Agrarian Progress and Human Growth:  
An Analysis of School Records in Meiji Rural Japan

Osamu Saito

Institute of Economic Research, Hitotsubashi University, Kunitachi, 186-8603 Tokyo  
O.Saito@srv.cc.hit-u.ac.jp

Introduction

One stylised fact in historical anthropometry is that in early stages of economic development, the tempo of human growth was retarded in comparison with that of economic growth. In explaining this phenomenon, much attention has been paid to the effects of migration and urbanisation on height. Both town-ward migration and the concentration of people in densely inhabited areas, it is demonstrated, heightened exposure to pathogens, increasing claims on the nutrients and thus worsening their nutritional status. What I would like to suggest in this paper is that in addition to such “urban penalty” factors, there must have also been rural factors.

In a peasant society like Meiji rural Japan, where landlessness was virtually non-existent, farming populations had better access to food. However, one negative aspect of peasant family farming was women’s workload, which was particularly heavy in rice-growing areas. Wet-rice cultivation also increased exposure to parasites and water-born diseases, both of which are believed to have exerted a negative impact on the levels of children’s height and weight-for-height. The other was the commercialisation of agriculture which increased rural people’s exposure to outside influences. It is likely, moreover, that this negative impact of market penetration interacted with other rural factors, thus reducing the positive impact of output growth and resultant economic betterment in the countryside.

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Unlike Britain and the United States, pre-war Japan did not experience a phenomenal decline in physical status in the process of economic development, but her achievement in terms of human growth was modest in relation to her performance in economic growth. According to a comparative table of eight countries, whereas the nation achieved economic growth from the annual level of 1.0 per cent in the 1880-1900 period to 2.2 per cent in the 1920-40 period, final height of Japanese men increased only by 3 cm from 157 cm (Steckel and Floud 1997b, p.425). Young school children’s growth was even more modest. A comparison between boys and girls born in 1894 and those born in 1914 reveals that improvements in height were marginal until age 9. It was only after the First World War that their height started to increase (Honda 1997, pp.271-272).

Regional breakdown of the nation’s height statistics points to some more interesting phenomena. Conscripts from agricultural prefectures were generally shorter than more urbanised districts, while remote areas such as prefectures in the North-east (Tōhoku) had initially enjoyed superiority over central districts such as Tokyo, but their position in the height table was soon overtaken by other prefectures (Shay 1994, Mosk 1996, Honda 1997, Bassino 2006). This latter fact echoes what John Komlos described about central European people: soldiers from least developed provinces had once been the tallest in the Hapsburg monarchy, but their nutritional status deteriorated with the provinces’ integration into a wider commercial economy (Komlos 1989). The former finding of the link between short stature and farming, on the other hand, suggests that there must have been specifically rural factors that suppressed the beneficial effects of agrarian growth on children’s physical status.

Agriculture in rice-growing countries is generally labour-intensive. One salient feature of agrarian progress in the Japanese past is, according to Shigeru Ishikawa, that an increase in the yield of land in early phases was accompanied by increasing work intensity. In rice cultivation, it seems that the turning point came around 1910, after which labour input started declining. Even in that period, however, much of released labour went into the cultivation of a second crop. Thus, year-round labour input per unit of land kept increasing with agrarian progress (Smith 1959; Ishikawa 1978). In this process, multiple cropping was often accompanied by the introduction of a more market-oriented activity such as sericulture and a good deal of additional tasks were carried out by women. By the 1930s, therefore, farm women’s hours actually worked became very long—3,440 hours a year according to a 1933 survey. It is worth noting, moreover, that the higher the landholding class the longer the women’s working hours, hence offsetting the beneficial effect of their higher level of food consumption. This must have had an adverse influence on their children’s nutritional status (Saito 1996a).

This paper, by adopting children’s growth, rather than final height as an anthropometric measure, looks at height and weight data collected by school authorities in a rural
prefecture called Yamanashi before the First World War, and examines how the levels of children’s height and weight-for-height (measure by BMI) as well as the tempo of growth differed according to economic and environmental factors that varied across towns and villages within the prefecture.

The analysis will be conducted, first, by looking at the urban-rural differences in age-specific height and weight-for-height data. This is to examine if urban penalty effects were operating in Meiji Japan and also to delineate rural profiles of human growth in Japan’s early stage of development. Second, attention will be turned to factors affecting children’s growth in the rural areas. The rural variables examined are crop yields, seicultural development, and exposure to an endemic disease. Since the endemic disease was concentrated in low-lying, high-yielding arable areas, and since sericulture was an agent of growing market nexus in the countryside, this is to examine geography of the multiple impact of agrarian progress in the Meiji period and after. In other words, the paper pays attention to both positive and negative effects of the two sides of the coin, i.e. of rural development and of isolation or remoteness.

Since height is a variable that measures the accumulated impact of past nutritional experiences of the individual child, it is expected that height at younger ages reflects the mother’s nutritional status around the time of delivery more than current levels of nutritional intake of the child, while BMI is largely determined by the current nutritional levels. On the other hand, changes in height and BMI during the child’s growing years are sensitive to the current levels of nutrition, so that the process of height growth can be more complex than that of BMI growth. It is, therefore, likely that interactions may have been operating between the economic and environmental variables.

The area

Yamanashi, formally Kai province, is an inland prefecture, some 70 km west of Tokyo. Surrounded by high mountain ridges, some of whose peaks are over 3,000 metres including Mt Fuji, the highest in the country, much of the prefecture’s 4,500 sq km land area is well over 1,000 metres above sea level. In the middle of the prefecture, however, is a low-lying river basin with the lowest point being 250 metres above sealevel, and the basin occupies an area of 300 sq km. The provincial capital Kofu is located in the centre of this intermontaine basin, the only town that held a city status in the period before the Second World War. The city had a population of 40,000 at the time of the school surveys.

The Kofu basin consists of piedmont alluvial plains of the Rivers Kamanashi and Fuefuki (the upper reaches of the River Fuji) and its surrounding fan areas. From medieval times, the soils of the inner area (190 sq km) of the plains were fertile and wet-rice cultivation intensive, hence yields per unit of land were generally high. Thanks to the existence of
this granary, according to official statistics from 1883 to 1955, Yamanashi ranked
generally higher among the 47 prefectures except for the period 1907-1912 when
exceptionally severe floods ruined the harvests drastically. In the 1900-5 period, for
example, Yamanashi prefecture’s land productivity came eighth in the nation’s league
table, which is said to have been accounted for by higher inputs of labour and fertiliser as
well as by better geographical conditions. And as such it was an outcome of the trend in
agricultural progress that had started in Tokugawa years (Sato 1987; Yamanashi ken-shi,
tsūshi-hen 5, 2005). However, for economic historians, Yamanashi is known as a leading
sericultural prefecture. The inner area of the Kofu basin in the Meiji period was
surrounded by the fan and foothill areas where mulberry orchards and other dry-field
crops were planted. With the abundant output of mulberry leaves, Yamanashi was one of
major cocoon-producing areas in pre-war Japan. This enabled a vast majority of the farm
households to combine rice cultivation with this highly commercialised activity of
sericulture, which meant a further increase in land intensity. As Shigeru Ishikawa noted,
this increase in land intensity was made possible by a further input of family labour
(Ishikawa 1978/81). It is true that Yaamanashi’s total area of mulberry orchards increased
by some 30 per cent over the latter half of the Meiji period, yet more decisive was a move
by sericulturists to raise silkworms twice or even three times during the year. The result of
this was a three-fold increase in the prefecture’s cococon output from 1887 to 1912. In
some other districts of Yamanashi, especially the Tsuru districts in the east, its related
trades, i.e. silk reeling and weaving, were carried out in a proto-industrial manner. While
both rice cultivation and sericulture were concentrated in the basin and surrounding
hillside districts, the areas in the mountains turned their eyes to the production of timber,
firewood and charcoal as a source of cash earnings. Forestry had long been established in
this mountainous province, sold to Tokyo and its neighbouring towns such as Yokohama,
but full-time foresters were not many. A majority of the mountain villagers combined
forestry with some form of agriculture. And its growth became noticeable only after the
period of the Yamanashi school surveys, since a Kofu-Tokyo rail link was opened in 1903
and since Tokyo’s urbanisation accelerated after the First World War (for economic
history of Yamanashi in the late nineteenth and early twentieth centuries, see Tussing
1966; Smethurst 1986; Yamanashi ken-shi, tsūshi-hen 5-6, 2005-6).

All this raised income levels of Yamanashi’s rural population. According to a quantitative
attempt to assess the performance of the prefecture’s economic development, there was a
steady rise in farm income in real terms. The process benefited both upper and lower
classes of the agrarian society: the owner-farmer’s after-tax household income increased
at 1.1 per cent per annum from 1885 to 1909 and the tenant-cultivator’s at 1.3 per cent.
And much of this dynamism was found in the Kofu basin and its surrounding areas of rice
and silk (Nishikawa 1989, p.251). At the same time, it should be noted that the whole
process intensified the rice-and-silk areas’ contacts with cash nexus and, hence, also
increased their exposure to outside influences. As forestry took off after the First World
War, this adverse effect spread to the remote, mountain villages as well.
For medical historians, on the other hand, the Kofu basin is known as a home for Schistosoma japonicum, endemic to low-lying river deltas (Farley 1993; Tanaka and Tsuji 1997). The disease had been known locally from the mid-nineteenth century, the worms and the host were first identified in 1905. The S. japonicum worms are transmitted from snails of the species Oncomelaria hupenisis living in brooks, creeks and paddies into human beings’ blood vessels, causing emaciation and liver troubles. As early as 1847, a village doctor of a rice-growing area called Katayama in western Japan described symptoms of the disease as follows:

“I have been observing patients suffering from severe itches associated with small rashes on the legs … Such cases were associated with entering into rice fields around Katayama Hill. The other manifestations are diarrhoea, jaundice, emaciation and tachycardia. Cases with emaciation show severe diarrhoea, tenesmus and bloody stool. In advanced cases, the legs and hands become thin, while only belly is swollen like a drum. … and finally edema develops on the legs and the patients die” (quoted in Tanaka and Tsuji 1997, p.1468).

In Yamanashi too, the S. japonicum was known as its symptom of the swollen belly. For example, a tenant union activist of the 1920s and the 30s, born in the middle of the Kofu basin, recalled in the postwar period that ‘I had an uncle living nearby. It’s painful to see him coming out, with his big swollen belly, to drink water at the well, gasping breathlessly. When the belly becomes too big, he sticks a reed stem into the belly to get the water out. ‘As much as one sho [almost 2 litres]’, he often said. People like him were many around the area, and died after doing this several times’. Living in the schistosome-infested area, his family too must have contacted the snails from childhood. In fact he lost his brother by this endemic disease, but he could live to a great age of 99 (Yamamoto 1995, pp.24-25). This episode suggests that it took years for the patient to develop serious symptoms. Indeed, its overall fatality was not high. In 1912, Yamanashi’s public health authorities identified 7,893 as schistosomal patients. Subsequently it is recorded that a little more than 100 died of this disease every year; between 1915 and 1919, for example, the death total was 585 (Chihōbyō Kinenshi-henshū Iinkai 2003, p.146). Considering that the 1912 figure was an underestimate, and that new patients were added every year, the case fatality must have been well below 10 per cent. In terms of morbidity and mortality, therefore, it was a disease in adulthood. However, since the first contact with the worms was usually in childhood, it is not unlikely that its ill effect on health began to be felt before age 10, thus arresting the growth of children.

In the prefecture, the areas infested with the S. japonicum worms were confined in fertile flood plains of the Rivers Kamanashi and Fuefuki, the core area of the Kofu basin. This serious endemic disease was thus regarded as a price that the farming populations had to pay for the area’s superb grain yields.
The data

This article makes extensive use of data collected under a scheme introduced by the central government in order to examine the physical status of school children. The data we have for Yamanashi indicate that the survey was carried out twice a year (i.e. in April and October) between 1902 and 1906. For each school, therefore, ten survey reports must have been submitted, in which pupils’ height and weight are given as averages for each age. In other words, the records are not micro data; they had been aggregated at the school level although the size of school was often small.¹

The surveys covered all schools that existed in the prefecture at that time, but since those who went on to higher school were few, only primary school records are chosen for analysis. Unfortunately not all school reports survived. In some districts almost all reports are missing. Even for districts where coverage is good, there are many cases in which two or more half-yearly reports are missing. Given these defects as data, only schools whose April survey reports survived for at least four school years are selected for analysis. The number of such schools was 58.

During the period up to 1907, the nation’s formal education advanced. As far as male children were concerned, the enrolment rate went up from 64 per cent in 1889 to 98 per cent in 1905, the proportion of those who could write from 77 per cent to 98 per cent, and that of those who completed compulsory schooling from 42 per cent to 80 per cent (Saito 1996b, p.85). Under the education system before 1907, the years of compulsory schooling was four years from age 6. In the records, however, a number of pupils who were over nine years old are found.² For example, the number of boys recorded as 13-year-olds are not negligible at all. This is because the family was allowed to send their children to school at later ages. Furthermore, many children dropped out before the compulsory period ended, while some of drop-outs came back to school at much later periods. There were also unmistakable gender differences. The enrolment rate was generally higher for boys, whose rate of finishing compulsory schooling was also higher. In other words, far more girls than boys left school earlier and the proportion of girls who never came back to school was higher than that of boys. All this implies that physical examination records for girls must have been less representative of the student population at risk, especially at higher ages. Also implied is that every school year there were substantial turnovers among students, so that one cannot regard successive 5-year records of individual schools as longitudinal data.

¹ The EXCEL-formatted data are available on CD-ROM as a supplement to Yamanashi ken-shi, shiryō-hen 18 (2003).
² In the records, ages were given according to the traditional way of counting age in which the child was reckoned as age one when born and added an additional year on each New Year’s Day thereafter. Here, for the sake of convenience, they are adjusted to the western ages by subtracting one from the recorded ages.
For each of the 58 schools, therefore, yearly data are averaged out over four school years (five years if data permit) by using the numbers of children examined as weights. The following analysis is based on this data file.

**Urban-rural differences**

The sex-specific records thus processed are classified into the “urban” and “rural” sectors, i.e. Kofu city and communities in the countryside. The latter are further divided into settlements identified as “schistosomiasis-prevalent” in a 1925 ordinance by the prefectural government, and the rest. With the 58 schools, altogether 76 out of the total 242 rural settlements are covered since in some cases a school was built by two or three village authorities jointly.

[Table 1]

Table 1 summarises height and BMI statistics for Yamanashi children in 1902-6. According to the table, both 6-year-old boys and girls in the countryside were shorter than their counterparts in Kofu city. The height averages for the Kofu boys and girls were 106.8 cm and 106 cm, while those for the rural-born were a little below 105 cm and 104 cm respectively. On the other hand, the pattern for weight-for-height is less clear. Boys seem to have exhibited just the opposite pattern as observed for height: BMI for country boys was over 15 and superior to that for city boys. However, no clear pattern is revealed in the female table.

As for the tempo of height growth, gains from 6 to 9 were smaller in the city than in the countryside for both boys and girls. In Kofu boys grew by 10.7 cm and girls by 9.5 cm, while in the countryside the gains were 12-13 cm for both boys and girls. In the case of city boys BMI gains followed the same pattern as for height but just the opposite is observed for girls.

Turning to the effects of the disease environment, no substantial differences are found in height at age 6 between schistosome-infested and uninfested areas within the countryside. However, height growth of both boys and girls was undoubtedly stunted in the areas with *S. japonicum*, where their weight-for-height at age 6 also compared unfavourably with boys and girls in the areas with no endemic disease. Growth in BMI, on the other hand, seems to have been unaffected by the prevalence of the endemic disease.

Generally, the data quality of records for female children seems questionable. In the

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3 This section draws on my Japanese-language article (Saito 2003).
countryside, more girls failed to enrol and even those who did enrol tended to leave
school earlier than boys. The number of girls who stayed on dropped precipitately after
age 9. In the city, girls’ enrolment rates may have been higher than in the countryside, but
for some reason, their tempo of both height and BMI growth was much less stable. The
resultant growth curves are so volatile that there will be no point in conducting detailed
analysis with respect to height and BMI growth of girls in both rural and urban school
areas.

As far as boys are concerned, however, it is confirmed from Table 1 that at the youngest
school age children were shorter in the countryside, reflecting an adverse cumulative
effect of working mothers’ nutritional status. However, the average height of rural boys
caught up that of urban children during the growth period, while weight-for-height, which
measures their current nutritional status, tended to be greater in the countryside
throughout the school ages.

Rural factors

The Yamanashi countryside was known as a “rice-and-silk” area, but no two villages
were the same. Attention, therefore, should be turn to how agricultural factors affected
variations in children’s weight and weight-for-height across the 57 rural schools
(although 3 schools, where the number of observations was too small, will not be
included in the following exercise).

Unfortunately there is not much information available about individual settlements in the
survey period of 1902-6. We know that among the 54 rural settlements, there were five
which were recognised as country towns. For yields of rice, barley, wheat and other grains,
moreover, village-level data exist for 1904 and 1906. The mean grain yield per household
in the sample of 54 rural settlements was 128.6 yen in current prices, the highest 361.7
yen and the lowest 26.1 yen with a wide standard deviation of 74.2 yen. This extreme
variance may be explained by the likelihood that a low per-household grain yield was
associated with a higher share of earnings from other pursuits, such as sericulture, forestry,
and non-farm by-employment, in farm household income. In villages in the sample there
were also a small but non-negligible number of non-farm households such as merchants,
craftsmen and foresters. Indeed, while the per-household grain yield was positively
correlated with land productivity (grain yield per \(\text{tan}\) of cultivated land) with the
correlation coefficient \(r\) of 0.690,\(^4\) it was negatively associated with the proportion of
forests, pastures and wasteland in the village land area \(r = - 0.488\). It is also that two of
the five country towns were in lowland areas and the rest in hill and mountainous districts.
The former two were closer to the newly-built rail line while the other three were on old

\(^4\) 1 \text{tan equals 0.099 ha.}
transport routes. If the highest quartile in the per-household yield column are singled out, it is evident that most of them were in the lowland areas: only two had a higher-than-average forest ratio. On the other hand, the lowest quartile include eight settlements whose forest ratio was higher than the sample average, as well as all the five country towns, of which three were actually in the mountains with higher-than-average forest ratios. The case of the lowest 26.1 yen is in fact a settlement in one of the mountainous districts, Minami-Koma, which held both a large forest area (69 per cent of the total land area) as well as an old riverside town within the administrative area. Generally, therefore, the grain yield per household should not be regarded as a surrogate for household income; it is a variable that reflects land productivity in farming, on the one hand, and the existence of non-farm income sources, on the other. In other words, the combination of the latter two is thought to be able to capture geographical remoteness, while the land productivity factor is closely associated with the proximity to the fertile basin area. Indeed, if the physical distance to Kofu is correlated with the per-tan grain yield, the correlation coefficient is -0.674 whereas it is +0.628 with the proportion forested. In short, the wide variation in the mean grain yield per household was a reflection of the equally wide variation in geographical and topological conditions within the prefecture.

Silk-related activity is another important variable to account for geographical variations in height, as Jean-Pascal Bassino has found in his analysis based on prefectural-level data a silk dummy had a significant negative impact on height of conscripts (Bassino 2006). As for villages in Yamanashi, only information available is for a period after the First World War. That is the proportion of farm households engaged in sericulture in 1925. Although percentage levels may well have risen between 1902-6 and 1925, it is likely that the relative rankings among the individual communities did not change drastically. The variable adopted here, therefore, is a standardised index with the mean percentage (55.0 per cent) being set at 1. Thus the highest index is 1.82 (100 per cent) and the lowest 0.17 (9.4 per cent) with the standard deviation of 0.43 (23.5 percentage points). It is interesting to note that none of the five country towns is in areas whose the sericultural index was above the sample average. The index has no correlation with the grain yield per tan of land or with the forest ratio, either.

Finally, the prevalence of the endemic disease, *S. japonicum*, is also taken into account. The variable used here is a dummy one: 1 if at least a part of the village area was on the local government’s 1925 list of “schistosomiasis-prevalent” settlements and 0 if the entire area was not on the list. When the school catchment area consisted of two or more villages, the value is divided by the number of villages involved.

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5 Income is expected to exert a positive effect on height and weight-for-height if the effects of other variables are adequately controlled for. Recent research findings at both aggregate and micro levels suggest that it was indeed the case in Japan before the Second World War (Bassino 2006, Saito 2004).

6 In the following analysis, the natural logarithm of each yield figure is used.
[Table 2]

Table 2 shows correlation matrices for boys’ and girls’ height and BMI at age 6 with grain yield (logged), sericultural index and disease endemism. In order to make geographic patterns explicit, the distance from Kofu is also included. Note that the grain yield had a negative correlation with both height and BMI (though not statistically significant as far as height is concerned), while the proportion-sericultural index shows much obscure results with the two measures of physical status. For disease endemism, since the schistosomiasis-prevalent areas were concentrated in high yielding wet-rice districts of the Kofu basin (as indicated by high correlation coefficients of both grain and disease variables with the distance from Kofu), it also shows a negative relationship with BMI (hence a negative and significant correlation between BMI and the distance from Kofu). The endemic disease variable has a somewhat weaker correlation with height, suggesting that labour-intensive farm activity, especially that of wet-rice cultivation, exerted adverse effects—via mothers’ nutritional status—on children’s weight and weight-for-height at the youngest school age. One may suggest that since there is no strong correlation between grain and sericulture, multivariate analysis may be conducted in order to explain inter-village differences in children’s height and BMI levels. However, such multiple regressions did not produce any meaningful results, suggesting that more variables would probably be needed to account for geographical variations in the levels.

Thus we turn to the variations in the tempo of growth in height and BMI, measured here as a rate of growth from age 6 to age 9. For this analysis too, it is expected that interrelationships between the above three explanatory variables were complicated. One way to capture the effects of such interrelationships is to introduce the products of three paired variables on the right-hand side of the equation. Thus, multiple regression analysis is conducted for the growth rates in both height and BMI between ages 6 and 9 with the per-household grain yield and the proportion-sericultural index plus three cross terms in order to capture the interactions between all the variables, grain yield, sericulture and disease endemism, i.e. grain × sericulture, grain × disease, and sericulture × disease (disease endemism appears only in the cross terms since its inter-correlation with the grain yield is considerable).

[Table 3]

All the explanatory variables involved in the model reflect geographical variations across districts in the prefecture, rather than changes over the years corresponding to children’s growth period from age 6 to age 9. What we are going to look at, therefore, is how the tempo of children’s growth varied across the geographical districts as revealed in the variables adopted. Table 3 shows the results of this analysis for boys’ height growth and BMI growth. Although the goodness of fit is marginally better for the height equation,
both results are reasonably robust with all the interaction terms estimated statistically significantly. Turning to the behaviour of individual variables on the right-hand side of the equation, however, there are marked contrasts between the height and BMI equations. It seems—on the face of it—strange to see the signs of both yield and sericulture variables differently estimated between the height growth and BMI growth columns: positively related to height growth and negatively to BMI growth. It should be remembered, however, that here in the analysis, growth figures in both height and BMI are regressed, *not on temporal changes* in the yield and the proportion sericultural, *but on geographical variations* in those variables. It is more likely, therefore, that the signs are determined in relation to the initial levels at age 6. Thus the positive sign for the grain yield in the height equation, for example, means that the rate of growth in height was higher in areas where the grain yield was high because its level at age 6 tended to be low in those areas, whereas the negative sign in the BMI equation indicates that the rate of growth in BMI was low in those areas because there the initial level tended to be high.

More interesting perhaps is the signs of the interaction terms. In the height equation, the interaction terms with the grain yield (grain × sericulture and grain × disease) were negatively related with height growth, which implies that both sericulture and disease endemism tended to *widen* gaps with communities where the proportion engaged in this form of commercial activity was low or where the endemic disease was not prevalent. On the other hand, the opposite can be said about the effects of those variables for BMI growth. The positive sign of the third interaction term (sericulture × disease) suggests that those relationships were not necessarily proportional to the product of two variables. In areas where both active sericultural trades and disease endemism were found, that happened to be areas where the grain yield tended to be also higher, the gap-widening effects of the grain-sericulture and grain-schistosomal interactions on height growth became somewhat less acute. On BMI growth, on the other hand, the gap-narrowing effects were substantially counteracted in those areas.

In terms of schistosomal effects, the negative impact is not quite clear in the height equation, whereas it is well revealed in the BMI equation. In the former, the size of the positive coefficient of the sericulture-disease interaction is larger than that of the grain-disease interaction, suggesting that the net effect was positive rather than negative. Perhaps, this finding reflects the fact that it took many years for the schistosomal symptoms to develop, so that the *cumulative* impact of its adverse effects could only be felt at much later ages. In contract, BMI measures a *current* nutritional status, so that the above equation could probably capture any ill effect even at such an early stage of life.

**Simulations**

Complicated as those interactions may seem, it is evident that even within the countryside
before the First World War, forces were at work to dampen down the positive effects of agrarian progress on both height and BMI growth of children.

In order to visualise what such interactions meant for children’s growth in different types of rural communities, simulations may be tried. By using the equations in Table 3, it is possible to estimate growth rates of height and BMI between ages 6 and 9 for combinations of values of the three variables. The combinations of values represent hypothetical types of village economy, which are deliberately set at extremely high and extremely low values of both grain yield and the proportion sericultural with the assumption that the endemic disease was associated with the high grain yield case only. The values of the grain yield are taken from the actual Yamanashi table; they are the highest and the lowest of all the 54 cases in that table. On the other hand, the high and low values of the proportion sericultural are rather arbitrarily set at 100 and 0 per cent.

The four communities are as follows:

Community A:
High grain yield (361.7 yen); high proportion sericultural (100%); with endemic disease.

Community B:
High grain yield (361.7 yen); low proportion sericultural (0%); with endemic disease.

Community C:
Low grain yield (26.1 yen); high proportion sericultural (100%); with no endemic disease.

Community D:
Low grain yield (26.1 yen); low proportion sericultural (0%); with no endemic disease.

For the initial levels at age 6, it is assumed that both height and BMI were determined solely by the grain yield. The high and low values for the two physical status measures are calculated from the following regression results for boys:

\[
\begin{align*}
\text{Height} &= 107.7 - 0.623 \times \text{Grain yield} \quad (R = 0.204; \text{adjusted } R^2 = 0.023); \\
&\quad (54.8) \quad (-1.50) \\
\text{BMI} &= 17.0 - 0.338 \times \text{Grain yield} \quad (R = 0.335; \text{adjusted } R^2 = 0.095).^7 \\
&\quad (27.2) \quad (-2.57)
\end{align*}
\]

\(^7\) N is 54 for both cases and figures in parentheses are t-ratios. The height regression is not quite satisfactory with a low t-ratio for the grain yield. However, we have no better results than this. Also, since the results are not inconsistent with Table 1, the above equation is considered “usable”.
With the high and low values for the grain yield, the above equations provide us with the estimated initial levels: 104.1 cm with BMI of 15.0 for Communities A and B and 105.7 cm with 15.9 for Communities C and D. Note that despite the calculations based on two outlier values, the estimated high and low height figures for the countryside are lower than Kofu city’s average height in Table 1, while both the estimated rural BMIs are higher than the Kofu BMI, both of which are consisted with the observed urban-rural differences in Table 1.

With these parameters, simulated sets of height and BMI at age 9 are available for the four hypothetical communities, which are set out in Table 4.

[Table 4]

Let us look at the least developed case first. Community D is defined by low agricultural productivity and little contact with cash economy, which characterises much of what Ted Shay called “remoteness” in his analysis of Japanese regional conscription data (Shay 1994). There, children’s height is intermediate while they enjoy a high rate of growth in weight-for-height and the highest score of BMI at age 9 among the four communities in the table. It is worth noting here that the advantageous effect of remoteness was found more on BMI than on height growth.

On the other hand, Community A, the most advanced area in terms of both agricultural productivity and commercialisation for this early phase of agrarian development, displays the lowest record of height growth with a modest score of BMI at age 9. This may be called the case of “rural penalty”, associated with agrarian progress. In contrast with the advantages of remoteness, its impact was more pronounced on height growth than on BMI.

While Community C, a rather unrealistic case in Meiji economic history, occupies an intermediate position on both measures, Community B represents an advanced grain-growing case, i.e. a combination of high productivity with no sericulture. There, the height score is the highest and the weight-for-height index the lowest of all the four cases. On the face of it, a comparison with the case of Community A seems to suggest that the endemic disease factor carried more weight for growth in weight-for-height than for height growth. However, since the non-existence of sericulture meant a much lower household income and hence a lower nutritional intake in Community B than in Community A, it is more likely that the effect of income on the current status of nutritional intake outweighed other effects in this case.
A generation later

In the 1930s a comprehensive study of history and geography of Yamanashi prefecture was conducted by a team from the prefecture’s two teacher training colleges. Unlike economic and social history practised in other higher education institutions of the day, the study, Sōgō kyōdo kenkyū, looked at children’s height and weight as components of the standard of living. Table 5 is taken from the study report and shows the results of the 1934 school survey for one city and nine districts (gun). This table is arranged in much the same manner as Table 1 for 1902-6, although instead of dividing the rural districts into the Schistosome-infested and the uninfested (which cannot be done without village-level information), the nine districts are grouped into three remote, mountainous districts and the rest.

Table 5 reveals that children’s height increased between the two survey periods. The average height of 6-year-old boys and girls in 1934 are 2-3 cm higher and the gains over the growth period of ages 6-9 were greater than in the 1902-6 records. This is in line with the observations from national-level statistics: after a period of stagnant growth, young children’s height started increasing, however modestly, in the interwar period, the change which is also parallel to the pattern of change in infant mortality. In contrast, there was virtually no improvement in weight-for-height. The 1934 statistics for BMI of boys and girls at age 6 and the gains over the 6-9 growth period were not necessarily better than the situations in 1902-6. Since weight-for-height reflects a population’s current nutritional status, and since the performance of interwar Japan’s agriculture was poor in comparison with that in the period before the First World War, the results for BMI in Table 5 are likely to have been accounted for by the sluggish agrarian economy of the interwar period. On the other hand, this makes it more difficult to account for why young children’s height, measuring the cumulative impact of their past nutritional statuses, began to increase in that period.

Two points can be made from Table 5, however. The first one concerns the question of how the advantageous effect of remoteness changed over the three decades. Indeed, the study report noted that while the average height of children in a remote, mountainous district called Minami-Koma had once been on the tall side, they became ‘stocky’ among all the Yamanashi children by the time the survey was made (Sōgō kyōdo kenkyū, p.708). The foregoing analysis of the 1902-6 data for children’s growth suggested that there was an advantage in life in a remote community. Table 5 indicates that heights for both boys and girls at ages 9 and 13 set out in the column for the remote districts are clearly shorter than those in other columns, so that the gains are the smallest among the three. The corresponding BMI data do not reveal the same pattern. While boys follow a pattern

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8 The infant mortality rate showed no tendency to decline up until 1920. It was in the 1920s and the 30s that it started to decline across the country.
similar to height, girls in remote communities do not exhibit any disadvantage. Generally, however, the 1934 survey suggests that as forestry became increasingly commercialised since the First World War, advantages associated with remoteness were lost.

The second point the 1934 data suggest is concerned with the countryside in general. The 1902-6 data showed that although rural children at age 6 were smaller than city boys of the same age, they were free from any “urban penalty”, so that they could enjoy a better growth performance than their city counterparts. The comparison of the column for other rural districts with that for Kofu indicates that this was no longer the case in 1934. Unlike the situations in 1902-6, heights of rural children did not catch up with those in the city: even in the rural districts that were not particularly remote and isolated, 13-year-old boys were 3.5 cm shorter, and girls of the same age were as much as 13 cm shorter, than their counterparts in Kofu. Although BMI data show less clear patterns, the 1934 survey suggest that while urban penalty was not visibly at work, the advantages generally associated with rural life were eroded by the 1930s.

Conclusion

Findings from the foregoing analysis of a rather rare dataset on physical growth of primary school children in Meiji rural Japan and the comparison of its results with a later-day statistics of children’s height and weight-for-height may be summarised as follows:

First, first-year primary school children in the countryside tended to be shorter than their urban counterparts. This is interpreted as the labour-intensive mode of agriculture having exerted an apparently adverse cumulative effect on children’s height. However, their height caught up with urban children’s height during the growth period, reflecting probably what is known as “urban penalty”.

Second, growth in height and weight-for-height, both sensitive to their nutritional status, of children living in various types of communities in the countryside seems to have been determined as a result of complex interaction processes that output growth had with the commercialisation of agriculture, on the one hand, and with a rural disease environment, on the other.

Third, one reason why intensive agriculture had a negative interaction with the disease environment is that for wet-rice cultivation, fertile soils were found in low-lying river deltas. In Yamanashi, such fertile river deltas were also a habitat for snails that acted as a host for the *Schistosoma japonicum*, an endemic disease which was not necessarily lethal but was nonetheless serious in the sense that it had a depressing impact on children's growth, especially on their weight-for-height. A similarly depressing effect on height is
expected to have begun to appear in early adulthood.

Fourth, the negative anthropometric impact of commercialisation, another component of agrarian progress, seems to have stemmed from its role in bringing rural populations under the stronger influence of pathogens coming from the outside. Increased mobility of people and commodities meant that locals had more frequent contact with pathogens of which they had no immunity. The accelerated commercialisation of agriculture, well under way in the Meiji period, and of forestry, which started with a time lag in the 1920s and 30s, undermined the advantages of “remoteness”.

All this strongly suggests that despite rising rural material standards of living, farming populations’ claims on the nutrients were increasing and, hence, their nutritional status deteriorating during the early phase of agrarian progress.
References


Press.

**Official publications**

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*Yamanashi ken-shi*, tsūshi-hen 6, kingendai 2 (Kofu: Yamanashi-ken, 2006).
*Yamanashi-ken tōkeisho* (Kofu: Yamanashi-ken, various years).
*Sōgō kyōdo kenkyū*, edited by Yamamashi-ken Shihan Gakkō and Joshi Shihan Gakkō (Kofu: Yamanashi-ken, 1936).
Table 1. Urban-rural differences in height, height gains, BMI and BMI gains: Yamanashi boys and girls aged 6-13, 1902-6

<table>
<thead>
<tr>
<th></th>
<th>Boys</th>
<th></th>
<th></th>
<th>Girls</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kofu city Rural Schistosome-infested</td>
<td>Rural Un-infested</td>
<td></td>
<td>Kofu city Rural Schistosome-infested</td>
<td>Rural Un-infested</td>
<td></td>
</tr>
<tr>
<td><strong>Height</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 6 (cm)</td>
<td>106.8</td>
<td>104.7</td>
<td>104.9</td>
<td>106.0</td>
<td>103.9</td>
<td>103.8</td>
</tr>
<tr>
<td>Age 9 (cm)</td>
<td>117.5</td>
<td>117.2</td>
<td>118.2</td>
<td>115.5</td>
<td>116.2</td>
<td>117.1</td>
</tr>
<tr>
<td>Age 13 (cm)</td>
<td>--</td>
<td>(132.8)</td>
<td>134.3</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td><strong>Gain</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-9 (cm)</td>
<td>10.7</td>
<td>12.5</td>
<td>13.3</td>
<td>9.5</td>
<td>12.3</td>
<td>13.3</td>
</tr>
<tr>
<td>6-13 (cm)</td>
<td>--</td>
<td>(28.1)</td>
<td>29.4</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td><strong>BMI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 6</td>
<td>14.9</td>
<td>15.2</td>
<td>15.5</td>
<td>15.0</td>
<td>14.8</td>
<td>15.3</td>
</tr>
<tr>
<td>Age 9</td>
<td>15.0</td>
<td>15.5</td>
<td>15.7</td>
<td>16.3</td>
<td>15.3</td>
<td>15.6</td>
</tr>
<tr>
<td>Age 13</td>
<td>--</td>
<td>(16.5)</td>
<td>17.0</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td><strong>Gain</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-9</td>
<td>0.1</td>
<td>0.3</td>
<td>0.2</td>
<td>1.3</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>6-13</td>
<td>--</td>
<td>(1.3)</td>
<td>1.5</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td><strong>No. of observations</strong></td>
<td>1,221</td>
<td>2,629</td>
<td>4,144</td>
<td>1,364</td>
<td>2,086</td>
<td>3,851</td>
</tr>
<tr>
<td>Age 9</td>
<td>1,227</td>
<td>2,978</td>
<td>4,479</td>
<td>1,239</td>
<td>1,928</td>
<td>3,026</td>
</tr>
<tr>
<td>Age 13</td>
<td>--</td>
<td>884</td>
<td>1,557</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Note: Cells with -- indicate the number of observations for 13-year-olds smaller than 500 and figures in parentheses smaller than 1,000.
Table 2. Correlation matrix of height, BMI and other variables: boys and girls aged 6 in 54 schools in rural Yamanashi, 1902-6

A. Boys aged 6

<table>
<thead>
<tr>
<th></th>
<th>Height</th>
<th>BMI</th>
<th>Grain yield</th>
<th>Sericulture</th>
<th>Disease</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>-0.458**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield (logged)</td>
<td>-0.204</td>
<td>-0.335*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sericulture</td>
<td>-0.043</td>
<td>-0.115</td>
<td>0.240</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schistosomal disease</td>
<td>-0.135</td>
<td>-0.318*</td>
<td>0.619**</td>
<td>0.001</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Distance from Kofu</td>
<td>0.181</td>
<td>0.450**</td>
<td>-0.493**</td>
<td>-0.215</td>
<td>-0.669**</td>
<td>1</td>
</tr>
</tbody>
</table>

B. Girls aged 6

<table>
<thead>
<tr>
<th></th>
<th>Height</th>
<th>BMI</th>
<th>Grain yield</th>
<th>Sericulture</th>
<th>Disease</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>-0.397**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield (logged)</td>
<td>-0.114</td>
<td>-0.396**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sericulture</td>
<td>0.009</td>
<td>-0.217</td>
<td>0.240</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schistosomal disease</td>
<td>-0.123</td>
<td>-0.386**</td>
<td>0.619**</td>
<td>0.001</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Distance from Kofu</td>
<td>0.052</td>
<td>-0.499**</td>
<td>-0.493**</td>
<td>-0.215</td>
<td>-0.669**</td>
<td>1</td>
</tr>
</tbody>
</table>

Note:
1) N is 54 for both boys and girls.
2) ** indicates a statistically significant case at the 1 per-cent level and * at the 5 per-cent level.
Table 3. Children’s growth in height and BMI regressed on grain yield, proportion sericultural and disease endemism: boys aged 6-9 in 54 schools of rural Yamanashi, 1902-6

<table>
<thead>
<tr>
<th></th>
<th>Height growth</th>
<th>BMI growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-2.84</td>
<td>23.6</td>
</tr>
<tr>
<td></td>
<td>(-0.46)</td>
<td>(2.00)</td>
</tr>
<tr>
<td>Grain yield (logged)</td>
<td>4.07</td>
<td>-5.89</td>
</tr>
<tr>
<td></td>
<td>(2.78**)</td>
<td>(-2.08*)</td>
</tr>
<tr>
<td>Proportion sericultural</td>
<td>11.0</td>
<td>-22.4</td>
</tr>
<tr>
<td></td>
<td>(1.89¶)</td>
<td>(-1.98¶)</td>
</tr>
<tr>
<td>Grain × sericulture</td>
<td>-3.01</td>
<td>5.74</td>
</tr>
<tr>
<td></td>
<td>(-2.26*)</td>
<td>(2.22*)</td>
</tr>
<tr>
<td>Grain × disease</td>
<td>-1.27</td>
<td>2.45</td>
</tr>
<tr>
<td></td>
<td>(-2.89**)</td>
<td>(2.89**)</td>
</tr>
<tr>
<td>Sericulture × disease</td>
<td>4.36</td>
<td>-11.3</td>
</tr>
<tr>
<td></td>
<td>(2.35¶)</td>
<td>(-3.13**)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>R²</th>
<th>R² adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height growth</td>
<td>0.225</td>
<td>0.144</td>
</tr>
<tr>
<td>BMI growth</td>
<td>0.203</td>
<td>0.120</td>
</tr>
</tbody>
</table>

Notes:
1) N is 54 for both columns. Figures in parentheses are t-ratios.
2) ** statistically significant at the 1 per-cent level, * at the 5 per-cent level, and ¶ at the 10 per-cent level.
Table 4.  Height and BMI of boys at ages 6 and 9 by type of community: simulation results

<table>
<thead>
<tr>
<th>Community</th>
<th>Height (cm)</th>
<th>BMI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age 6</td>
<td>Age 9</td>
</tr>
<tr>
<td>Community A:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High grain yield;</td>
<td>104.1</td>
<td>114.4</td>
</tr>
<tr>
<td>high % sericultural; with endemic disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community B:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High grain yield;</td>
<td>104.1</td>
<td>124.6</td>
</tr>
<tr>
<td>low % sericultural; with endemic disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community C:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low grain yield;</td>
<td>105.7</td>
<td>119.8</td>
</tr>
<tr>
<td>high % sericultural; with no endemic disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community D:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low grain yield;</td>
<td>105.7</td>
<td>117.9</td>
</tr>
<tr>
<td>low % sericultural; with no endemic disease</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 5. Urban-rural differences in height, height gains, BMI and BMI gains:
Yamanashi boys and girls aged 6-13, 1934

<table>
<thead>
<tr>
<th></th>
<th>Boys</th>
<th></th>
<th></th>
<th>Girls</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kofu</td>
<td>Rural</td>
<td></td>
<td>Kofu</td>
<td>Rural</td>
</tr>
<tr>
<td></td>
<td>city</td>
<td>3 remote districts</td>
<td>Other</td>
<td>city</td>
<td>3 remote districts</td>
</tr>
<tr>
<td>Height</td>
<td></td>
<td>6 districts</td>
<td></td>
<td></td>
<td>6 districts</td>
</tr>
<tr>
<td>Age 6 (cm)</td>
<td>109.0</td>
<td>107.6</td>
<td>108.0</td>
<td>108.4</td>
<td>105.9</td>
</tr>
<tr>
<td>Age 9 (cm)</td>
<td>122.4</td>
<td>121.1</td>
<td>121.2</td>
<td>122.6</td>
<td>119.9</td>
</tr>
<tr>
<td>Age 13 (cm)</td>
<td>143.1</td>
<td>139.0</td>
<td>139.6</td>
<td>154.0</td>
<td>139.6</td>
</tr>
<tr>
<td>Gain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-9 (cm)</td>
<td>13.4</td>
<td>13.5</td>
<td>13.2</td>
<td>14.2</td>
<td>14.0</td>
</tr>
<tr>
<td>6-13 (cm)</td>
<td>34.1</td>
<td>31.4</td>
<td>31.6</td>
<td>45.6</td>
<td>33.7</td>
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</tbody>
</table>

BMI

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th>Girls</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kofu</td>
<td>Rural</td>
<td></td>
<td>Kofu</td>
<td>Rural</td>
</tr>
<tr>
<td></td>
<td>city</td>
<td>3 remote districts</td>
<td>Other</td>
<td>city</td>
<td>3 remote districts</td>
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<tr>
<td></td>
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<td>6 districts</td>
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<td>6 districts</td>
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<tr>
<td>Age 6</td>
<td>14.9</td>
<td>15.4</td>
<td>15.0</td>
<td>14.6</td>
<td>15.4</td>
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<tr>
<td>Age 9</td>
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<td>16.0</td>
<td>15.4</td>
<td>15.4</td>
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<td>Age 13</td>
<td>17.3</td>
<td>17.3</td>
<td>17.3</td>
<td>15.9</td>
<td>18.2</td>
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<tr>
<td>Gain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-9</td>
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<td>0.2</td>
<td>1.0</td>
<td>0.8</td>
<td>0</td>
</tr>
<tr>
<td>6-13</td>
<td>2.4</td>
<td>1.9</td>
<td>2.3</td>
<td>1.3</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Source: Sōgō kyōdo kenkyū, p.710.

Note 1) The numbers of observations are not given there, but they are believed to have been sufficiently larger than those for Table 1 above.

2) The three “Remote districts” are Minami-Koma, Kita-Tsuru and Mimami-Tsuru gun.