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Research Article

Children's Height in Japan, South Korea and China: Is Gene Potential Valid for Explaining Differences? An Application of the A/P/C model

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Objectives

Japanese, South Koreans and Chinese have traditionally been shorter than Europeans, but grew appreciably taller in varied patterns but the growth has ended in recent years (Figures 1-2). Have they depleted their genetic potentials [1]?

Introduction

People grow in height as they age from birth to late-adolescence, say 17 or 18 for males and 15 or 16 for females, and cease to grow under normal circumstances. Some grow fast in primary school years, whereas others in high school years. If one is poorly fed in primary school years, he or she may or may not catch-up in growth in later years. In identifying mean height of population, most studies try to correlate the mean height of the young adults, at age 20 with the current nutritional status, such as per capita animal protein [2].

In some countries, like South Korea, for example, per capita protein from animal products rose very quickly from 108 kcal/day in 1970 to 230 in 1980 and 317 in 1990[3]. Children's growth is affected by nutritional situation throughout childhood, including prenatal periods. In conducting international comparisons, correlation between the mean height of young adults and the nation's per capita food supply in a current period could be misleading [4].

In this respect, the age-period-cohort model (A/P/C), as defined in (1), seems to be a robust tool for analysis, if the model is specified in a normal sense, as discussed below.

Hit = B + Ai + Pt + Ck + Eit --------- (1)
Hit: Mean height of subject age i and period t
B: Grand mean effect
Ai: Effects attributable to age i
Pt: Effects attributable to period t
Ck: Effects attributable to cohort k
Eit: Random errors

Data

For Japan and South Korea, we have the observations for school children, 12 age classes from age 6 to 17, every year from 1955 to 2010 for Japan and 1965 to 2010 for South Korea [5,6]. For China, the observations are limited, age from 7 to 18, at 5 year-intervals, from 1985 to 2019 [7]. The author decided not to take every year but 1965, 1970, ----, 2005 and 2010, at 5 year-interval for Japan and South Korea.

Data for age 6, the first year in primary school for Japan and South Korea, are dropped. Also, age 18 is dropped for China, in the recognition that differences between 17 and 18 in mean height are actually very small. Since national surveys are conducted in the first month of the school year, mean height at the beginning of junior school is almost identical to that of the end month of primary school. Thus, age 7 to 12 may actually represent the primary school. In short, we apply the A/P/C model to the two age groups, primary school, from 7 to 12 in age and junior-senior high schools from 12 to 17, uniformly for the three countries.

Findings from the A/P/C model, as applied to changes in male school children's height, Japan, South Korea and China in the past half century.

We have two sets of data of male school children's mean height by age, 7 to12 for primary school years and 12 to 17 for junior and senior high school years, uniformly for the three countries, based on national health surveys[*1] conducted by the national governments.

The author derived age, period and cohort effects of student's mean height, by two age groups of 6 to 12 and 12 to 17 in Japan, South Korea and China in the past half century.

The basic structure of the A/P/C analysis is presented in equation (1)[*2], stated above and looks easy to solve by the ordinary least square approach. However, when k represents birth cohort, p= i + k, the typical multi-collinearity is observed, called "identification problem" in cohort analyses. The author adopts the Nakamura's Bayesian model, which is based on a natural assumption about gradual changes between adjacent parameters, mechanically judged by the objective standards, Akaike's Bayesian Information Criteria [8].

	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010
Jp_7	118.8	120	120.8	121.3	122.1	122.5	122.6	122.4	122.5	122.6
Kr_7	115.2	117.6	118.5	120.5	121.9	123	124.7	125.9	126.8	127.7
Jp_12	144.7	147	148.6	149.5	150.1	151.5	152	152.8	152.6	152.4
Kr_12	141.8	143.7	143.2	145.2	147.6	149.7	152	154.8	156.9	158
Jp_17	166.7	167.9	168.8	169.6	170.2	170.5	170.9	170.9	170.8	170.7
Kr_17	163.8	166.1	166	167.3	168.9	169.7	171	172.9	173.7	173.7

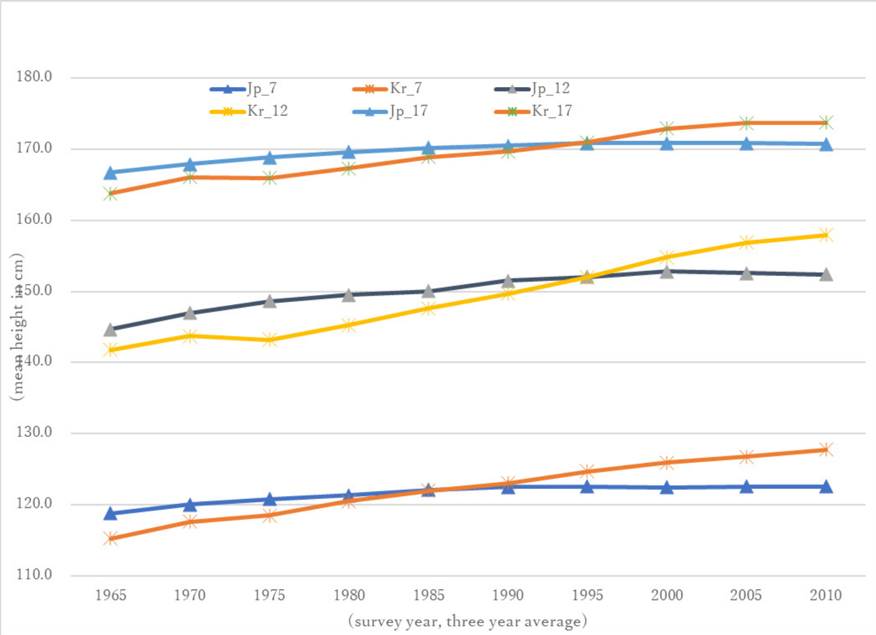

Figure 1: Meam height of school boys at ages, 7, 12 and 17, Japan and South Korea, 1965 to 2010.

	1975	1980	1985	1990	1995	2000	2005	2010	2014	2019
Kr_7	118.5	120.5	121.9	123.0	124.7	125.9	126.8	127.7		
Cn_7			119.51	120.87	122.23	122.58	124.15	125.52	126.62	126.87
Kr_17	166.0	167.3	168.9	169.7	171.0	172.9	173.7	173.7		
Cn_17			167.54	168.24	168.94	170.20	170.78	171.39	172.05	173.03

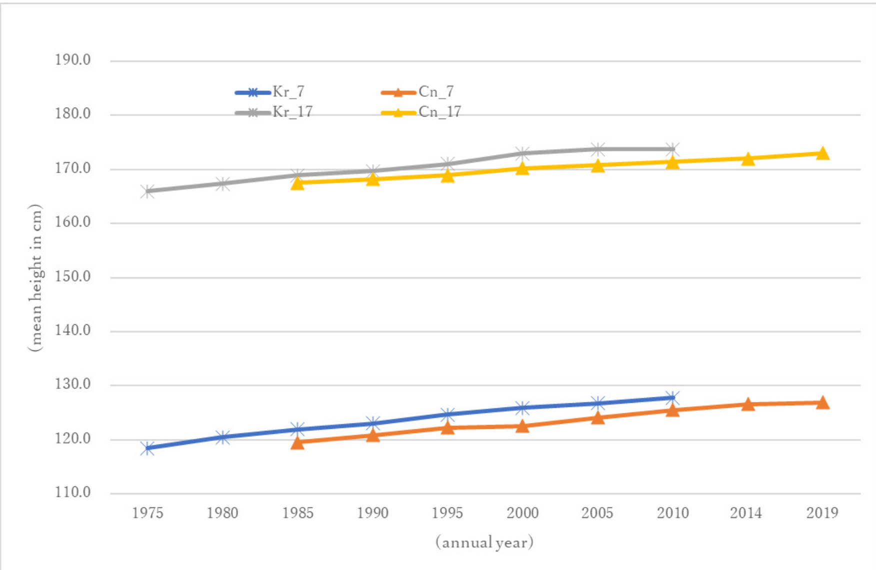

Figure 2: Mean height of school boys at ages, 7 and 17, South Korea and China, 1975 to 2019.

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*1 People vary substantially in height between urban and rural areas and by geographical locations, north-eastern and south-western provinces in China [9], whereas disparities by regions, north and south have virtually disappeared in Japan [9]. The author has no idea of how national average figures of mean height were worked out in the CNSSCH, Chinese National Surveys of Students' Constitution and Health.

*2 For those readers who are not familiar with cohort analyses, it is recommended to refer to declining orange consumption in Japan—generational changes or something else? ERS#71, USDA, Mori, Dyck et al, 2009, pp.23, described for non-mathematicians [10].

First, primary school years, **Tables 1-A, B and C**:

Table 1(A): Changes in mean height of primary school boys in Japan decomposed into age, period and cohort effects, 1965 to 2010.

Grnd Mean Effect=129.33(0.04); ABIC=88.82

Age Effects		SE	Period Effects		SE	Birth Cohort Effects		SE
7	-13.58	0.21	1965	-2.95	0.36	1	-1.23	0.55
8	-8.02	0.14	1970	-1.85	0.29	2	-0.71	0.49
9	-2.58	0.08	1975	-1.02	0.22	3	-0.17	0.41
10	2.61	0.08	1980	-0.51	0.15	4	0.23	0.33
11	7.85	0.14	1985	0.12	0.1	5	0.41	0.25
12	13.72	0.73	1990	0.78	0.1	6	0.54	0.18
ΣAi	0		1995	1.11	0.15	7	0.6	0.12
			2000	1.28	0.22	8	0.62	0.09
			2005	1.45	0.29	9	0.52	0.12
			2010	1.6	0.36	10	0.34	0.18
			ΣPt	0.01		11	0.15	0.26
						12	-0.07	0.33
						13	-0.25	0.41
						14	-0.41	0.49
						15	-0.57	0.55
						ΣCk	0	

Table 1(B): Changes in mean height of primary school boys in S. Korea decomposed into age, period and cohort effects, 1965 to 2010.

Grnd Mean Effect=128.87(0.06); ABIC=158.23

Age Effects		SE	Period Effects		SE	Birth Cohort Effects		SE
7	-12.52	0.5	1965	-6.75	0.89	1	-3.42	1.38
8	-7.48	0.31	1970	-5.29	0.7	2	-2.02	1.2
9	-2.71	0.14	1975	-4.8	0.51	3	-0.9	1
10	2.43	0.14	1980	-2.44	0.33	4	0.13	0.8
11	7.33	0.31	1985	-0.83	0.17	5	0.7	0.61
12	12.95	1.79	1990	0.46	0.17	6	1.51	0.42
ΣAi	0		1995	2.36	0.33	7	1.88	0.25
			2000	4.26	0.51	8	1.55	0.15
			2005	5.83	0.7	9	1.49	0.25
			2010	7.19	0.89	10	1.12	0.42
			ΣPt	-0.01		11	0.77	0.61
						12	0.19	0.8
						13	-0.34	1
						14	-1.03	1.2
						15	-1.63	1.38
						ΣCk	0	

Table 1(C): Changes in mean height of primary school boys in China decomposed into age, period and cohort effects, 1985 to 2019.

Grnd Mean Effect=136.02(0.06); ABIC=122.98

Age Effects		SE	Period Effects		SE	Birth cohort effects		SE
7	-12.71	0.43	1985	-4.65	0.60	1	-1.99	1.01
8	-7.87	0.27	1990	-3.36	0.44	2	-0.87	0.86
9	-2.94	0.14	1995	-1.91	0.28	3	0.06	0.69
10	2.02	0.14	2000	-1.07	0.15	4	0.43	0.53
11	7.65	0.27	2005	0.42	0.15	5	0.51	0.37
12	13.85	1.13	2010	1.98	0.28	6	0.7	0.21
ΣAi	0		2014	3.66	0.44	7	0.8	0.14
			2019	4.92	0.60	8	0.97	0.21
			ΣPt	-0.01		9	0.69	0.37
						10	0.39	0.53
						11	0.03	0.69
						12	-0.53	0.86
						13	-1.19	1.01
						ΣCk	0	

Sources: calculated by the author, using Nakamura's Beyesian cohort model.

Grand mean effects for Japan and South Korea are 129.3 and 128.9 cm, respectively, with very small SDs.

Age effects, from 7 to 12, are quite similar in the two countries, ranging from -13 cm for the 1st grade to 13 cm for the end of 6th grade.

Period effects are not similar at all between the two countries. Japan increased from -3.0 cm in 1965 to 1.6 cm in 2010, whereas South Korea increased from -6.8 cm to 7.2 cm over the same period. South Korean primary school boys increased in mean height by 9.4 cm more than their Japanese peer.

Cohort effects may signify various effects on height incurred during the pre-survey years. Honestly, the author can't explain what they are from (1) to (15) in Tables 1-A and B. What the author suspects is that the Korean primary school boys should carry little bid negative effects on their height in pre-survey years such as insufficient food intakes, as compared with their Japanese peers. But the differences are not large and insignificant statistically.

Second, junior-senior high school years, **Table 2-A, B and C**:

Table 2(A): Changes in mean height of middle-high school boys in Japan decomposed into age, period and cohort effects, 1965 to 2010.

Grand Mean Effect=163.09(0.04)

Age Effects		SE	Period Effects		SE	Birth Cohort Effects		SE
12	-12.99	0.21	1965	-4.42	0.49	1	0.86	0.76
13	-5.42	0.18	1970	-2.43	0.40	2	0.48	0.66
14	0.69	0.10	1975	-0.78	0.29	3	-0.06	0.55
15	4.46	0.10	1980	0.28	0.20	4	-0.70	0.45
16	6.24	0.18	1985	0.77	0.12	5	-0.88	0.35
17	7.02	0.99	1990	1.38	0.12	6	-0.93	0.24
ΣAi	0.00		1995	1.66	0.20	7	-0.85	0.16
			2000	1.70	0.29	8	-0.85	0.12
			2005	1.18	0.40	9	-0.74	0.16
			2010	0.66	0.49	10	-0.41	0.24
			ΣPt	0.00		11	-0.04	0.35
						12	0.37	0.45
						13	0.89	0.56
						14	1.31	0.66
						15	1.55	0.76
						ΣCk	0.00	

Table 2(B): Changes in mean height of middle-high school boys in S. Korea decomposed into age, period and cohort effects, 1965 to 2010.

Grand Mean Effect=162.07(0.15)

Age Effects		SE	Period Effects		SE	Birth Cohort Effects		SE
12	-13.00	0.63	1965	-7.58	1.09	1	0.74	1.63
13	-6.45	0.45	1970	-5.19	0.40	2	0.44	1.44
14	-0.60	0.31	1975	-3.92	0.69	3	-0.35	1.23
15	4.84	0.31	1980	-1.82	0.51	4	-1.45	1.01
16	6.98	0.45	1985	-0.01	0.39	5	-1.86	0.79
17	8.23	2.17	1990	1.24	0.39	6	-1.74	0.59
ΣAi	0.00		1995	2.93	0.51	7	-1.70	0.44
			2000	4.53	0.69	8	-1.71	0.38
			2005	5.04	0.89	9	-1.38	0.44
			2010	4.78	1.09	10	-0.87	0.59
			ΣPt	0.00		11	-0.02	0.79
						12	0.96	1.01
						13	2.19	1.23
						14	3.14	1.44
						15	3.61	1.63
						ΣCk	0.00	

Table 2(C): Changes in mean height of middle-high school boys in China decomposed into age, period and cohort effects, 1985 to 2019.

Grand Mean Effect=163.52(0.05)

Age Effects		SE	Period Effects		SE	Birth Cohort Effects		SE
12	-14.03	0.57	1985	-4.81	0.80	1	1.01	1.36
13	-5.71	0.35	1990	-2.58	0.58	2	-0.15	1.15
14	0.46	0.14	1995	-0.59	0.36	3	-1.24	0.92
15	4.64	0.14	2000	0.34	0.15	4	-1.69	0.69
16	6.91	0.35	2005	0.91	0.15	5	-1.72	0.47
17	7.73	1.52	2010	1.67	0.36	6	-1.60	0.25
ΣAi	0.00		2014	2.17	0.58	7	-1.36	0.11
			2019	2.90	0.80	8	-1.06	0.25
			ΣPt	0.01		9	-0.62	0.47
						10	0.29	0.69
						11	1.46	0.92
						12	2.81	1.15
						13	3.85	1.36
						ΣCk	-0.02	

Sources: calculated by the author, using Nakamura's Beyesian cohort model.

Grand mean effects for Japan and South Korea are 163.1 and162.1 cm, respectively, with very small SDs in both cases.

Age effects, from 12 to 17, for Japan and South Korea are also similar at all ages, ranging from -13.0 cm for 1st graders in junior-high in both countries to 7.0 cm for high school seniors in Japan and 8.2 cm in South Korea with meaningful SDs.

Period effects are quite different at all years. Period effects for Japan in 1965 are -4.4 cm, as compared to -7.6 cm for South Korea. Japan reached the greatest period effects in 1995-2000 at 1.7 cm, whereas South Korea reached the highest period effects at 5.0 cm in 2005. South Korean students increased by 12.6 cm, substantially more than Japanese, which increased by 6.1 cm.

The author does not fully comprehend what "cohort effects" imply in this version of analysis*3. The only thing he can see is that Japan and South Korea are quite similar in patterns and the estimates of cohort effects are not large in value as age and period effects.

*3 When the model is applied to food consumption, age effects refer to pure age, the one in the teens or the fifties, for example, whereas cohort effects refer to generations, such as those born in the 2000s, compared to older generations, born in the 1960s, for example [11].

Chinese Students as Compared to Korean Students
First, primary school years, Tables 1-B and C:
Grand mean effects for China and South Korea are 136.0 and 128.9 cm, respectively, with very small SDs. The difference is substantial. The author has no idea how to explain this.

Age effects for Chinese primary school boys are only slightly wider, from -12.7 to 13.9 cm, as compared to -12.5 to 13.0 cm for Korean primary school boys.

Second, junior-senior high school years
Grand mean effects for China and South Korea are 163.5 and 162.1 cm, respectively, with very small SDs. The difference is statistically significant but not large. The survey started in 1965 in South Korea, 20 years earlier than in China. This may explain the difference.

Age effects for Chinese junior-senior high school boys ranges from -14.0 to 7.7 cm in mean height, as compared to -13.0 to 8.2 cm for South Korean students.

Period effects range from -4.8 in 1985 to 2.90 cm in 2019 for Chinese students, as compared to -7.6 cm in 1965, -0.0 in 1985 and 4.8 cm in 2010 for Korean peers, both kept increasing positively.

Cohort effects are not easy to interpret here again. As stated earlier, cohort effects imply various environmental effects on the current height, such as prenatal nutritional inputs. China and South Korea are common in showing statistically negative effects, in the order of 1.5, on the current heights by age. The effects are statistically minor in value but statistically positive towards the end terms. The author is not experienced to picture the situation.

Conclusion

School children in Japan began to grow only slowly in height in the end of the 1970s in the midst of the bubbling economic prosperity and ceased to grow at all in the mid-1990s. School children in South Korea were substantially shorter than their Japanese peers in the 1970-80s but grew faster in height to catch-up their Japanese peers in the mid-1990s and still kept growing steadily to bypass their Japanese peers by 3-4 cm at all ages in the mid-2000s and then almost suddenly plateaued in height. Per capita supply from animal products is estimated at 474 and 170 kcal/day in Japan and S. Korea, respectively in the mid-1970s, 577 and 275 in the mid-1980, and 578 and 475 in the mid-2000s [3].

Per capita animal protein alone can't explain the changes in the picture. These biological phenomena are well described by a noted historian in Europe: the two nations should have depleted gene potential; the more directly, Koreans should carry higher gene potential. Our estimates in grand mean effects stated above do not support his explanations. The readers are recommended to refer to the authors' notes published lately [12,13]. In short, a high consumption of animal protein alone does not result in increasing body height, if overall consumption of calories and other essential nutrients is insufficient [14].

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