopausal female subjects.

**Keywords:** stature, growth patterns, food consumption, fruit & vegetables, Japan vs. S. Korea

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

## Introduction

By casual observation, children tend to grow tall, when mothers and/or fathers are tall in stature. This contention may apply to individuals within the same race, say the north-eastern Asians and between different races, say the Europeans and Asians. This aspect of the key determinants of human height, genetics, is not the subject of this review article. Majoring in agricultural economics, the author will focus on "the supply of inputs to health," food consumption as a main theme.

People in northern Europe are tall in body stature. The Dutch particularly are often considered to be among the world's tallest. Young male adults in the Netherlands averaged 184 cm in height in the mid-1990s (Schonbeck et al., 2013; J. Amos, 2016; eLife, 2016; etc.). But a look back into the 19<sup>th</sup> century provides a much different perspective. The mean height of conscripts in the Netherland in 1850 was 164 cm, 3 cm shorter than their French peers (Steckel, p.1919), and even 7 cm shorter than current Japanese young men in their 20s (*National Nutrition Surveys*).

Individually as well as over the period and regions/countries, "final body height is subject

to a combination of genetics and environmental factors" (Silventoinen, 2003, p.263; Blum, 2013; Baten and Blum, 2014; etc.) which include hygienic and medical circumstances, food intakes, housing conditions, life styles, education, physical training, labor conditions, possibly climate, etc. Before reaching certain stages of economic and social development, these environmental conditions can be represented by the rates of infant mortality in the relevant societies as proximate indicators (Rona, 2000; Reidpath and Allotey, 2003; Hatton and Bray, 2010; Hatton, 2013; etc.).

Having drafted a couple of notes on secular trends in body stature of Japanese youths after WW II, particularly in comparison with South Korea (Mori, June 2016; Mori, July, 2016; Mori, November 2016), the author has reviewed a number of relevant articles on the growth of body size. Many, if not the majority of which emphasize the importance of early life, the first one or two years after birth, post-neonatal period (Schmit et al., 1995; Deaton, 2007; etc.), for example. There is a saying in Japan, "chiisaku unde, okiku sodateru" (small at birth but raise it grow big). The author, however, is not denying the importance of a healthy pregnancy, well-nourished breast-feeding and well-balanced supplements to infants, etc. But he also believes naively in the importance of intakes of nutrients desirable for every stage of growth of children in life. Qi and Niu (2015) state based on the 2008 national survey in China that the respondents who had less access to nutrients-rich diets during late childhood, at age 14 tend to be shorter when they grow up (p.664).

Personally, the author has two male children, both of whom are 175-6 cm in height, 5cm taller than their contemporaries and approximately 10 cm taller than father and nearly 20 cm taller than mother. When their mother was pregnant, she was advised rigorously by her doctors to refrain from eating much. The babies were both not big at birth. Whether this was a consequence of her doctor's dietary restrictions is not certain. The younger one in particular was very ill, when he was 19-20 months old. As the author recalls, his entire family may have eaten substantially more meat and fruit than the contemporary Japanese middle-class families in the late 1960s and the 1970s, since they lived for some time in the United States and the children often spent months with their parent's friends in the United States, when they were in primary schools and high schools. They were not homeschooled nor participated in iyukus (private after-schools). They were engaged in sports and other activities so they were far from "the sedentary lifestyles" (Murata, 2000).

### **Is the Secular Increase in Adult Height Mainly Determined by an Increase in Growth during the First Years of Life?**

Observing the mean height of conscripts in 11 European countries during the period of 1960-1990, Schmidt et al. (1995) conclude that growth during early life is an important determinant of adult height, because adult height is determined by a genetic potential which is modified by adverse environmental factors such as poor nutrition and infection acting mainly during early life (p.65). This view is shared by a number of researchers in

**Table 1 Secular Changes in Mean Height of Japanese Boys by Age, 1950 to 2010** (cm)

age/year	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010
4-6 ave	102.6	104.1	105.0	107.4	108.1	108.6	109.1	109.4	110.2	109.9	109.9	110.1	109.8
9-11 ave	126.9	129.0	131.0	133.4	134.9	136.1	136.9	137.2	138.0	138.6	138.4	138.6	138.6
14-16 ave	152.1	155.6	157.8	161.6	163.0	164.2	165.7	166.1	166.6	167.5	167.6	167.4	167.7
19-21 ave	161.4	162.0	162.8	165.4	166.5	167.4	169.6	170.6	170.8	171.3	171.7	171.5	170.6
24-25 ave	161.8	162.2	163.0	164.5	165.5	166.5	168.3	169.9	170.7	171.6	170.8	170.9	170.5

Notes: All years represent three year averages, such as 1950=(1949-1951)/3; except 1975=(1975+1976)/2.

Sources: *National Nutrition Survey*, various issues.

**Table 2 Secular Changes in Mean Height of Japanese Girls by Age, 1950 to 2010** (cm)

age/year	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010
3-4 ave	92.7	94.0	95.1	97.4	98.3	98.8	98.8	99.2	99.3	99.2	99.1	99.9	98.9
8-9 ave	119.7	121.4	123.3	125.3	127.0	127.7	128.5	129.3	129.7	130.5	130.2	130.3	130.6
13-14 ave	143.9	146.5	148.7	151.2	152.2	153.6	154.3	154.8	155.4	155.3	155.1	156.1	155.2
18-19 ave	150.8	151.6	152.5	154.0	154.2	155.4	156.5	157.2	158.1	158.2	158.0	158.3	157.8
23-24 ave	150.5	150.7	151.7	153.0	153.7	153.9	155.6	156.8	157.6	157.9	157.9	158.4	157.6

Notes: the same as Table 1.

Sources: the same as Table 1.

biological and social sciences (Ruel.,1995; Silventoinen,2003; Deaton, 2007; Hoddinott et al., 2013; etc.).Cole (2003), depending on the case of secular increase in height of Japanese children by age over the period of 40 years from 1950 to 1990, states that the secular trend in adult height occurs during the first 2 years of life and it is restricted to this period (p. 164).

The young Japanese adults of both sexes increased remarkably in height over the period from 1950 to 1990, nearly 10 cm for males and 7 cm for females and stopped growing any taller since the mid-1990s. Many researchers in anthropology, clinical nutrition, pediatrics, etc., seem to presume that the current Japanese may have reached their genetic potentials (Kouchi, 1996; Murata and Hibi, 1992; Murata, 2000; A. Ali et al., 2000; T. Mizu et al., 2015; etc.). Tables 1 and 2 provide the secular changes in mean height of Japanese children classified by 5 year bracket, with boys from 4-6 to 9-11, 14-16, 19-21 and 24-26 and girls from 3-4 to 8-9, 13-14, 18-19 and 23-24 years old, respectively over the period from 1950 to 2010 by every 5 year. These cohort tables are decomposed into age, period and cohort effects in mean height by means of the Nakamura's Bayesian cohort model (Nakamura, 1986; Clason; Mori et al., 2009; Mori, 2014; etc.), which are provided in Tables 3 and 4. Quick visual inspections of Tables 1 and 2, fortified by the results of our cohort analyses, the period effects and cohort effects, in particular, clearly suggest that the Japanese youths, both males and females, may have ceased to grow any taller in the mid-1990s (The basic cohort model is provided in equation (1) below).

$$H_{it} = B + A_i + P_t + C_k + e_{it} \quad (1)$$

$H_{it}$  : mean height of  $i$  years old at period  $t$

$B$  : grand mean effect

$A_i$  : age effect to be attributed to age  $i$

$P_t$  : period effect to be attributed to period  $t$

$C_k$  : cohort effect to be attributed to birth cohort  $k$

$e_{it}$  : random error

**Table 3 Boys' Height Decomposed into Age/Period/Cohort Effects**

Grand Mean Effect= 148.2 (0.13) (cm)

Age Effects		Period Effects		Cohort Effects	
Age (y. old)		Annual Years		Born in	
4-6	-41.2 (.52)	1949-51	-4.0 (1.5)	1923-27	-2.5 (2.0)
9-11	-13.6 (.32)	1954-56	-2.8 (1.3)	1928-32	-3.0 (1.7)
14-16	15.0 (.22)	1959-61	-1.9 (1.0)	1933-37	-4.2 (1.5)
19-21	19.9 (.32)	1964-66	-0.5 (0.8)	1938-42	-3.6 (1.3)
24-26	19.8 (2.9)	1969-71	-0.3 (0.6)	1943-47	-2.2 (1.0)
		1974-76	-0.1 (0.5)	1948-52	-1.1 (0.8)
		1979-81	0.7 (0.4)	1953-57	-0.3 (0.6)
		1984-86	1.0 (0.5)	1958-62	0.8 (0.5)
		1989-91	1.4 (0.6)	1963-67	1.5 (0.4)
		1994-96	1.8 (0.8)	1968-72	1.6 (0.5)
		1999-01	1.6 (1.0)	1973-77	1.6 (0.6)
		2004-06	1.6 (1.3)	1978-82	1.8 (0.8)
		2009-11	1.4 (1.5)	1983-87	1.9 (1.0)
				1988-92	1.8 (1.3)
				1993-97	2.2 (1.5)
				1998-02	2.0 (1.7)
				2003-07	1.6 (2.0)

Note: Values in parentheses denote standard errors.

Source: Decomposed by the author, using the Nakamura's model.

**Table 4 Girls' Height Decomposed into Age/Period/Cohort Effects**

Grand Mean Effect= 137.5 (0.10) (cm)

Age Effects		Period Effects		Cohort Effects	
Age (y. old)		Annual Years		Born in	
3-4	-40.5 (.30)	1949-51	-3.7 (0.8)	1925-28	-1.7 (1.0)
8-9	-10.7 (.21)	1954-56	-2.6 (0.7)	1930-33	-2.0 (0.9)
13-14	14.9 (.17)	1959-61	-1.5 (0.6)	1935-38	-2.6 (0.8)
18-19	18.3 (.21)	1964-66	-0.3 (0.5)	1940-43	-2.5 (0.7)
23-24	18.0 (1.5)	1969-71	0.1 (0.4)	1945-48	-1.9 (0.6)
		1974-76	0.3 (0.3)	1950-53	-1.4 (0.5)
		1979-81	0.6 (0.3)	1955-58	-0.6 (0.4)
		1984-86	0.9 (0.3)	1960-63	0.3 (0.3)
		1989-91	1.2 (0.4)	1965-68	0.8 (0.3)
		1994-96	1.3 (0.5)	1970-73	1.2 (0.3)
		1999-01	1.1 (0.6)	1975-78	1.3 (0.4)
		2004-06	1.4 (0.7)	1980-83	1.4 (0.5)
		2009-11	1.0 (0.8)	1985-88	1.4 (0.6)
				1990-93	1.6 (0.7)
				1995-98	1.6 (0.8)
				2000-03	1.7 (0.9)
				2005-08	1.3 (1.0)

Note: the same as Table 3.

Source: the same as Table 3..



**Table 6 Comparison of Girls' Height by Age, Jp vs Kr, 1965-2005**

age_y.old	1964-66		1965		1975-76		1975		1984-86		1984		1996-98		1997		2004-06		2005		(cm)
	jp	kr	(jp·kr)	jp	kr	(jp·kr)	jp	kr	(jp·kr)	jp	kr	(jp·kr)	jp	kr	(jp·kr)	jp	kr	(jp·kr)	jp	kr	
1	78.4	72.8	5.6	79.1	74.8	4.3	79.0	76.2	2.8	78.2	76.9	1.3	79.1	77.6	1.5	79.1	77.6	1.5	79.1	77.6	1.5
2	86.9	81.5	5.4	88.3	84.6	3.7	88.0	86.9	1.1	87.6	87.0	0.6	88.4	89.0	-0.6	88.4	89.0	-0.6	88.4	89.0	-0.6
3	94.3	87.7	6.6	95.3	90.2	5.1	95.7	92.9	2.8	95.3	94.2	1.1	96.5	97.0	-0.5	96.5	97.0	-0.5	96.5	97.0	-0.5
4	100.4	94.0	6.4	102.1	97.1	5.0	102.4	100.9	1.5	102.7	102.1	0.6	103.3	103.4	-0.1	103.3	103.4	-0.1	103.3	103.4	-0.1
5	106.3	100.2	6.1	107.8	103.7	4.1	108.9	108.1	0.8	108.9	108.6	0.3	109.4	109.9	-0.5	109.4	109.9	-0.5	109.4	109.9	-0.5
6	111.7	106.5	5.2	113.8	109.2	4.6	114.7	113.4	1.3	114.8	114.7	0.1	115.9	116.0	-0.1	115.9	116.0	-0.1	115.9	116.0	-0.1
7	117.6	112.0	5.6	119.2	116.9	2.3	120.9	119.4	1.5	121.3	121.1	0.2	122.3	123.7	-1.4	122.3	123.7	-1.4	122.3	123.7	-1.4
8	122.6	117.3	5.3	125.1	121.6	3.5	126.6	124.9	1.7	126.8	126.0	0.8	127.8	129.6	-1.8	127.8	129.6	-1.8	127.8	129.6	-1.8
9	128.0	122.0	6.0	130.2	126.5	3.6	131.8	130.1	1.7	132.7	132.2	0.5	132.8	135.5	-2.7	132.8	135.5	-2.7	132.8	135.5	-2.7
10	133.9	128.6	5.3	137.0	131.8	5.1	137.9	135.5	2.4	139.2	137.7	1.5	140.1	142.3	-2.2	140.1	142.3	-2.2	140.1	142.3	-2.2
11	140.4	133.5	6.9	142.6	137.5	5.1	144.8	141.8	3.0	145.5	144.2	1.3	145.6	148.6	-3.0	145.6	148.6	-3.0	145.6	148.6	-3.0
12	146.7	138.7	8.0	149.8	142.0	7.8	150.5	147.8	2.7	150.9	150.9	0.0	152.0	154.2	-2.2	152.0	154.2	-2.2	152.0	154.2	-2.2
13	150.0	144.8	5.2	152.6	148.1	4.5	154.1	152.1	2.0	154.6	155.0	-0.4	155.7	157.5	-1.8	155.7	157.5	-1.8	155.7	157.5	-1.8
14	152.3	149.0	3.3	154.7	152.0	2.7	155.8	154.9	0.9	155.5	157.8	-2.3	156.6	159.0	-2.4	156.6	159.0	-2.4	156.6	159.0	-2.4
15	153.2	152.9	0.3	154.8	154.0	0.8	156.8	155.8	1.0	157.4	159.0	-1.6	157.0	159.7	-2.7	157.0	159.7	-2.7	157.0	159.7	-2.7
16	153.9	154.7	-0.8	155.9	155.6	0.3	156.7	156.7	0.0	157.3	160.0	-2.7	157.6	160.4	-2.8	157.6	160.4	-2.8	157.6	160.4	-2.8
17	154.0	155.5	-1.5	155.8	156.3	-0.6	156.6	156.6	0.0	157.6	160.4	-2.8	158.2	160.2	-2.0	158.2	160.2	-2.0	158.2	160.2	-2.0
18	153.9	155.7	-1.8	155.9	156.6	-0.8	157.6	157.3	0.3	158.0	160.5	-2.5	157.9	161.3	-3.4	157.9	161.3	-3.4	157.9	161.3	-3.4
19	154.1	155.7	-1.6	155.9	157.0	-1.1	156.8	157.2	-0.4	158.0	160.1	-2.1	158.7	161.6	-2.9	158.7	161.6	-2.9	158.7	161.6	-2.9
20	153.7	155.9	-2.2	156.2	157.1	-0.9	157.2	157.6	-0.4	158.2	160.4	-2.2	157.9	161.3	-3.4	157.9	161.3	-3.4	157.9	161.3	-3.4

Sources: the same as Table 5.

About a year ago, the author came across a newspaper article that senior high-school male students in South Korea have stopped growing taller in the mid-2000s at mean height of 173.7 cm, 3 cm higher than their Japanese peers (*Chosun Ilbo*, February 25, 2016). The statistical data, collected by the courtesy of Professor S-W Park (2016), revealed the fact that the Korean youths leveled off in mean height with their Japanese peers in the mid-1980s and became 2.0 cm taller in the mid-1990s and 3.0 cm taller in the mid-2000s than their Japanese peers.

Tables 5 and 6 compare the Japanese children, by both sexes, by age from 1 to 20 years old with their Korean peers in mean height over the period from 1965\*<sup>1</sup> to 2005. The Japanese boys at 2-3 years of age were nearly 4.0 cm, approximately 4% taller than their Korean peers in the mid-1970s and those at age of 13-14 were 4.0 cm taller than the latter in the mid-1980s. But the Japanese boys at age 20 were 2.5 cm shorter than their Korean peers in the mid-1990s. The Japanese boys at 3 years of age were 1.9 cm taller than their Korean peers in the mid-1980s but the first at 20 years of age in the mid-2000 were 3.3 cm shorter than the latter. Almost the same phenomena are observed with the girls from 1 to 20 years of age in the two countries over the corresponding period.

What draws the author's attention is the statistical fact that the Korean boys tend to grow remarkably faster than the Japanese boys past the age of 14-15 and similarly the Korean girls grow much faster than their Japanese peers past the age of 13-14. Can this be explained by the supposed differences in "net nutrition in the first years of life" (Deaton, p. 13232) between the two countries over the period in question? Given the fact that South Korea was far behind Japan in terms of per capita GNI and per capita food supply, meat and milk, in particular, in the 1970s and 1980s\*<sup>2</sup>, this presumption cannot be taken as a plausible explanation for the taller Korean youths than their Japanese peers in the 1990s through 2000s.

### **Food Consumption as Key Determinants of Human Statue**

Normally, men reach their peak in height around the age of 20 and women around the age of 18 in the modern societies. Changes in socio-economic and hygienic conditions may not affect human physical height any further after one has passed these maturity ages. Children in the same country or even within the limited areas of the country should vary distinctly in the growth pattern of height, e.g., some children grow fast when they are in junior high-schools, while others grow distinctly fast after they finish senior high-schools,

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\*<sup>1</sup> The years 1965, 1975, 1984, 1997, and 2005 are only available for the body size data for children by age in South Korea. J-Y Kim et al., 2008; J-S. Moon, 2011.

\*<sup>2</sup> S. Korea achieved a rapid and steady economic progress since the beginning of the 1970s, where per capita GNI increased from \$640 in 1975, to \$2,510 in 1985 and \$11,650 in 1995, whereas that of Japan increased more moderately from \$5,060 to \$11,360 and \$41,270 over the same period (World Bank national account data file). Per capita supply of meat increased remarkably in Korea from 7.1 kg in 1975 to 18.4 kg in 1985 and 38.4 kg in 1995, whereas that in Japan increased from 23.4 kg to 33.7 kg and 44.1 kg over the same period, as will be provided in Table 10, below.

although either type should stop growing normally after they have reached the age of maturity, boys at 20 years of age and girls at 17-18. When children grow bigger in stature, they tend to eat more and less likely, though, they tend to grow bigger in stature, when they eat more. It is practically plausible that they should only be heavier, as they eat more. This premise applies to individual children but to a mass of growing children, as well.

What factors are behind the statistical facts observed in the preceding section that the Japanese children in their early life were distinctly taller in height than their Korean peers during the 1970s through 1980s but they were distinctly shorter than their Korean peers 10 to 20 years later after they passed their adolescent period lately in the 1990s and 2000s. One straightforward answer should be the alleged differences in genetics that the Japanese had long been shorter than the Koreans “ethnically” (S. Pak, 2016). The author came across a journal article which confirms this contention. Choi and Schwekendiek (2009) show the data that average height of Korean Seodaemun Prison male inmates, 20-40 years of age in the early 1930s during the period of Japanese colonization were recorded at 164-65 cm, 4-5 cm taller than the Japanese male adults in their 20s to 40s then. *The National Nutrition Surveys* by the Japanese government, 1949-1951, show that males in their 30s in 1950 averaged 160.4 cm and those in their 40s and 50s 159.2 and 157.7 cm in height, respectively, indicating that Japanese young men in the 1920s through 1930s should have been slightly lower than 160 cm in mean height\*<sup>3</sup>.

The average height differences of these magnitudes should not be overlooked to presume too easily that Koreans and Japanese ethnically belong to the same race. There exist, however, a number of academic observations to show that people in the north-eastern regions of Honshu, Japan are a few cm taller than those in the south-western regions (Akiyama et al., 2006; Yokoya, 2010; Hamazaki, 2016; etc.). The regional differences in height may apply to Korea (M. Kimura, 1993, Table 6, p.645). It is often remarked with good evidence that people in the southern parts of China are remarkably shorter than those in the northern regions such as Manchuria. As stated in the Introduction, young Dutch men were shorter than their French peers one and half centuries ago but they are now more than 7-8 cm taller on average than the latter. As a personal inclination, the author would like to refrain from attributing all the differences in body size easily to the ethnic origins, whether the Westerners or the Asians, or between the regions in question. Moradi and Hirvonen (2016), in exploring “the African Enigma: the mystery of tall African adults”, state that environmental factors are more likely candidates to explain the catch-up growth, rather than genetics (p.17). Over the long spurn of time, say 50 years or a century, the average body height of a chosen ethnical origin can be affected appreciably by changes in

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\*<sup>3</sup> According to different data sources, statistically more comprehensive than ad hoc observations of the limited subjects (Kimura, 1993; Choi and Schwendiek, 2009; etc.), Japanese male adults in their 20s in and around 1930 were recorded at 163-4 cm in height (Umemura, 1988; H. Matsuda, 2003). Personally, spending 15 years or so in Seoul before the end of WW II, the author had not intuitively perceived distinct difference in body height between Korean people and Japanese expatriates.



the standard of living, including food intakes, particularly for this review note.

There seem to exist almost unanimous agreements in bio-medical and social sciences that under the given genetic and early life health conditions, human adult stature is largely determined by nutritional intakes, in terms of total calories and animal proteins, in particular, across the countries over the long-spun of time, say 50 years or a century or two (Fogel,1994; Silventonien, 2003; Cole, 2003; etc.). Above all, milk and dairy products and meat are considered as major determinants of growth in stature (Hoppe et al., 2006; Baten, 2009; Berkey et al., 2009; Beer, 2012; Grasgruber et al., 2014 and 2016; etc.). Needless to mention, people cease growing in height at the ages of maturity, as mentioned above. Anything in any amount taken after one passes this maturity does not contribute to any further increases in height. It is therefore desirable to take the nutrient-intakes by age groups, say under 5, 6-10, 11-15 and 16-20 during the children's growing period, in place of simple per capita supply of any food products based on food balance sheets, to explain the secular changes in body height by countries or regions. When one compares countries which differ much in the age structure of populations with apparent cohort effects present (Mori, Inaba, and Dyck., 2016), this consideration is important, if not crucial for the correlation analyses of adult height by countries or regions.

Tables 7, 8 and 9 provide per capita at-home consumption of fresh meat, fresh fish and fluid milk by age groups in Japan from 1980 to 2010, derived by the author from the annual consumption data classified by the age groups of household head, *Family Income and Expenditure Surveys*, using the TMI model (Mori and Inaba, 1997; Tanaka, Mori, and Inaba, 2004), built after “the behavioral equations” (Prais,1953). As regards fresh meat consumption, children in their high-teen age years consume substantially more than those in their middle and old age but their per capita consumption kept unchanged over the 30 year period from 1980 through 2010, whereas per capita consumption of household members in the middle and old age groups increased remarkably over the same period. In regard to fresh fish consumption, total average per capita consumption decreased steadily from 14.3 kg to 11.0 kg and the children in their high-teen age group, in particular, drastically decreased their fresh fish consumption from 10.9 kg to 2.9 kg from 1980 to 2010. Total per capita fluid milk consumption at-home increased steadily from 25.2 l in 1980 to 31.5 l in 1990 and kept growing to 32.4 l in 2000, whereas the children in their high-teens decreased their at-home consumption from 28.3 l in 1990 to 25.9 l in 2000 and further down to 19.5 l in 2010.

To the best knowledge of the author, there are no published data concerning per capita food consumption by age in S. Korea comparable to Tables 7 to 9, above. According to food balance sheets published in FAOSTAT, per capita net supply of meat, both fresh and processed meat which includes in and out of home consumption, was 18.4 kg in S. Korea and 33.7 kg in Japan in 1985 and that of milk was 16.9 kg in S. Korea and 73.6 kg in Japan, for example (Table 10). As Grasgruber et al., 2016, surmise, the Japanese youths are predicted

**Table 7 Changes in per capita At-home Consumption of Frsh Meat by Age Groups, 1980 to 2010** (kg/cap)

age/year	1980-81	1989-91	1999-01	2009-11
15~19	16.2	16.9	16.1	16.8
20~24	13.0	13.3	13.4	14.1
25~29	12.4	12.2	13.2	13.9
30~34	12.9	12.4	12.9	14.4
35~39	13.5	13.2	12.9	15.0
40~44	13.6	14.5	13.8	15.6
45~49	13.5	15.1	14.4	15.8
50~54	13.0	14.0	14.6	15.7
55~59	12.0	12.9	14.4	15.8
60~64	11.7	12.0	13.8	16.1
65~69	10.4	10.5	12.2	14.6
70~74	9.0	9.0	10.4	12.4
all age ave	12.1	12.5	12.5	13.9

Notes: 4 age groups, 0~4, 5~9, 10~14, and 75+ not shown.

Sources: estimated by the author.

**Table 8 Changes in per capita At-home Consumption of Fresh Fish by Age Groups, 1980-2010** (kg/cap)

age/year	1980-81	1989-91	1999-01	2009-11
15~19	10.9	7.9	5.0	2.9
20~24	11.4	7.9	5.9	3.7
25~29	12.2	7.9	6.6	4.8
30~34	14.1	10.2	7.9	6.1
35~39	15.4	12.3	9.8	7.4
40~44	15.6	14.6	12.5	8.7
45~49	16.7	17.1	15.2	10.2
50~54	18.6	18.5	18.3	12.1
55~59	19.8	19.1	20.2	14.6
60~64	19.9	19.3	20.3	17.2
65~69	18.5	18.8	19.9	18.2
70~74	17.1	17.8	18.7	17.2
all age ave	14.3	13.4	13.3	11.0

Notes: the same as Table 7.

Sources: the same as Table 7.

**Table 9 Changes in per capita At-home Consumption of Fluid Milk by Age Groups, 1980-2010** (lt/cap)

age/year	1980-81	1989-91	1999-01	2009-11
15~19	26.8	28.3	25.9	19.5
20~24	28.8	26.6	22.9	19.1
25~29	29.8	26.9	21.8	19.3
30~34	27.8	31.4	27.4	21.7
35~39	21.3	31.8	33.1	24.5
40~44	20.0	32.8	36.7	27.1
45~49	21.8	31.9	36.3	28.4
50~54	23.0	31.1	34.6	28.8
55~59	22.4	32.8	35.2	30.1
60~64	23.6	35.7	37.7	32.3
65~69	24.6	36.9	40.9	34.8
70~74	25.0	37.3	43.5	37.0
all age ave	25.2	31.5	32.4	27.1

Notes: the same as Table 7.

Sources: the same as Table 7.

to be 2 cm taller in height than their Korean peers from the model variables of actual per capita intakes of "high-quality proteins" in the two countries (ibid. Fig. 12, a). To repeat, it does not seem plausible to explain the above observed differences in young adult height between Japan and South Korea in recent years by the commonly alleged differences in consumption of animal proteins. As proximate indicators, simple per capita net supply (= consumption), based on food balance sheets, of meat, fish, and milk in the two countries from 1965 through 2000 is provided in Table 10. As mentioned earlier, footnote \*2, South Korea was substantially behind Japan until the mid-1990s in terms of per capita consumption of animal protein foods, milk in particular. As compared with the Netherlands, however, per capita consumption of milk both in Japan and South Korea is substantially smaller in amount. Therefore, it does not seem convincing to attribute any differences in height growth between the two countries to changes in milk intakes.

**Table 10 Changes in per capita Supply of Animal Protein Food Products in Japan and South Korea, 1965 to 2000** (kg/capita)

	meat		fish		milk		reference: Netherlands		
	jp	kr	jp	kr	jp	kr	meat	fish	milk
1965	11.5	5.0	51.6	17.6	38.5	2.8	49.9	12.4	320.5
1975	23.4	7.1	66.6	38.9	51.4	4.2	65.9	13.1	330.9
1985	33.7	18.4	69.6	47.3	73.6	16.9	78.1	13.1	371.4
1990	38.3	25.3	71.5	46.7	78.0	19.3	84.8	10.8	314.8
1995	44.1	38.4	71.2	50.4	82.6	20.7	92.9	17.3	380.0
2000	45.3	47.6	67.3	45.8	81.7	28.0	90.1	21.7	353.2

Sources: FAOSTAT: food balance sheets, countries and years.

### Fruit and Vegetable Consumption and Bone Mineral Density

NARO Institute of Fruit Tree Science, in conjunction of Hamamatsu University School of Medicine, has been conducting the longitudinal cohort studies of the residents of Mikkabi-cho, known for production of quality mandarin oranges, to ascertain intakes of fruit, particularly mandarins, to be associated with bone mineral density continuously for 10 years since 2003. The major and consistent findings include that high intakes of fruits, particularly mandarins, tend to reduce the risk of developing osteoporosis and related fractures among post-menopausal female subjects, by contributing to keeping high serum concentrations of  $\beta$ -cryptoxanthin and  $\beta$ -carotene in blood for better bone health. In a few words, high intakes of fruit and vegetables are clinically found in strong positive associations with bone mineral density, among menopausal female subjects in their cohort studies (Sugiura et al., 2008; Sugiura et al., 2012; Sugiura et al., 2015; etc.). There exist several clinical studies overseas which provide good evidence for positive associations between intakes of fruit and vegetable and bone mineral density for male and female adolescents (McGartland et al., 2004; whiting et al., 2004; Vatanparast et al., 2005; Prynne et al., 2006; J-J Li et al., 2012; etc.).

Traditionally, people in South Korea have been consuming lots of vegetables typically in the form of Kimchi, "largest contributor to vegetable consumption". It is estimated that consumption of Kimchi has risen steadily since 1969 increasing from 58 g to 117 g/person/day in 2009 (Lee, Duffey, and Popkin, 2012, p.619; Kim, E-K et al., 2016; etc.). As shown in Table 11, people in South Korea have been consuming substantially more vegetables than people in Japan since the early 1970s, whereas South Koreans' consumption of fruit was substantially less than Japanese in the 1970s but has risen remarkably since 1980 to the comparable level of Japanese in 1990 and exceeded the latter by 30% in the mid-1990s.

**Table 11 Changes in per capita Net Supply of Vegetables and Fruit in Japan and South Korea, 1970 to 2005** (kg/cap)

year	Vegetables		Fruit	
	Jp	Kr	Jp	Kr
1970	126.8	104.0	53.9	12.3
1975	121.3	147.7	61.9	14.6
1980	122.6	197.9	55.6	23.3
1985	119.5	181.7	51.9	35.1
1990	116.7	200.6	50.2	47.0
1995	116.6	222.3	53.2	69.6
2000	112.8	235.7	51.4	69.6
2005	107.8	215.8	60.3	76.1

Sources: FAOSTAT, Food Balance Sheets, various years.

At-home consumption of fruit in Japan reached its peak on per capita basis in the mid-1970s and has kept declining steadily by 25-30% toward the beginning of the 2000s, whereas that in S. Korea has more than tripled over the same period. Commodity-wise, mandarins (= tangerine) were by far the largest item in Japan, accounting for 45.8% of total fresh fruit consumed at-home in 1974 and 39.4% in 1980. The percentage rapidly dropped down to 18.6% of steadily declining total fruit consumption over the period in question. On the contrary, tangerine was in South Korea a minor item in 1980, accounting for 18.8% in 1980 and steadily up to 26.3% of drastically risen total fruit consumption in the early 2000s.

Tables 12 and 13 provide the author's estimates of at-home consumption of fresh fruit and mandarins by age groups of individual household members from 1980 to 2010. Some 20 years ago, *White Paper on Agriculture-1994* officially expressed a concern on declining fruit consumption, particularly wakamono-no-kudamono-banare (moving away from fruit by the young). Table 12 demonstrates that those in their 20s decreased their fruit consumption from 30kg per person in the early 1980s to a little over 10kg in 2000 and less than 10kg in 2010 and those in the high-teens more drastically reduced it from 29kg to 4.4kg over the same period, while those elderly groups above 60 years of age kept their fruit consumption at fairly high level of 55kg throughout the period. As shown in Table13, the young under their 40s decreased their consumption of mandarins more dramatically from 20kg in 1980 to less than 2.0kg in 2010 and those in their high-teens seem to have quit eating mandarins in the past 20 years or so. As compared to Japan, fruit as a whole and particularly tangerine, grapes, and pears are new comers in the market in the South Korean society

**Table 12 Changes in per capita At-home Consumption of Fruit by Age Groups, Japan, 1980-2010** (kg/capita)

age/year	1980-81	1989-91	1999-01	2009-11
15~19	29.0	15.4	7.6	4.4
20~24	30.3	16.8	10.3	7.8
25~29	31.5	19.4	13.5	12.0
30~34	39.7	27.2	18.5	15.2
35~39	47.0	36.1	24.3	17.9
40~44	49.8	42.8	31.0	20.4
45~49	53.9	48.4	36.0	24.7
50~54	56.9	51.0	44.4	30.9
55~59	57.4	55.9	51.7	39.3
60~64	58.4	59.3	58.1	48.9
65~69	56.3	59.8	61.2	54.9
70~74	55.5	60.3	62.5	57.6
all ages	40.2	33.5	31.5	28.3

Sources: derived from FIES by the author, using the TMI model.

Notes: 4 age groups, 0-4, 5-9, 10-14, and 75+ not provided.

**Table 13 Changes in per capita At-home Consumption of Mandarins by Age Groups, Japan, 1980-2010** (kg/capita)

age/year	1980	1985	1990	1995	2000	2005	2009-11
15~19	9.31	4.82	2.26	1.79	1.18	0.96	0.79
20~24	9.54	4.85	2.69	2.02	1.48	1.01	1.06
25~29	9.60	5.09	3.27	2.25	1.84	1.20	1.34
30~34	11.68	8.82	6.55	2.83	2.74	2.74	1.68
35~39	19.66	9.74	10.12	3.18	3.35	3.45	2.06
40~44	19.39	13.96	11.10	8.13	6.76	4.21	2.49
45~49	20.37	14.52	12.26	8.36	7.42	4.69	3.00
50~54	21.24	14.59	12.70	9.12	8.29	7.34	3.67
55~59	20.52	15.57	14.03	11.72	8.82	8.45	4.58
60~64	20.51	16.51	14.60	12.11	11.70	9.23	7.18
65~69	20.54	16.26	13.91	12.63	12.31	9.92	8.45
70~74	20.59	16.13	13.63	12.86	13.02	10.44	8.90
all ages	14.50	9.60	7.80	6.30	5.90	5.13	4.14

Sources: the same as Table 12.

Notes: the same as Table 12.

**Table 14 Changes in per capita Consumption of Fresh Fruit by Variety in South Korea, 1980-2001** (kg)

Year	Fruit	Apples	Pears	Peaches	Grapes	Kaki	Tangerine	Others
1980	22.3	10.8	1.5	2.3	1.5	0.2	4.2	1.8
1985	36.0	13.0	3.1	3.2	3.7	1.6	9.1	2.3
1990	41.8	14.5	3.6	2.7	3.1	1.5	11.5	4.9
1995	54.8	15.8	3.9	2.9	7.0	3.4	14.0	7.8
1999	56.1	10.5	5.5	3.4	10.2	4.6	13.9	8.9
2000	58.4	10.4	7.6	3.6	10.3	4.8	14.0	8.6
2001	59.2	8.4	8.6	3.5	9.7	4.1	15.5	9.4

Source: S-M Son, "Food Consumption Trends," 2003, Table 3.

Original sources: MAF (2002): The Basic Statistics.

(Table 14). The author, with some 20 year experience in cohort analyses of various food products (Mori et al., 2009; Mori and Saegusa, 2010; Mori and Stewart, 2011; Mori, 2014; etc.), suspects that the young, more precisely the newer generations in Korea are prone to eat more fruit, particularly tangerine, pears and grapes than the older generations, as opposed to the cases of fruit and mandarins in Japan observed in Tables 12-13 above.

### **Brief Concluding Remarks**

There lie no arguments that stature is a net measure that captures the supply of inputs to health: net nutrition in the first years of life (Deaton); intakes of high quality animal proteins, such as meat and milk on the top of total energy intake (Grasgruber et al., op.cit.) before reaching the ages of maturity. In an effort to identify the growth patterns of children

in the two countries, Japan and South Korea, intuitively presumed to be very close in genetic potentials, we have come to notice the crucial differences in food intakes in the past few decades, when the South Korean youths began to exceed their Japanese peers in stature. The young, more precisely the newer generations, in Japan started to eat less and less fruit, particularly mandarins, in and around 1980, whereas people in South Korea started eating fruit, particularly tangerine and grapes, about the same time and in the mid-1990s exceeded Japan by 35% in terms of per capita fruit consumption. As mentioned earlier, the author's gut feeling is that the younger generations in South Korea should be eating more tangerine, the new comer in the market as compared to apples, than the older generations, just opposed to the cases in Japan, shown in Table 13.

The author is not contending vigorously that the children would grow taller in height, if they eat more fruit, mandarins, in particular, or more directly, Japanese children would catch up with their Korean peers in height, if they begin to eat more mandarins. He is, however, seriously concerned that Japanese children have been consuming so little fruit, particularly mandarins in the past few decades, to face possible adverse effects on their health. In the words of Steckel, cited at the outset, "inputs to health" seem to have been somehow inadequate.

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