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The biological standard of living in Taiwan under Japanese occupation

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Abstract

This paper presents evidence on the biological standard of living in Taiwan from 1842 to 1931 using Taiwanese height and weight data collected by the Japanese authorities from 1921 to 1931. This study shows that in the late Ch'ing adult heights were not increasing over time, while the adult heights of those born after the Japanese takeover did begin to increase rapidly. Evidence from children's heights confirms that this growth in height continued through the 1920s. The body mass index of Taiwanese, however, did not increase in the 1920s. By most measures, the biological standard of living was better in the north of the island. Comparison with modern data shows that heights have continued to increase.

Keywords: Biological standard of living; Taiwan; Height and weight data

1. Introduction

The effect of the Japanese occupation between 1895 and 1945 on the population is an important question in the economic history of Taiwan. The Chinese gave up Taiwan to the Japanese as part of the peace treaty ending the Sino-Japanese War (1894–1895). The Ch'ing dynasty, which controlled Taiwan until then, collected only foreign trade statistics.[1] Hence, most economic time series for Taiwan begin after the Japanese takeover, which makes it difficult to compare economic conditions in Taiwan before and after the beginning

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[1] Taiwan was originally a Dutch colony. The Ch'ing dynasty, established by the Manchus, took control of Taiwan in 1683, shortly after being established on the mainland China. The Ch'ing was toppled by Sun Yat-sen's Nationalist party in 1911, but had already lost control of Taiwan to the Japanese in 1895. The Ch'ing dynasty is often written as "Qing dynasty", the Pinyin romanization used in mainland China. In this paper, the Wade–Giles system is used to romanize Chinese words, because that is most common in Taiwan.

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of Japanese occupation. In order to overcome this hiatus in the literature, this study uses Taiwanese adult's heights data collected by the Japanese from 1921 to 1931 to estimate the net nutrition of the population during its growing years as children and adolescents. The relationship between the physical stature of a population and its consumption, health and welfare has been frequently documented (Tanner, 1987; Komlos, 1991). The analysis presented below indicates that the biological standard of living of the Taiwanese was stagnating at best and might even have been declining during the late Ch'ing dynasty, but began to improve in the 1890s, contemporaneously with the beginning of Japanese occupation. This suggests that in some respects Taiwanese welfare increased earlier than many previous studies have estimated. The improvement probably continued through the 1920s, even if the evidence is somewhat ambiguous: while the heights of children born in the 1920s continued to increase, and crude death rate decreased, adult body mass index (BMI) did not rise during this period.

There is general agreement among scholars that Taiwanese consumption began to increase significantly during the 1920s. Two early pioneers of this literature, Samuel Ho (1968, 1978) and Yhi-min Ho (1966) reached this conclusion using data collected by the Japanese. Scholars have refined these estimates without significantly changing their interpretation. Subsequently, Mizoguchi and Umemura (1988) argued that there was not a significant increase in Taiwanese per capita consumption from 1903 to 1925.

One problem affecting this previous research is that the pertinent economic data commence several years after the beginning of Japanese rule, and therefore cannot be compared to those of the prior period. Yhi-min Ho's time series actually indicates that agricultural production per capita grew up to 40% from 1902 to 1905, and Mizoguchi and Umemura documents a similar pattern, but because Ho's data begin in 1901, he argues that the increase in productivity merely reflects a return to pre-takeover conditions.

The notion that Taiwanese consumption did not begin to rise until the 1920s also conflicts with the views of contemporary foreign observers. For example, Pickering (1898) suggests that Taiwan under the late Ch'ing dynasty was basically an anarchy in which large-scale investment and transactions were practically impossible, and predicted that the Taiwanese economy would grow quickly under Japanese rule. Moreover, Davidson (1903) argued that Taiwanese wages roughly doubled after the Japanese occupation. He attributed Taiwan's newfound wealth to improvements in transportation and an increase in government investment in infrastructure. Takekoshi (1907) agreed that the Taiwanese economy was growing quickly in that period and thought that growth was brought about by the introduction of Japanese law and its enforcement.[2] Although the views of these contemporary observers might not have been objective, in as much as they viewed matters from a colonial perspective, and they did not have systematic data at their disposal, their unanimous opinion, nonetheless, does deserve serious consideration. This paper's conclusion basically supports the views expressed by these three eyewitness accounts: the welfare of the Taiwanese

[2] Chang and Myers (1963) show that early Japanese policy in Taiwan emphasized the establishment of property rights, the standardization of money and weights and measures, improvement of the transportation and communication network and the establishment of public sanitation and education systems.

population improved, in so far as there was a clear improvement in its biological standard of living.

2. Estimating change in Taiwanese adult heights

The Japanese conducted a series of local health and sanitation surveys in 70 areas of Taiwan between 1921 and 1931.[3] They described the basic conditions of the area in question and provided data on population, birth and death rates, disease patterns, prevalent parasites, diet, clothing worn, and housing. They also measured the height, weight, chest, and cranial circumferences of each resident and calculated the average measurement of each age group. Of the 70 studies, 62 are extant and are used in this study[4] (Table 1).

From the raw data on adult height, ages 21 years and above, it does appear that there may have been an increase in height among those born (1) in the late Ch'ing period before 1880 and (2) after 1890 for males and after 1900 for females in the early era of Japanese rule. However, this evidence is misleading, because the early birth cohorts were older by the time of measurement, and people's height has a tendency to shrink after about the age of 50 years. Furthermore, there is a selection bias, since short people tend to die younger and we only observe the heights of those still alive. However, the information that the Japanese studies were done over an 11-year period, can be used to separate the effects of age and of year of birth on physical stature. In fact, after controlling for age, we find that the pre-1880 growth is not robust and can be entirely accounted for by shrinkage due to aging. It appears that those born earlier were not actually shorter, but merely had a longer time in which to shrink (Table 2).

In each of the 62 localities, Taiwanese and under 80 years of age were divided into 14 age groups,[5] and separate regressions are run for males and females,[6] with height (cm) as

[3] Local health and sanitation reports are located in Taipei in the Taiwan section of the National Library and the special collections section of the National Taiwan University library. The five earliest inspections done in Taipei and Kaohsiung prefectures are recorded in the ninth volume of the final overall report published by the Taiwan Government-General, Hoko Police Department, Sanitation Office (1930, 1931, 1932); Karenko Police Department, Sanitation Office (1933); Shinchiku Police Department, Sanitation Office (1934); Taichu Police Department, Sanitation Office (1933); Tainan Police Department, Sanitation Office (1923, 1924, 1925, 1926, 1927, 1930, 1931); Taito Police Department, Sanitation Office (1927, 1929, 1931); Takao Police Department, Sanitation Office (1928, 1929, 1931, 1932, 1933); Taihoku Police Department, Sanitation Office (1928); and Tainan Police Department, Sanitation Office (1932).

[4] The results of the studies were printed by the Japanese colonial government in small quantities. The reports always contain a note saying which government office published the material. Being just for internal government use, the reports were never sold and were not widely circulated. There are several copies still existing of many of the reports published by the Taiwan Government General. There has been a couple of attempts to index all the surviving Japanese material, and this study uses all the indexed reports that have been found. Some materials were destroyed by US bombing in 1944 and 1945. However, lots of material in storage has not been indexed, and it is possible that some of the missing studies could turn up in Japan.

[5] Only adults over the age of 21 years are used in this study because there is some growth until this age. The statistics for the Japanese in each locality were listed separately as were the statistics on the unassimilated aborigines living in Taiwan's eastern frontier districts. I do not use this material in this regression.

[6] There is a particular problem with females; in the 1920s many women still had bound feet. In Hsinchu, Japanese researchers compared the heights of bound and unbound women and found little difference but they did not control for other factors and did not explain how they made their measurements. Women with bound feet could not stand upright without wearing their bindings.

Table 1
Characteristics of the data

Locality	Year (months)	Population surveyed	Characteristic				
			Unhealthy	Urban	Mountain	Fishing	Commercial
Taipei (Taihoku) prefecture							
Ch'ihsing, Shihlin	1922 (2)	3125	1	1	0	0	1
Keelung, Chinshan	1923 (2)	2096	1	0	0	1	1
Wenshan, Shenk'eng	1924 (3)	1586	1	1	0	0	1
Ilan, Ch'iaohsi	1925 (2)	2873	1	0	0	0	1
Hsinchuang, Luchou	1926 (2)	3190	1	0	0	0	0
Luotung, Sanhsing	1927 (2)	2524	No data	No data	No data	No data	No data
Hsinchuang, Link'ou	1927 (11)	2834	1	0	1	0	0
Taipei, Talungtung	1930 (2)	4873	No data	No data	No data	No data	No data
Haishan, Shulin	1930 (10)	5972	No data	No data	No data	No data	No data
Ch'ihsing, Peit'ou	1931 (6)	5981	No data	No data	No data	No data	No data
Taipei, Tongyuanting	1931 (6)	3349	No data	No data	No data	No data	No data
Hsinchu (Shinchiku) prefecture							
Hsinchu, Hsinchu	1922 (3)	2003	1	0	0	0	0
Chunan, Nanchuang	1923 (2)	1122	1	0	1	0	1
Chungli, Yangmei	1923 (10)	2404	1	0	0	0	0
Miaoli, Yuanli	1924 (10)	2686	1	0	0	0	0
Chutung, Peipu	1925 (11)	2346	1	0	0	0	1
T'aoyuan, Tayuan	1927 (1)	1824	1	0	0	0	0
Miaoli, Kungkuan	1927 (11)	2757	1	0	0	0	0
Tahsi, Tahsi	1929 (1)	2735	0	0	0	0	0
Miaoli, T'unghsiao	1929 (9)	3192	0	0	0	0	1
Chungli, Hsinwu	1930 (5)	6513	0	0	0	0	0
Hsinchu, Hsiangshan	1931 (4)	7480	0	0	0	0	0
Hsinchu, Chioukang	1931 (4)	2204	0	0	0	1	0
Taichung (Taichu) prefecture							
Tachia, Shalu	1922 (3)	1934	1	0.5	0	0	1
Peitou, Peitou	1922 (11)	1391	1	0.5	0	0	1
Tat'un, Wufeng	1923 (9)	1417	1	0	0	0	0
Changhua, Fenyuan	1923 (11)	3877	1	0	0	0	0
Tachia, Ta'an	1924 (10)	2510	1	0	0	0	0
Nengkao, P'uli	1925 (6)	3127	1	0	1	0	1
Yuanlin, Puyan	1926 (11)	2865	1	0	0	0	0
Chushan, Luku	1927 (6)	2480	1	0	1	0	0
Nant'ou, Chungliao	1928 (6)	2486	1	0	1	0	0
Tachia, Tachia	1929 (7)	4851	0	0	0	0	0
Fengyuan, Fengyuan	1930 (10)	7187	0	0	0	0	1
Yuanlin, Yuanlin	1931 (9)	6619	0	0	0	0	1
Tainan (Tainan) prefecture							
Hsinhua, Hsinshih	1921 (10)	5275	1	0	0	0	0
Hsinying, Houpi	1922 (10)	5190	1	0	0	0	0
Peimen, Chiali	1923 (1)	3289	1	1	0	0	1
Chiayi, Chongp'u	1923 (9)	2090	1	0	0	0	0
Chiayi, Shueishang	1923 (9)	2940	1	0	0	0	0
Tsengwen, Kuant'ian	1924 (8)	2381	1	0	0	0	0
Hsinying, Paihe	1925 (11)	2304	1	0	0	0	0

Table 1 (*Continued*)

Locality	Year (months)	Population surveyed	Characteristic				
			Unhealthy	Urban	Mountain	Fishing	Commercial
T'ungshih, Luts'ao	1925 (11)	2661	1	0	0	0	0
Touliou, Tapei	1926 (11)	2504	No data	No data	No data	No data	No data
Hsinfeng, Kueijen	1926 (11)	2441	No data	No data	No data	No data	No data
Peiliao, Yuanch'ang	1927 (11)	2600	No data	No data	No data	No data	No data
Hsinhua, Yuching	1928 (10)	2780	1	0	0	0	0
Huwei, Erlun	1924 (10)	3236	0	0	0	0	0
Hsinfeng, Yungning	1929 (10)	6265	0	0	0	1	0
Hsinhua,Hsinshih	1930 (10)	4472	0	0	0	0	0
Peimen, Chiali	1931 (11)	5384	0	0	0	0	1
Kaohsiung (Takao) prefecture							
Kaohsiung, Kaohsiung	1922 (3)	2013	1	0	0	0	1
Fengshan, Hsiaokang	1923 (5)	874	1	0	0	0	0
Kangshan, Mituo	1924 (9)	2406	1	0	0	1	0
P'ingtung, Ch'anghsing	1925 (11)	2270	1	0	0	0	0
Ch'ishan, Ch'ishan	1926 (8)	1604	1	0	0	0	0
Ch'aochou, Wanyuan	1927 (7)	2289	1	0	0	0	0
Tungkang, Hsinyuan	1928 (5)	2577	1	0	0	0	0
Fengshan, Jenwu	1929 (5)	2471	0	0	0	0	0
Kangshan, Hunei	1930 (4)	7565	0	0	0	0	0
Tongkang, Tongkang	1931 (10)	10392	0	0	0	1	0
Taitung (Taito) district							
T'aitung and Lilung	1926 (9)	3833	1	0	0	0	0
T'aitung and Tawu	1928 (10)	1824	1	0	0	0	0
Hsinkang, Ch'engkuangao	1930 (6)	2367	1	0	0	0	0
Hualien (Karenko) district							
Hualien, Chiyeh and P'ingyeh	1927 (8)	3128	1	0	0	0	0
Hualien, Shou	1929 (7)	2261	1	0	0	0	0
Fenglin, Rueysuey	1931 (6)	3128	1	0	0	0	0
Pescadores (Hoko) district							
Huhsi	1929 (6)	3180	1	0	0	0	0
Paisha	1930 (6)	3303	1	0	0	0	0
Hsiyu	1931 (5)	4201	1	0	0	0	0

From the Health and Sanitation Surveys listed in the references. Romanization in Chinese, Japanese.

the dependent variable. Using OLS regressions on these 868 observation points would be inappropriate because each of these groups contain a different number of individuals. In addition, error terms for each group are not independent, in so far as there is local variation which the 14 age groups in each of the 62 localities share in common. To correct for the first problem, a weighted regression is used, and to correct for the second problem, an error components model is used. The error components model assumes that there are two different error terms associated with each of the observations: an independent

Table 2
Descriptive statistics

Variable	Mean value
Adult height (cm)	
Males	161.8
Females	150.4
Adult BMI values (kg/m^2)	
Males	20.1
Females	20.5
Residence (%)	
Urban	5.4
Commercial areas	22.3
Fishing villages	10.7
Unhealthy areas	62.2
Mountain areas	6.5
Ethnic groups (%)	
Hakka minority	13.6
Assimilated aborigines	1.5
Unassimilated aborigines	7.5
Japanese	1.5
Agriculture (%)	
Irrigated fields	50.1

Source: see Table 1.

error term specific to the observation, and another shared by all 14 groups within each locality.[7] The models are estimated using restricted maximum likelihood.[8]

Three sets of independent variables are used. The first set of dummy variables is used to differentiate age groups in order to control for the effects of age on height. Two regressions are run on each sex. In the first regression, dummy variables differentiate all 14 age groups using the ages 35–39 years as the reference group. This regression shows that average group heights peak in the late 1940s for males and in the late 1950s for females. Clearly, individuals do not continue growing until these ages but group heights could be rising due to the death pattern. In early 20th century Taiwan, over 2% of adults aged 20–40 years died each year. Those that died would have been less healthy than the average person and, as such, they

[7] This error components model gives virtually identical estimates for coefficient values as the corresponding weighted-least-squares estimation procedure. The practical effect of using the error components model is to drastically lower the value of the T-statistics for each locality-specific variable. If there was one fishing village in the sample and all 14 age groups in this village were taller than would be otherwise predicted, a least-squares regression would take this to be 14 independent observations confirming the hypothesis that people living in fishing villages were taller. In an error components model, all 14 age groups share a common error term, so that this model would see this example as just one independent confirmation of the hypothesis. The extra locality-specific error term is necessary because there are almost certainly locality-specific factors affecting height for which we have no data, e.g. the fishing village may have had a more effective waste disposal system.

[8] The restricted maximum likelihood method first estimates the variance–covariance components of the model using maximum likelihood, and then uses GLS to estimate the fixed effects given the variance–covariance estimates. SAS program's MIXED procedure was used.

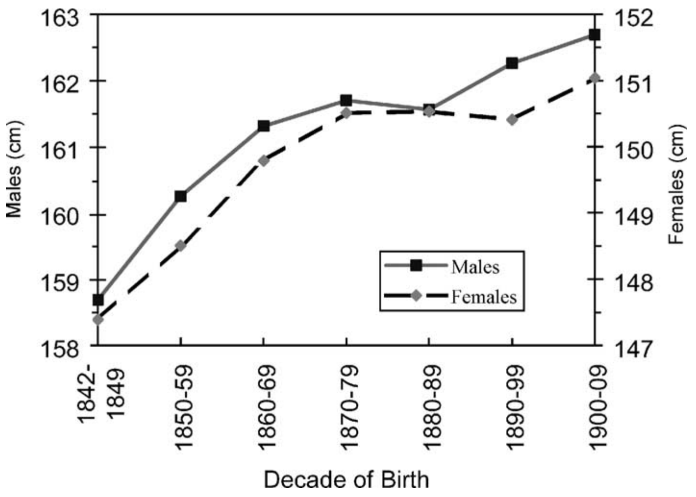

Fig. 1. Heights of adults by the decade of their birth (from the Health and Sanitation Surveys).

may have been shorter. As these people dropped out of the population, average heights may have increased. However, one might doubt that this selection effect could explain such a large rise in heights. Age and year of birth in this sample are closely correlated and it is possible that the age variables are actually picking up an effect due to the year of birth. Therefore, a second regression is run in which ages 23–49 years are all included in the reference group so that no age effect is allowed in these persons, who have not yet begun to shrink.

The second set of dummy variables (representing 3-year time periods) captures the effect of the year of birth, between 1842 and 1910 (Fig. 1). There was a clear difference between people growing up in the late Ch'ing period and those growing up under Japanese rule. Under both alternate age specifications, neither the height of males nor females was increasing before the birth cohorts of 1890, but did so thereafter (Table 3 and Figs. 2 and 3).[9] Men born in 1908–1910 were of 1.15–2.47 cm taller than those born in 1887–1889. Although females' heights began increasing a few years later than those of men, women born in 1908–1910 were 1.29–1.64 cm taller than those born in 1890–1892. The increase in net nutrition occurred for groups born at roughly the same time as the Japanese takeover began. Since children who suffer a deficit in net nutrition when young can catch up when they are older, it is possible that the improvement may have actually occurred after 1900. In

[9] These figures show estimated heights for the reference group of Taichung residents who live in healthy areas with no special characteristics when these residents were 35–39 years old. To derive the estimated heights of other groups, a parallel shift upward or downward of the graph is required. One possible source of error in these regressions is the strong collinearity between age and year of birth. To test for the seriousness of such problems, I have run 14 separate regressions on the 14 different age groups. Out of these, 12 regressions show the same general results as shown by the regression presented. Year of birth does not significantly affect those age groups born before 1890, but there is a significant correlation for those age groups born afterwards.

Table 3
Covariates of height

Independent variables	Model 1		Model 2	
	Male	Female	Male	Female
Intercept	162.54[a]	150.01[a]	162.77[a]	150.08[a]
Age (years)				
22	−0.92	−0.74	0.17	−0.46
23	−1.04	−0.27	Reference	Reference
24	−1.00	−0.45	Reference	Reference
25–29	−0.83	−0.08	Reference	Reference
30–34	−0.50	0.01	Reference	Reference
35–39	Reference	Reference	Reference	Reference
40–44	0.24	−0.04	Reference	Reference
45–49	0.37	0.21	Reference	Reference
50–54	0.29	0.34	−0.37	−0.59[a]
55–59	0.08	0.88	−0.84[b]	−1.22[a]
60–64	−0.29	−1.61	−1.48[a]	−2.03[a]
65–69	−0.98	−2.39	−2.42[a]	−2.88[a]
70–74	−1.18	−3.48[b]	−2.89[a]	−4.06[a]
75–79	−2.62	−4.45[b]	−4.60[a]	−5.10[a]
Birth-year				
1842–1844	−0.85	2.26	1.40	2.98
1845–1847	0.76	1.89	2.88	2.58[b]
1848–1850	−1.47	1.36	0.51	2.00[b]
1851–1853	−0.65	0.91	1.14	1.51
1854–1856	−0.49	1.34	1.15	1.89[a]
1857–1859	−0.05	1.38	1.54	1.88[a]
1860–1862	−0.33	0.83	0.98	1.28[b]
1863–1865	0.27	1.25	1.46[b]	1.66[a]
1866–1868	−0.22	1.00	0.77	1.36[a]
1869–1871	−0.07	0.72	0.80	1.03[a]
1872–1874	−0.28	0.99	0.41	1.26[a]
1875–1877	0.23	0.40	0.74[a]	0.63[a]
1878–1880	−0.11	0.69	0.32	0.83[a]
1881–1883	−0.35	0.35	−0.11	0.43[b]
1884–1886	0.13	0.30	0.32	0.32
1887–1889	Reference	0.26	Reference	0.19
1890–1892	0.77[a]	Reference	0.51[b]	Reference
1893–1895	1.21[a]	0.49[b]	0.79[a]	0.45[b]
1896–1898	1.85[a]	0.47	1.13[a]	0.40[b]
1899–1901	1.55[a]	0.63	0.69[a]	0.46[b]
1902–1904	1.97[a]	1.11[b]	0.92[a]	0.92[a]
1905–1907	2.34[a]	1.32[b]	1.13[a]	0.91[a]
1908–1910	2.47[a]	1.64[b]	1.15[a]	1.29[a]
Residence				
Taipei	−0.44	0.18	−0.39	0.19
Hsinchu	−0.31	−0.08	−0.35	−0.09
Taichung	Reference	Reference	Reference	Reference
Tainan	−1.87[a]	−0.69[b]	−1.95[a]	−0.71[b]
Kaohsiung	−2.84[a]	−0.89[a]	−2.86[a]	−0.89[a]

Table 3 (*Continued*)

Independent variables	Model 1		Model 2	
	Male	Female	Male	Female
Taitung and Hualien districts	−1.47[a]	0.04	−1.27[b]	0.02
Pescadores	1.14[b]	2.83[a]	1.42[a]	2.91[a]
Characteristics				
Urban	0.26	−1.04[b]	0.12	−1.07[b]
Commercial	−0.02	0.63[b]	−0.03	0.61[b]
Fishing	1.45[a]	1.00[a]	1.46[a]	1.00[a]
Unhealthy	−0.38	0.18	−0.70[a]	0.09
Mountain	−0.80[b]	−0.52	−0.84[b]	−0.50
Ethnicity				
Hakka	0.43	−0.80	0.50	−0.79
Assimilated aborigines	2.84	3.74[b]	3.05	3.81[b]
N	845	855	845	855

Source: see Table 1.

[a] Indicates significance at 1% level.

[b] Indicates significance at 5% level.

any case, the evidence clearly points to an improvement shortly after the occupation began. Average height may have been falling prior to the Japanese takeover, but the estimates for early birth cohorts suffer from large standard errors and the evidence is ambiguous in this regard.

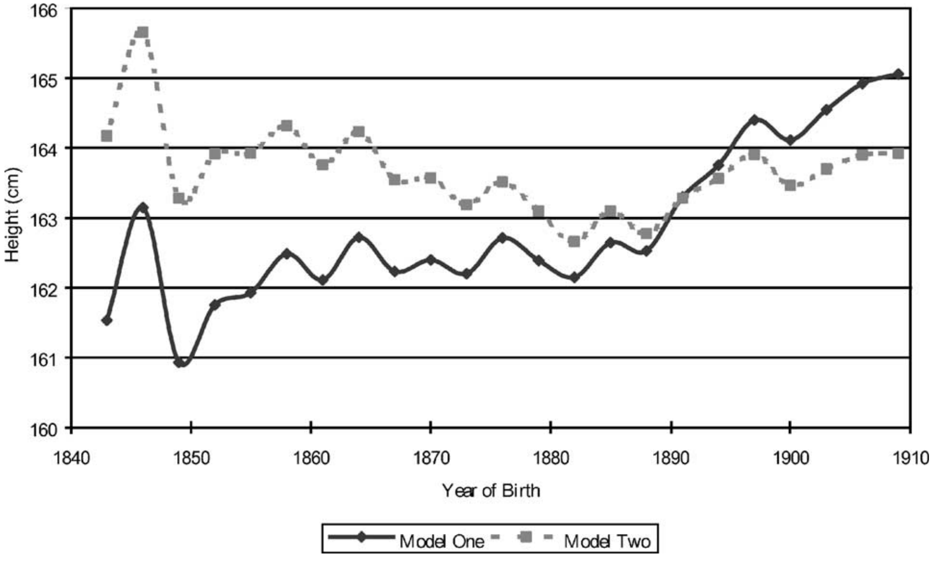

Fig. 2. Trend of Taiwanese male heights: two estimates (source: see Table 1).

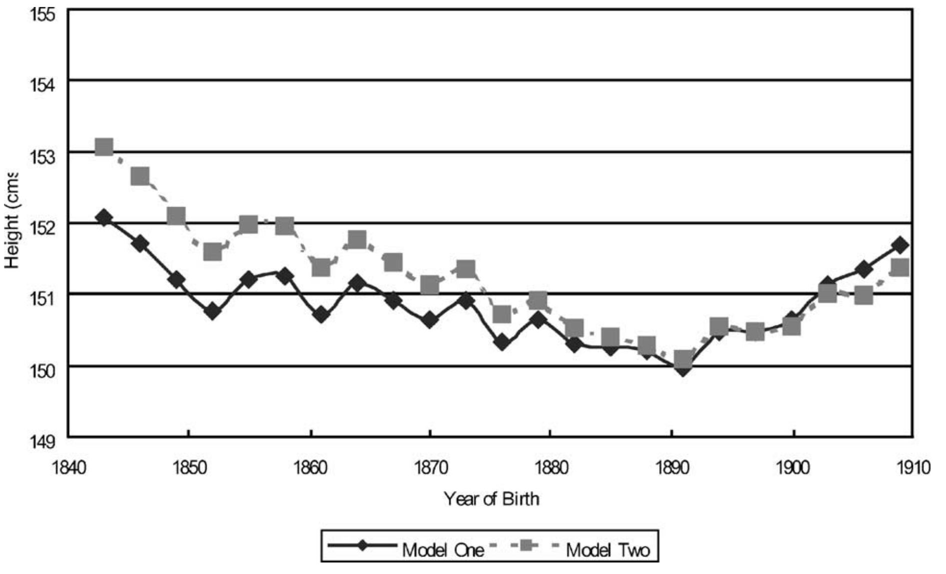

Fig. 3. Trend of Taiwanese female heights: two estimates (source: see Table 1).

The third set of variables controls for systematic regional differences. The Japanese divided the island into healthy and unhealthy areas based mainly on the prevalent death rate.[10] The dummy variable, "unhealthy" is included to distinguish between these two types of localities (Table 3). Males may have been shorter in the unhealthy areas, but the evidence is ambiguous. There was a rapid decline in death rates after the Japanese occupation, so that the epidemiological environment at the time of these studies may not be indicative of the healthiness of the region throughout the growing years of the population.

Taiwan was divided into five prefectures: Taipei, Hsinchu, Taichung, in the north and Tainan and Kaohsiung in the south; and three districts, one in the Taiwan Straits (Pescadores—a total of eight political units) and the other two on the east coast; all of which are included in the analysis[11] (Table 1). The most obvious regional difference was that the shortest people were in the south, a relatively unhealthy region with a higher crude death rate and a declining population during much of the 19th century (Taiwan Provincial Archives, 1972). Chinese men in the frontier region of the eastern coast, Taitung and Hualien districts, were also shorter than men in the north. People were tallest in the Pescadores district, an archipelago in the Taiwan Straits. Four other dummy variables were used to distinguish special characteristics of these localities:

[10] The earlier studies were done primarily in unhealthy areas.

[11] The districts were not very different from the prefectures, except that their populations were much smaller. The Pescadores were islands in the Taiwan Straits. The other two districts were on the east coast. Taiwan's east coast was settled late and transportation was undeveloped because in most places the mountains come right down to the sea. The Chinese living there were outnumbered by the aborigines.

(a) “Urban” used to demarcate localities the Japanese labeled as “urban”.[12] This study finds that Taiwanese women were shorter in urban areas.
(b) “Commercial” is included to demarcate the localities in which the Japanese researchers recorded the presence of merchants. Women in these localities were somewhat taller.[13]
(c) Men, and probably women, living in mountain areas were shorter than those living at lower elevations.[14]
(d) People living in fishing areas tended to be taller, perhaps due to an enriched protein diet.[15] Fishing was important also throughout the Pescadore Islands and hence the relatively tall population there may also be related to this occupational advantage.

Finally, two variables control for ethnicity using the proportion of the locality’s population that belonged to “Hakka” and “assimilated aborigines” minorities as shown by the 1930 census (Taiwan Government-General, Secretariat, Provisional Census Bureau, 1932–1933). Besides race, the main difference between these minority groups and the majority “Minnan” people was that Hakka and aborigines tended to live at higher elevations and the women tended to do more outdoor work and live less secluded lives. Assimilated aborigines females were taller than other Taiwanese females. Males were also probably taller, but the difference, though large, is not statistically significant.

3. Contemporary conditions in 1920s Taiwan

Adult heights provide information on the conditions under which the adults grew up. Other means must be used to measure the contemporaneous biological standard of living of adult Taiwanese during the period 1921–1931. The crude death rate, reliable data which are available after 1905, is another measure of the biological well being. Mortality generally fell from 1906 to 1942 with the exception of the period during and immediately following World War I (Fig. 4). Death rates remained higher in the south suggesting that the biological standard of living remained lower there after 1910.

Another means of measuring the contemporaneous biological welfare is the body mass index (BMI).[16] In the BMI analysis, two culturally non-Chinese groups were added in addition to the variables used in the height regressions. The Japanese authorities collected data on eight groups of unassimilated aborigines in the six localities on the east coast of Taiwan. Unlike the data on assimilated aborigines in the more populous prefectures, the unassimilated

[12] Strictly speaking, this is a ternary variable. In two cases, only a portion of the area was labeled “urban” and this variable was set to 0.5. Residents of pre-20th century cities were often shorter than the rural population due to sickness caused by lack of modern sanitation (Steckel, 1995).

[13] This study assumes differences in localities of a permanent nature, but the differences may, in fact, have been changing over time. If so, the variables will not accurately reflect the characteristics of the locality when the older adults were children. This means the coefficients of the local variables may be underestimated. This would probably be most important for the dummy variables that specify urban and commercial areas.

[14] This variable shows areas which were either labeled mountainous by the Japanese or were over 300 m above sea level.

[15] Goto (1931) measured the heights of Taiwanese prisoners and also found that Taiwanese fisherman tended to be taller than the average population.

[16] BMI is weight (kg) divided by the square of height (m).

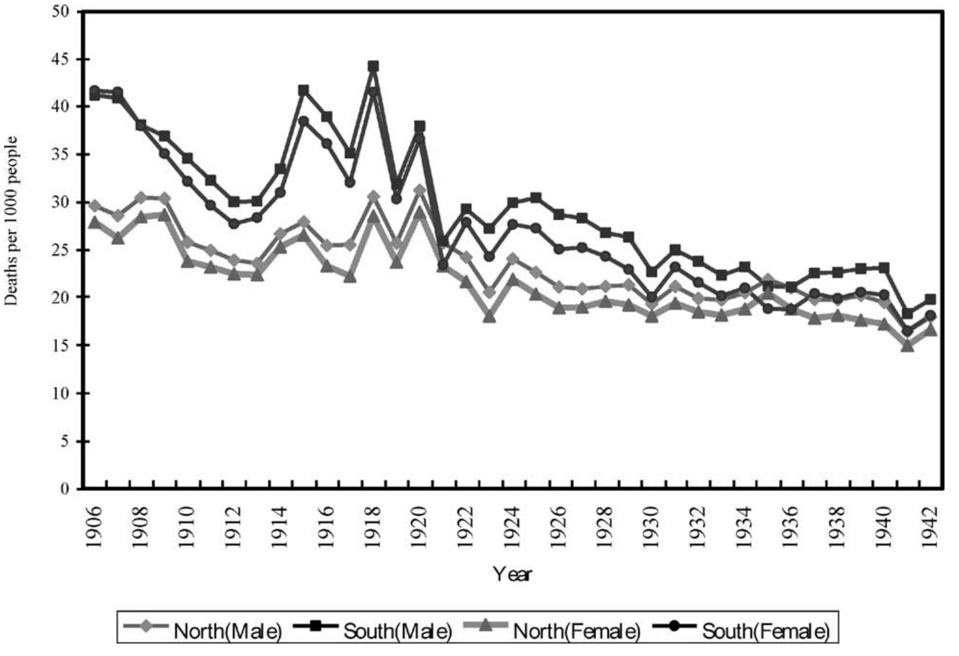

Fig. 4. Annual death rates, 1906–1930 (note: crude death rates are calculated by dividing the number of deaths in each area by the estimated population of the area; source: Taiwan Government-General, Secretariat, Statistics Office (1907–1943).

aborigines data was kept separate from Chinese data. The Japanese authorities also collected data on Japanese who were living in any of the localities. The Japanese were widely scattered throughout western Taiwan and usually worked for the government or big businesses. They had a very different background than most Taiwanese. However, there was a large concentration of immigrant Japanese farmers in the frontier Hualien district who were more comparable with the Taiwanese population. The data on both the unassimilated aborigines and the Hualien Japanese were included in the BMI regressions. The independent variables used in the BMI regressions are the same as those used in the height regressions except:

(a) A "continuous time" variable indicating the year and month, treated as a fraction of a year: the data was collected and is included.[17]
(b) Two dummy variables are added indicating whether the people measured were unassimilated aborigines or Hualien Japanese.
(c) A variable is added to indicate the proportion of farmland in each locality that was irrigated as of 1921 (Taiwan Government-General, Agriculture and Industry Bureau, Agricultural Department, 1921).
(d) A variable is added to indicate malaria deaths per 1000 inhabitants during the period 1917–1921 (Taiwan Government-General, Interior Bureau, Sanitation Office, 1925).

[17] January 1921 was treated as time zero.

The last two variables were not used in the height regressions because irrigation and disease patterns were swiftly changing during the early years of Japanese rule. Irrigation was becoming much more common, particularly in the south and malaria and other diseases were in retreat. Thus, irrigation and disease patterns circa 1920 are very poor instruments in indicating the conditions under which adults in different localities grew up.

A healthy BMI for both males and females is in the range of 20–25. With a BMI below 18.5, chronic energy deficiency may be a problem (Shetty and James, 1994). The average Taiwanese BMI in the 1920s was near the very bottom of the healthy range: 20.11 for males and 20.47 for females (Table 4). The most underweight area was in Peitou in Taichung prefecture (presently in Changhua County). This area had a high population density and the average BMI for males and females was only 18.82 and 19.22, respectively. Chronic energy deficiency may have remained a serious problem there. The Taiwanese males with the highest average BMI (22.10) were found in the southern fishing village of Mit'uo. Taiwanese females in mountainous Nanchuang in Hsinchu prefecture had the highest average BMI of any area—22.20. The dummy age variables indicate that male BMIs tended to rise after the age of 20 years, peaked in 30–40 years and then declined. Adult women showed no increase in BMI after the age of 20 years, but their BMI also began to decline after 30–40 years and declined more than that of men.[18]

There was no clear north–south pattern for BMI as there was for heights. As with heights, the highest male BMI estimates were for the Pescadores. Although men were shorter in the eastern coastal districts, they had a relatively high BMI, as probably did women, in these districts. Men and women had a higher BMI in mountain areas. Male aborigines and Japanese, male and female, had higher BMI than their Taiwanese counterparts, although they were shorter. It is possible that there is a connection between the stoutness of aborigines and the stoutness of people in mountainous and frontier areas. People on the frontier and in the mountains would have had closer relations with aborigines and through intermarriage may have been influenced genetically and culturally. As with heights, there was no clear difference between the Hakka and the majority Minnan people.

The regressions also show evidence that diseases had a negative effect on BMI. The average BMI was significantly lower for women in unhealthy areas with high death rates. The male BMI was significantly lower in areas with high incidences of death from malaria. When the Japanese occupied Taiwan, many of their soldiers died from disease. Therefore, understanding and improving the disease environment became a high priority for the Japanese government. In so far as disease affects height, as well as BMI, this regression shows that the improvement in the disease environment brought about by Japanese policies (Chang and Myers, 1963) was a factor in the earlier increase in heights.[19] The death-from-malaria rate in malarial districts rose to somewhat more than 10 deaths per 1000 people per 5 years. Thus, taken at face value, this regression suggests that male BMI would have increased by about 2% in these districts if malaria had been eliminated. However, the correlation

[18] Besides the problem with bound feet, another problem with female BMI data is that the Japanese do not explain whether or how they adjusted for pregnancy when measuring weight.

[19] Important changes made by the Japanese early in their rule which may have significantly altered Taiwan's disease patterns were: (1) trade with China was increasingly replaced by trade with Japan which had a healthier population, and (2) health inspections were instituted for ships entering Taiwanese harbors.

Table 4
Covariates of BMI

Independent variables	Estimate	
	Male	Female
Error intercept	19.68[a]	20.72[a]
Age (years)		
22	Reference	Reference
23	0.16	0.01
24	0.24[b]	−0.03
25–29	0.40[a]	0.00
30–34	0.48[a]	−0.02
35–39	0.47[a]	−0.05
40–44	0.30[a]	−0.33[a]
45–49	0.09	−0.77[a]
50–54	−0.05	−1.19[a]
55–59	−0.24[a]	−1.48[a]
60–64	−0.57[a]	−1.51[a]
65–69	−0.61[a]	−2.07[a]
70–74	−0.88[a]	−2.25[a]
75–79	−0.89[a]	−2.65[a]
Residence		
Taipei	0.71[a]	0.22
Hsinchu	0.72[a]	0.96[a]
Taichung	Reference	Reference
Tainan	0.13	−0.34
Kaohsiung	0.53[a]	0.23
Taitung and Hualien districts	1.06[a]	0.40
Pescadores	1.32[a]	0.77[a]
Characteristics		
Urban	−0.14	0.93[a]
Commercial	−0.10	−0.18
Fishing	0.30[b]	0.00
Unhealthy	−0.26	−0.64[a]
Mountain	0.58[a]	0.96[a]
Irrigation	0.19	0.66[a]
Malaria	−0.04[a]	0.03
Ethnicity		
Hakka	−0.15	0.10
Assimilated aborigines	1.61[b]	0.55
Unassimilated aborigines	1.17[a]	0.27
Japanese	0.87[a]	0.93[a]
Time trend	−0.04	−0.01
N	966	972

Source: see Table 1.

[a] Indicates significance at 1% level.

[b] Indicates significance at 5% level.

between malaria and BMI shown in this regression should be treated cautiously. There were numerous other endemic diseases not controlled for in these regressions whose geographic distribution may have been correlated with malaria. Malaria does seem to be the disease that most concerned Japanese health authorities. The special study they did of the disease from which this data is derived shows that in the 1917–1921 period, 7.6% of all Taiwanese deaths were attributed to malaria.

The female BMI was higher in the cities and in irrigated areas. Using irrigated paddy land was a capital-intensive means of farming. Thus, the high BMI in irrigated areas and cities could be evidence of a wealth effect. The high BMI could also be due to the fact that women did less farm work in these areas. Women did heavy work in dry fields but seldom worked in paddies.

Although statistics show that Taiwanese consumption began increasing in the late 1920s, this regression shows no evidence that the BMI of Taiwanese increased during the period 1921–1931. In fact, the coefficient for the male time trend is negative, although not significantly so. Another measure of the biological standard of living in the 1920s, the heights of children growing up in this period, paints a more optimistic picture.

Columns 1 and 2 in Table 5 present the results of regressions on the log of children's heights (cm). For further reference, columns 3 and 4 show the results of the identical regressions using levels. The regressions consider the heights of all children from ages 2 to 12 years.[20] Children in the south, as well as on the east coast tend to be shorter and urban children tend to be taller. Japanese children were shorter as were the adults. Girls in mountain areas were significantly shorter. The heights of children, both boys and girls, were clearly increasing over time. The reference groups were children born in the 1920–1922 period. Those born earlier had been significantly shorter and those born later reached significantly greater heights.

The BMI and children's height regressions seem to agree that people were healthier in urban areas, but they otherwise show some conflicting results besides the difference in time trend. Japanese had higher BMI, but their children were shorter. Adult Japanese were also shorter, although the Japanese researchers who did the original research note that the average Hualien Japanese was roughly 2 cm taller than the average farmer in Japan (Taiwan Government-General, Interior Bureau, Sanitation Office, 1936). These Chinese–Japanese differences are not specific to the 1920s. Chen et al. (1974) found the same results. Similarly, Taiwanese living on the east coast, although shorter, had a higher BMI. The same may have been true for those living in the mountains. Adults living in the mountains were shorter with a larger BMI and their children were also shorter.

The regression on children's heights also shows that southern Taiwanese remained shorter than northern Taiwanese, but the BMI regression does not show any clear disadvantage for southerners. One possible explanation for this, and for the difference in time trends, is that the biological standard of living was increasing due to the decrease in disease,

[20] The log of heights is used since the shift upward in heights is not a parallel shift but a roughly proportional shift. Children under the age of 2 years are not included in this regression because a comparison of children's heights in healthy and unhealthy areas showed that the proportional difference in heights for this age group was much less than for the 2–12 years age group. The heights of teenagers also rose significantly over time but I do not use this group in the regressions to avoid problems with the timing of the adolescent growth spurt.

Table 5
Factors affecting the height of children (ages 2–12 years)

Independent variables	Log height (cm)		Height (cm)	
	Male	Female	Male	Female
Intercept	4.41[a]	4.39[a]	82.2[a]	81.02[a]
Age (years)				
2	Reference	Reference	Reference	Reference
3	0.08[a]	0.09[a]	6.6[a]	7.1[a]
4	0.15[a]	0.16[a]	13.0[a]	13.5[a]
5	0.21[a]	0.22[a]	19.0[a]	19.1[a]
6	0.27[a]	0.27[a]	24.6[a]	24.6[a]
7	0.31[a]	0.32[a]	29.8[a]	30.1[a]
8	0.35[a]	0.36[a]	34.5[a]	34.9[a]
9	0.40[a]	0.41[a]	39.6[a]	39.8[a]
10	0.43[a]	0.44[a]	44.0[a]	44.4[a]
11	0.47[a]	0.48[a]	48.8[a]	49.0[a]
12	0.50[a]	0.52[a]	52.0[a]	54.5[a]
Birth-year				
1908–1910	−0.02[b]	−0.04[a]	−3.1[a]	−4.4[a]
1911–1913	−0.01[b]	−0.02[a]	−1.6[b]	−2.1[a]
1914–1916	−0.01[a]	−0.01[a]	−1.2[a]	−1.2[a]
1917–1919	0.00	−0.01[b]	−0.1	−0.6[b]
1920–1922	Reference	Reference	Reference	Reference
1923–1925	0.01	0.00	0.5	0.1
1926–1928	0.01[b]	0.01	0.9[b]	0.6
1929–1931	0.01	0.02[b]	0.7	1.1
Residence				
Taipei	−0.01	−0.01[b]	−0.6	−1.2[b]
Hsinchu	0.00	−0.01	−0.1	−0.6
Taichung	Reference	Reference	Reference	Reference
Tainan	−0.02[a]	−0.02[a]	−1.8[a]	−2.2[a]
Kaohsiung	−0.02[a]	−0.03[a]	−2.5[a]	−3.0[a]
Taitung and Hualien districts	−0.03[a]	−0.04[a]	−2.8[a]	−3.7[a]
Pescadores	0.00	−0.01	0.5	−1.1
Characteristics				
Urban	0.03[a]	0.02[a]	2.8[a]	2.3[a]
Commercial	0.00	0.00	−0.3	0.3
Fishing	0.01	0.01	0.8	1.0
Unhealthy	−0.01	0.00	−0.7	−0.2
Mountain	−0.01	−0.01[a]	−0.7	−1.4[a]
Irrigation	0.01	0.01	1.4[b]	0.9
Malaria	0.00	0.00	−0.1	−0.1
Ethnicity				
Hakka	0.01	0.00	0.5	0.3
Assimilated aborigines	0.06	0.04	6.5	4.6
Unassimilated aborigines	−0.01	0.00	−1.3	−0.2
Japanese	−0.03[a]	−0.02[b]	−2.8[a]	−2.2[a]
N	788	787	788	787

Source: see Table 1.

[a] Indicates significance at 1% level.

[b] Indicates significance at 5% level.

which disproportionately affected children, rather than an increase in caloric intake. Certainly more work needs to be done before any firm conclusions can be reached in this regard.

4. Conclusions

Foreign observers in Taiwan in the early years of Japanese rule claimed that there was significant economic growth. They attributed the increase in economic welfare to improvements in transportation and law enforcement. Later scholars put together time series that did show rapid growth in these years but because these time series did not go back before the 20th century, they assumed this growth was simply a return to the pre-takeover level. Using height measurements, we argue on the basis of evidence on the height of the Taiwanese population that soon after the Japanese occupation began, the biological standard of living did increase. This may have been due to an increase in consumption, but it is also possible that the increased height was due solely to an improvement in the disease environment. In any event, the increase in the biological standard of living is evidence of an increase in human welfare.

In Japan itself, adult heights were also increasing in the early 20th century (Mosk, 1996). Korea was another important Japanese colony during this period. Gill (1998) shows that, judging by heights, the biological standard of living in Korea fell after 1925 and did not begin to rise again until after the war. However, since the limited data he presents for the pre-1925 period does not show falling heights, it is possible that the Japanese occupation of Korea initially had a favorable impact on the biological standard of living similar to that in Taiwan. Post-war studies of Taiwanese height and weight shows that these continued to increase although it is not clear how much of this increase came in the remaining years of Japanese rule (1931–1945) and how much came in the post-war period. Chen et al. (1974) measured the heights of 47,387 young people from ages 1 to 25 years throughout Taiwan and the Pescadores from 1970 to 1972. Fig. 5 shows the increase in height from the 1920s to the early 1970s among Chinese and unassimilated aborigines males by age. The final height of Chinese males increased roughly by 6 cm, to 167.5 cm.[21] The height of aborigines males also increased, but only by somewhat less than 3 cm. There was a small increase in BMI. The BMI of 20-year-old Chinese males increased from 19.55 to 20.25 and the BMI of 20-year-old aborigines males increased from 21.15 to 21.86. Female height and BMI (not shown in this paper) show similar patterns. Wu et al. (1994), using data for Chinese adults collected in the early 1980s, show an increase in final Chinese heights of about 1 cm over the 1970s data, but no apparent increase in BMI among 20-year-old Chinese. Compared with the 1920s, there is a large increase in BMIs, which is not represented in the 1970s data. Chinese males 45–55 years, for example, had an average BMI of roughly 19.8 in the 1920s. This had risen to 23.6 in the early 1980s. For females, the respective increase was from 20.0 to 23.1. This probably reflects the shift away from farming to less physically strenuous, and thus calorie consuming, occupations.

[21] Change in average post-war heights may have also been affected by the massive influx of Mainland Chinese after World War II. These newcomers are roughly one-sixth of the population.

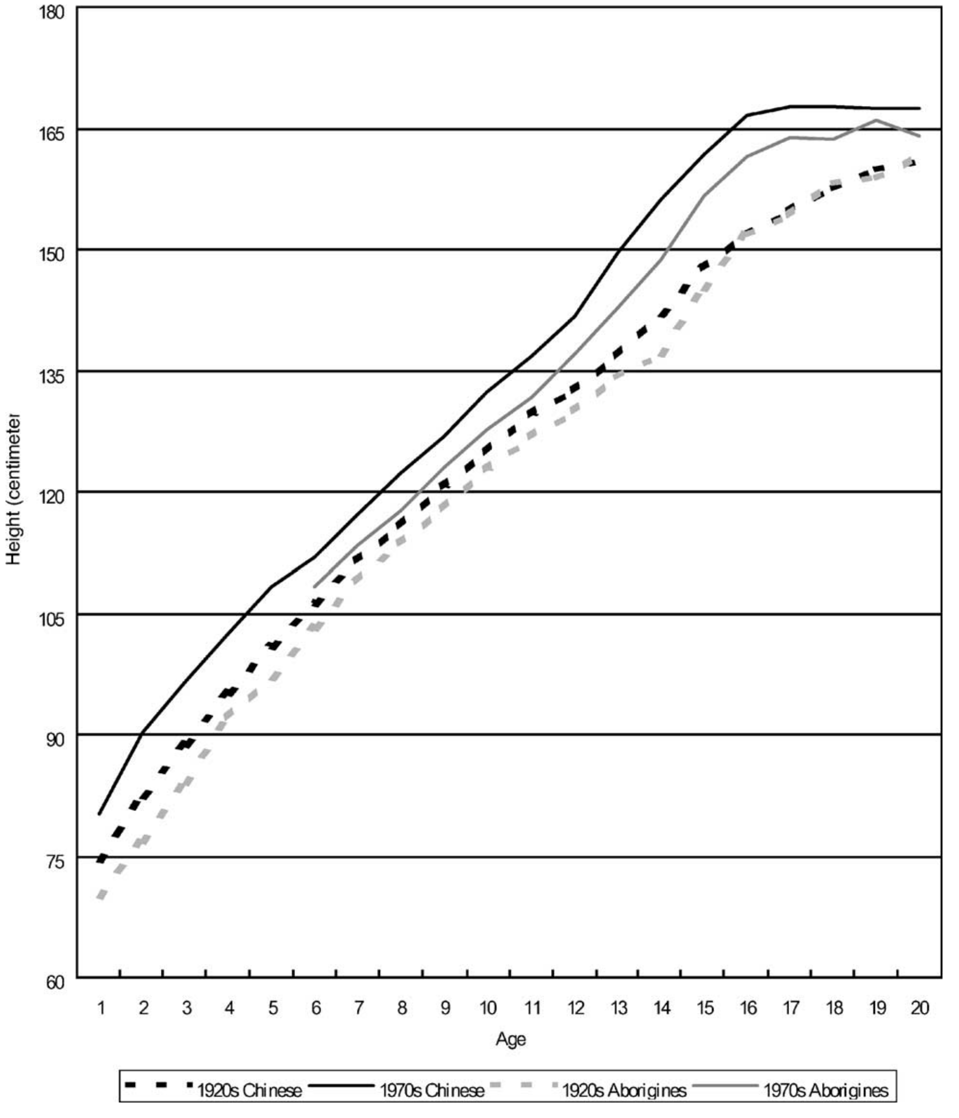

Fig. 5. The height of young Taiwanese males, 1920s vs. early1970s (sources: Chen et al., 1974, p. 377; Table 1). The 1970s sample included no aborigines under 6 years old.

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