NBER WORKING PAPER SERIES

HEIGHT AND PER CAPITA INCOME

Richard H. Steckel

Working Paper No. 880

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge MA 02138

April 1982

The author has benefited from comments or discussions with Robert Fogel, Stanley Engerman, Robert Margo, Edward Ray, Lars Sandberg, and Daniel Scott Smith. The research reported here is part of the NBER's research program in Development of the American Economy. Any opinions expressed are those of the author and not those of the National Bureau of Economic Research.

NBER Working Paper #880
April 1982

Height and Per Capita Income

ABSTRACT

As an aid to interpreting the results of height-by-age studies this paper investigates the relationship between average height and per capita income. The relationships among income, nutrition, medical care, and height at the individual level suggest that average height is nonlinearly related to per capita income and that the distribution of income is an important determinant of average height. Empirical analysis rests on 56 height studies and per capita income estimates for 20 developed or developing countries.

Richard H. Steckel
Department of Economics
Ohio State University
1775 College Road
Columbus, Ohio 43210

(614) 422-5008

Introduction

The recent spate of papers analyzing height-by-age data has left some economists and historians uneasy about the methodology employed and the meaning of the results.[1] Although the papers typically include a discussion of human growth and its determinants, scholars unfamiliar with this literature have difficulty assessing the behavioral significance of cross-sectional differences or time profiles of height. One solution to this problem has been to conduct or to propose height-by-age studies of various populations with the objective of establishing a benchmark of performance against which other populations can be compared. Height differences among U.S. whites, slaves, and some Europeans during the nineteenth century, for example, reveal that U.S. whites undoubtably had environmental advantages.

The advantages enjoyed by U.S. whites may be explained by diet, caloric intake relative to physical exertion, the disease environment, public health measures, etc. Any discussion along these lines must also address the possible role of genetic factors. While efforts in this direction are essential for understanding the details of these societies, interpreting the results in these terms probably requires a greater commitment to the literature of human biology than most economists and historians are willing to make.

As an aid to interpreting the results of height-by-age studies, it would be helpful to compare and contrast height with other measures of well-being. This paper investigates the relationship between height and per capita income. Height is an index of nutrition and health that depends largely on income. The connections among height, nutrition, and health, and among nutrition, health, and income are considered separately. Empirical analysis rests on 56 height studies and per capita income estimates for 20 countries.

Nutrition, Health, and Height

Human growth from birth to maturity follows a well-defined pattern.[2] The change in height, or velocity, is greatest during infancy, falls sharply, and then ordinarily declines into the pre-adolescent years. During adolescence velocity rises sharply to a peak that equals approximately one-half of the velocity during infancy, then falls sharply and reaches zero at maturity. In girls the adolescent growth spurt begins about two years earlier, and the magnitude of the spurt is smaller than in boys. Girls and boys are about the same height prior to the spurt.

The height of an individual reflects the interaction of genetic and environmental influences during the period of growth. According to Eveleth and Tanner:

> Such interaction may be complex. Two genotypes which produce the same adult height under optimal environmental circumstances may produce different heights under circumstances of privation. Thus two children who would be the same height in a well-off community may not only be smaller under poor economic conditions, but one may be significantly smaller than the other.... If a particular environmental stimulus is lacking at a time when it is essential for the child (times known as 'sensititive periods') then the child's development may be shunted as it were, from one line to another."[3]

Although genes are important determinants of the heights of individuals, studies involving genetically similar and dissimilar populations under various environmental conditions suggest that differences in average height across most populations are largely attributable to environmental factors. Using data from various social classes and several developed and developing countries, Habicht _et al._, argue that height (and weight) standards chosen to represent optimal pre-school growth can be drawn from studies of well-off children, regardless of race or ethicity, because "any racial or ethnic effect on mean preschool growth is small compared with environmental effects."[4] In a review of studies covering populations in Europe, New Guinea, and Mexico, Malcolm concludes that "although the overall pattern such as the sex difference, the adolescent spurt and the general shape of the curves, is genetically determined, the differences between populations are almost entirely the product of the environment."[5] Although differences in average heights across many populations are related primarily to environment, comparisons involving Japanese adults are an exception that may have a substantial genetic basis; well-off Japanese reach, an average, the 15th height centile of well-off Britains.[6]

Physical growth is correlated with many environmental variables, but in the final analysis most of them operate through nutrition and disease.[7] Malnutrition combined with illness may produce a synergistic effect.[8] Poorly nourished children are more susceptible to infection and infection reduces the body's absorption of nutrients. The mortality rate from measles, for example, is several times higher in malnourished compared to well nourished children.[9]

The sensitivity of growth to malnutrition or illness depends on the age at which they occur. For a given degree of deprivation, the effects may be proportional to the velocity of growth under optimal conditions.[10] Thus young children and adolescents are particularly sensitive to environmental insults. At the end of a period of slow growth, normal height may be restored by catch-up growth. If the treatment following slow growth is insufficient for catch-up growth, normal adult height may be approached by an extension of the growing period. Prolonged and severe deprivation produces stunting, that is, a reduction in adult size.[11]

Wartime famines demonstrate the effects of deprivation on growth. The heights of German children of a given age declined by one to three inches when their food consumption was restricted during World War II.[12] Adolescent heights also declined in Japan and the Soviet Union during World War II.[13]

Income, Nutrition, and Health

Caloric intake is a reasonably reliable indicator of nutrition.[14] Calories are a measure of the potential energy available for maintenance of bodily functions and growth, and caloric consumption is correlated with the intake of protein, mineral, and vitamin nutrients.

Income is the most important determinant of diet.[15] Extremely poor families may spend two-thirds or more of their income on food, but a high proportion of a very low income purchases few calories. Malnutrition associated with extreme poverty is known to have a major impact on height. Once calorie requirements are satisfied, additional expenditures on food purchase largely variety, palatability, and convenience. An income level that is low by current European or North American standards is sufficient to purchase enough calories to prevent retarded growth and stunting.[16]

Impoverished families can afford little medical care, and additional income may have an important affect on health through control of infectious diseases. While tropical climates have acquired a bad reputation for diseases, King argues that poor health in developing countries is largely a consequence of poverty rather than climate.[17] There is a group of diseases which are spread by nectors that need a warm climate, but poverty is responsible for the lack of doctors, nurses, drugs, and equipment that combats these and other diseases. Private expenditures per capita on health care are necessarily small in developing countries and government expenditures per capita may be less than 1/100 of those in industrialized countries.[18]

Within industrialized countries height rises with income or socio-economic class.[19] The differences in height may be related to expenditures on health care. Expenditures on health services rise with income and there is a positive relationship between health services and health.[20]

Height is also a function of the disease environment. This variable is not measured easily, but one might argue that the expectation of life at birth is a suitable proxy that is independent of per capita income. In the data of this study the correlation between the expectation of life at birth and the log of per capita income is about .88, and consequently estimates of their separate effects on height are unreliable. Although the regressions discussed below include only the log of per capita income, the estimated coefficient of this variable reflects the effect of both income and health.

The Data

The most comprehensive data on human growth are published in Eveleth and Tanner, Worldwide Variation in Human Growth. This book summarizes and interprets the results of numerous growth studies primarily undertaken during the 1960s and 1970s. Tables in the appendix give the same type of information for each study, including country, the groups of people or place, date of publication, height by year of age up to age 18 (heights are not available for some ages), and adult height.[21] The tables include several national studies of height as well as studies of numerous smaller groups such as rural, urban, student, military, poor, and rich residents. Studies of relatively small groups such as tribes are excluded from this analysis on the basis that little information is available about their per capita income relative to the national average.

Extensive data on per capita income since 1950 for market-oriented economies are available in Summers et al (1980).[22] Per capita income estimates for centrally planned economies were interpolated from World Bank data.[23] Jain is the source of data on income distribution.[24] Unfortunately the match between height studies and income distribution studies is not very complete; the overlap permits analysis of 56 height studies in 20 countries.

Analysis

It is difficult to specify a priori the functional form of the relationship between height and per capita income, although it is argued below that it is probably nonlinear. At the individual level, extreme poverty results in malnutrition, retarded growth, and stunting. Higher incomes permit the purchase of a better diet, and height increases correspondingly. Once income is high enough to satisfy caloric requirements, there is little, if any, height gain available from changes in diet related to higher incomes. Height may continue to increase with income, however, because more or better medical care services are purchased. Consumption patterns change with income so that more and more of a person's genetic potential is realized; once the potential is reached environmental variables have no more effect. The limits to the process are apparent from the fact that people who grew up in very wealthy families are not physical giants.

If the relationship between height and income is non-linear at the individual level, then the relationship at the aggregate of country level depends on the distribution of income. Average height may differ for a given per capita income depending, for example, on the fraction of people with insufficient income to purchase adequate calories. Since the gain in height at the individual level increases at a decreasing rate as a function of income, one would expect average height at the country level to rise, for a given per capita income, with the degree of equality of the income distribution (assuming that there are people who have not reached their genetic potential). Food prices, the composition of the diet, knowledge and standards of personal hygiene, public health measures that control disease, the disease environment, as well as the amount of physical exertion required to earn a given income, and intergenerational factors (the length of time that a given per capita income has been sustained) may all affect a country's average height at a given level of per capita income; social and cultural values such as the pattern of food distribution within the family, methods of preparation, and tastes and preferences for foods may also be relevant.[25]

One should proceed with considerable caution, then, to estimate and interpret the relationship between per capita income and average height at the aggregate level. Despite the large number of factors that may influence average height at a given level of per capita income, there is a high correlation between these variables.[26] The functional form of the relationship was explored by regressing average height on various polynominals in per capita income and the log of per capita income. There is a substantial improvement in fit by going from the linear to the quadratic formulation, and a slight improvement by going from the quadratic to the cubic. Because the semilog form fits approximately as well as the cubic and the semilog is simpler, results are reported for the semilog formulation. Table 1 shows that the simple correlations between average height and the log of per capita income are as high as .90. Data on per capita income are most compatible with data obtained from national height studies; hence Table 1 includes only those countries for which national height studies are available.[27]

The analysis can be expanded to include height studies of various subsets of a country's population by employing a regression framework. Adolescents and adults are examined separately because the independent variables may have different effects on the heights of these groups. The independent variables available, in addition to the log of per capita income, include a Gini coefficient, dummy variables representing "poor", "rich", urban, rural, university student, and military residents.[28] The urban, rural, and student variables may operate as proxies for income because a relatively high proportion of the poor are located in rural areas,[29] and university students tend to come from high income families. The anticipated effect of military employment is ambiguous; some countries have minimum height standards, universal service is required in others and the bulk of the personnel in many countries is drawn from lower socio-economic classes.

The height studies involve populations of Europeans, Africans, Asians, Indo-Mediterraneans, and people with European ancestory or African ancestory.[30] In view of the emphasis given to environmental as opposed to genetic determinants of average height by human biologists, the dummy variables that represent these classifications may capture largely environmental effects (other than income) such as food prices, health care measures, the disease environment, cultural factors, etc.

The heights of children aged 10 through 14 are particularly sensitive to environmental influences. Children within this age group are included in the regression by introducing dummy variables for ages 11 through 14. The dummy variable representing sex has a genetic basis.

While it is safe to argue that causation runs one way from per capita income to the heights of children, per capita income and adult height are determined jointly. Height is an index of health and nutrition, and the health and nutrition of workers are known to affect output.[31] Healthy workers have greater physical vigor, fewer days lost from work, and longer working lives. By using two stage least squares it is not necessary to specify the complete model involving adult height and per capita income; exogenous variables excluded from the height equations must be employed, though, to identify the height equation. Any reasonable model of per capita income determination would probably include the value of the capital stock per worker, a measure of human capital per worker, and the percentage of the population of working age. Reliable estimates of the capital stock per worker are available for only a few countries, and therefore the other exogenous variables are used to identify the height equation. The adult literacy rate is used as a measure of human capital. The adult literacy rate and the percentage of the population of working age are available from the World Bank.

The estimated equations are given in Table 2. The income variable, the Gini coefficient variable, and the rural, poor, and rich variables have the expected signs.[32] The negative sign of the urban variable may reflect large migration from rural to urban areas; many urban areas also have large numbers of poor people.[33] Minimum height standards may dominate the effects of the military variable. The coefficient of the female variable is positive among adolescents probably because girls begin the growth spurt earlier than boys. The ethnic variables may capture possible genetic differences, but in view of the important role attributed to environment by human biologiests, environmental factors may underlie the results. Among adults the ethnic variables have no statistically significant effect, but among children all ethnic variables are negative and four out five are are statistically significant.

This finding may reflect that fact that children are relatively sensitive to the environment; some deprivation in childhood may be overcome by an extension of the growing period. Our understanding of environmental consequences would be improved by analysis of individual level data.

Some relationships between height and per capita income that are implied by the regressions in Table 2 are shown in Table 3. It should be recalled that the log of per capita income is highly correlated with the expectation of life at birth, and therefore the coefficient of the log of per capita income reflects both income and health. The estimated relationships apply to people with European ancestors; the Gini coefficient was evaluated at the sample mean. Height is particularily sensitive to income at low income levels. Among boys age 12, for example, height increases by 6.7 centimeters as per capita income increases from $150 to $1,000, whereas the gain is 5.7 centimeters as per capita income increases from $1,000 to $5,000.

The relationships in Tables 2 and 3 should be interpreted with considerable caution. Average height should not be used to infer per capita income because per capita income is only one determinant of average height. The relationships given in Table 3 change as a function of the income distribution, place of residence, and ethnic group. The coefficients in Table 2 show that average height is particularly sensitive to the income distribution; an increase of 0.1 in the Gini coefficient reduces average adult height more than 3 centimeters. Analyses of fluctuations or differences in the heights of populations should consider the possible role of the income distribution, or the distribution of variables such as nutrition that determine height.

The equations shown in Table 2 are based on mid-twentieth century data, and it is likely that different coefficients would be obtained from data for earlier time periods. Improved medical technology probably shifted the relationship between average height and per capita income. Knowledge of the germ theory of disease, for example, enabled individuals to improve health, and therefore increase height, with no change in income.

The difficulties of using the regression coefficients based on cross-sectional data to interpret historical time series are illustrated by the U. S. case. Troops who fought in the American Revolution were nearly as tall as World War II U.S. troops,[34] yet per capita income was several times higher during the later period. A change in the distribution of income towards greater inequality may explain a portion of the apparent contradiction.[35] Despite the fact that per capita income was low during the mid 1700s there may have been sufficient income for most people to achieve or nearly achieve their genetic potential. The coefficient in Table 2 implies that a reduction in the Gini coefficient of 0.2, for example, increases average adult height by more than 7 centimeters.[36] In addition, fertile land was abundant in the United States and the American diet of the mid 1700s was probably better than that in developing countries today, even though measured income was low in late Colonial America and is low in developing countries today.

Concluding Remarks

The average height of a population is a measure of economic welfare that is sensitive to the consumption of basic necessities, particularily food and medical care. Consequently, height data can be used to analyze questions traditionally posed with income data. Height studies that are underway for various countries reveal trends and fluctuations in living standards. Analysis of the timing and amplitude of fluctuations and trends may help to identify causes of changes in living standards. The distribution of height, the standard deviation of height, and differences in average height across social and economic classes are measures of the distribution of well-being that are useful in this area of research.

The distribution of income is an important determinant of average height. Among individuals height increases at a decreasing rate as a function of income, and a more equal distribution of income at the aggregate level increases average height. Studies of differences or changes in average height should consider the possible effects of differences or changes in the income distribution.

FOOTNOTES

1. Robert W. Fogel, Stanley L. Engerman, James Trussell, Roderick Floud, Clayne L. Pope, and Larry T. Wimmer, "The Economics of Mortality in North America, 1650-1910: A Description of a Research Project," Historical Methods 11 (Spring), 75-108; James Trussell and Richard Steckel, "The Age of Slaves at Menarche and Their First Birth, "Journal of Interdisciplinary History" 8 (Winter), 477-505; Richard H. Steckel, "Slave Height Profiles from Coastwise Manifests," Explorations in Economic History 16 (October), 363-380; Kenneth Sokoloff and Georgia Villaflor, "Colonial and Revolutionary Muster Rolls: Some New Evidence on Nutrition and Migration in Early America," NBER Working Paper No. 374 (1979); Robert A. Margo and Richard H. Steckel, "Height, Health and Nutrition: Analysis of Evidence for American Slaves," Unpublished draft (1980); Lars Sandberg and Richard H. Steckel, "Soldier, Soldier, What Made You Grow So Tall? A Study of Height, Health, and Nutrition in Sweden, 1720-1881," Economy and History 23 (1980), 91-105: Kenneth Wachter, "Graphical Estimation of Military Heights," Historical Methods 14 (Winter), 31-42.

2. J. M. Tanner, Growth at Adolescence (Springfield, Ill., 1962) pp. 1-27; J. M. Tanner, Foetus Into Man (Cambridge, 1978).

3. Phyllis B. Eveleth and J. M. Tanner, Worldwide Variation in Human Growth (Cambridge, 1976), p. 222.

4. Jean-Pierre Habicht Reynaldo Mortorell, Charles Yarbrough, Robert M. Malina, and Robert E. Klein, "Height and Weight Standards for Preschool Children: How Relevant are Ethnic Differences in Growth Potential?," The Lancet (April 6, 1974), 611-615. The countries or regions in the study are

Australia, Columbia, Guatemala, India, Japan, Thailand, United Kingdom, United States, and West Africa.

5. L. A. Malcolm, "Ecological Factors Relating to Child Growth and Nutritional Status," pp. 329-352 in Alexander F. Roche and Frank Falkner (eds.), Nutrition and Malnutrition: Identification and Measurement (New York, 1974).

6. Correspondence from J. M. Tanner (May 1981).

7. Tanner, Growth at Adolescence, pp. 94-155; M. T. Newman, "Nutritional Adaptation in Man," pp. 210-259 in A. Damon (ed.), Physical Anthropology (New York, 1975); Eveleth and Tanner, pp. 241-261.

8. N. S. Scrimshaw, C. E. Taylor and J. E. Gordon, Interactions of Nutrition and Disease, WHO Monograph Series, No. 52 (New York, 1968); Moisés Béhar, "A Deadly Combination," World Health (February-March 1974), 28-33.

9. Eveleth and Tanner, p. 246

10. J. M. Tanner, "Growth and Physique in Different Populations of Mankind," pp. 45-66 in Paul T. Baker and J. S. Weiner (eds.), The Biology of Human Adaptability (Oxford, 1966), p. 48.

11. A. Prader, J. M. Tanner, and G. A. VonHarnack, "Catch-up Growth Following Illness or Starvation: An Example of Developmental Canalization in Man," The Journal of Pediatrics 62 (May 1963), 646-659; M. S. Malhorta, "People of India Including Primitive Tribes--A Survey on Physiological Adaptation, Physical Fitness, and Nutrition," pp. 329-355 in P. T. Baker and J. S. Weiner (eds.) The Biology of Human Adaptability (Oxford, 1966).

12. Tanner, Growth at Adolescence, pp. 121-123.

13. E. Takahashi, "Growth and Environmental Factors in Japan," Human Biology 38 (February 1966), 112-130; V. G. Vlastovsky, "The Secular Trend in the Growth and Development of Children and Young Persons in the Soviet Union," Human Biology 38 (September 1966), 219-230.

14. Mary Alice Caliendo, <u>Nutrition and the World Food Crisis</u> (New York, 1979), p. 160; Alan D. Berg, <u>The Nutrition Factor</u> (Washington, 1973), p. 40.

16. Dov Chernichovsky and Douglas Coate, "The Choice of Diet for Young Children and Its Relation to Children's Growth," <u>Journal of Human Resources</u> 15 (Spring 1980), 255-263.

17. Maurice Henry King, <u>Medical Care in Developing Countries</u> (Nairobi, 1966), p. 4-5.

18. Alan L. Sorkin, <u>Health Economics in Developing Countries</u> (Lexington, Mass., 1976), pp. 17-20.

19. Eveleth and Tanner, p. 34.

20. Victor R. Fuchs, "The Contribution of Health Services to the American Economy," pp. 3-38 in Victor R. Fuchs (ed.), <u>Essays in the Economics of Health and Medical Care</u> (New York, 1972), pp. 15-18 and p. 43.

21. Income or health may have improved in some countries such that cohort effects may become relevant for studies involving adults; per capita income or health conditions may have been relatively lower during the growing years for older adults in the sample. Fortunately, the tables in the appendix usually report the age range of the study, and the subjects in most studies could be described as young adults. The age range in two Egyptian studies was 19-68, which is an exception. However, the Egyptian studies and the few studies in which the age range is not reported do not produce outliers; in each case the predicted height is within one standard error of the estimate of the observed height.

22. The method of comparative evaluation is an issue in the use of per capita income data for various countries. This issue is discussed in Simon Kuznets, <u>Modern Economic Growth: Rate, Structure, and Spread</u> (New Haven,

1966), pp. 359-399. It would be desirable to have data based on detailed price and output comparisons, as suggested in Robert Summers, Irving B. Kravis, and Alan Heston, "International Comparions of Real Product and its Composition, 1950-1977," The Review of Income and Wealth 26 (March 1980), 19-66, but the number of countries for which data are available is insufficient for the type of analysis undertaken here.

23. World Bank, World Development Report (Washington, 1980).

24. Shail Jain, The Size Distribution of Income: A Compilation of Data (Washington, 1975).

25. Cultural food practices are discussed in Caliendo, pp. 227-257.

26. Attained height is a function of income during the years of height growth, and a more elaborate model would include several lagged values of per capita income. In view of the large differences in per capita income across countries, lagged values would probably add little to the analysis; their inclusion does not justify the additional complexity.

27. If all height studies, including those for only urban, rural, poor, military, etc., are included in the analysis, the correlations are about .15 to .30 lower. The correlations reported for age 12 are representative of those for adolescents of other ages. The most abundant adolescent height data are for age 12. Per capita income is measured as of the year that the height study was published.

28. There are no studies involving "poor" or "rich" adults or involving "student" or "military" adolescents.

29. World Bank, p. 5.

30. Due to a lack of income distribution data, there are no observations for adult Africans.

31. Burton A. Weisbrod, Economics of Public Health: Measuring the Economic Impact of Diseases (Philadelphia, 1961); S. Mishkin, "Health as an Investment," Journal of Political Economy 70 (October 1962, Supplement), 129-157; Mark Perlman, "On Health and Economic Development: Some Problems, Methods, and Conclusions Reviewed in a Purusal of the Literature," Comparative Studies in Society and History 8 (July 1966), 433-448; Fuchs, pp. 3-38; Edward Meeker, "The Social Rate of Return on Investment in Public Health, 1880-1910," Journal of Economic History 34 (June 1974), 392-419.

32. One cannot rule out the possibility that the Gini coefficient is an indicator for other variables. It has been argued, for example, that income tends to become more evenly distributed during the course of economic growth. See Simon Kuznets, "Economic Growth and Income Inequality," American Economic Review 45 (March 1955), 1-28. The correlation between the log of per capita income and the Gini coefficient is only about -.17 in the data of this study.

33. Caliendo, pp. 158-160.

34. Kenneth Sokoloff and Georgia Villaflor, "Colonial and Revolutionary Muster Rolls: Some New Evidence on Nutrition and Migration in Early America," NBER Working Paper No. 374 (1979).

35. The course of the distribution of income is discussed in Jeffrey G. Williamson and Peter H. Lindert, American Inequality: A Macroeconomic History (New York, 1980), pp. 9-64.

36. The Gini coefficient in the U. S. during the mid twentieth century was approximately 0.4.

Table 1

Correlations Between Height[a]

and the Log of Per Capita Income

Group	Correlation	N
Boys Aged 12[b]	.90	16
Girls Aged 12[b]	.89	15
Adult Men[c]	.84	16
Adult Women[c]	.90	17

Sources: Eveleth and Tanner (1976), Summers et al. (1980), and World Bank (1980).

a. National height studies only.

b. The countries represented for boys and girls are Czechoslovakia, Egypt, German Democratic Republic, Ghana, India, Japan, Lebanon, Netherlands, New Zealand, Republic of Korea, Soviet Union, Taiwan, United States and Uruguay; the boys also include Mozambique. The United States has two height studies.

c. The countries represented for adults include Bulgaria, Czechoslavakia, India, Indonesia, Netherlands, Paraguay, Soviet Union, Taiwan, and the United States; adult men also includes Denmark and Zaire, and adult women also includes France, Republic of Korea, and Ireland. India and Zaire have multiple height studies.

TABLE 2

Regressions of Height on Income, Gini Coefficient, Place of Residence, Sex, Ethnic Group, and Age[a]

	Adolescents		Adults	
Variable	Coeff.	t-value	Coeff.	t-value
Intercept	116.0	33.38	160.5	13.99
Log Per Capita Income	3.545	7.644	3.490	2.223
Gini	-8.260	1.283	-36.74	4.408
Urban	-.3085	.3591	- .1478	.09090
Rural	-3.392	3.539	- 2.524	1.315
Poor	-7.968	4.938		
Rich	5.483	6.426		
Student			1.225	1.148
Military			2.599	1.765
Female	.1171	.2637	-11.24	16.05
European Ancestor	-4.452	3.313	- 1.170	.5954
African	-.6789	.3187		
African Ancestor	-3.328	2.010	-1.903	.9970
Asian	-6.315	4.582	-1.673	.6294
Indo-Mediterranean	-4.531	2.166	2.321	.7658
Age 11	5.250	7.961		
Age 12	11.11	16.85		
Age 13	16.81	24.80		
Age 14	21.43	31.32		
R^2	.92			
N	163		30	
Method	OLS		2SLS	

Table 2 (con't)

Definition of Variables: Dependent variable = height in centimeters; Log Per Capita = log of per capita income (in 1970 U.S. dollars) during the year that the height study was published; Gini = Gini coefficient; National = 1 if it was a national height study, 0 otherwise; Urban = 1 if it was a study of urban residents, 0 otherwise; Rural = 1 if it was a study of rural residents, 0 otherwise; Poor = 1 if it was a study of "poor" or "slum" residents, 0 otherwise; Rich = 1 if it was a study of "rich" or "well-off" residents, 0 otherwise; Student = 1 if it was a study of university student residents, 0 otherwise; Military = 1 if it was a study of military personnel, 0 otherwise; Female = 1 if it was a study of females, 0 otherwise; European = 1 if it was a study of Europeans, 0 otherwise; European Ancestor = 1 if it was a study of people with European ancestors, 0 otherwise; African = 1 if it was a study of Africans, 0 otherwise; African Ancestor = 1 if it was a study of people with African ancestors, 0 otherwise; Asian = 1 if it was a study of Asians, 0 otherwise; Indo-Mediterranean = 1 if it was a study of Indo-Mediterraneans, 0 otherwise; Age 10 = 1 if the group was age 10, 0 otherwise; Age 11 = 1 if the group was age 11, 0 otherwise; Age 12 = 1 if the group was age 12, 0 otherwise; Age 13 = 1 if the group was age 13, 0 otherwise; Age 14 = 1 if the group was age 14, 0 otherwise. National, European, and Age 10 are omitted variables.

Sources: Phyllis B. Eveleth and J. M. Tanner, Worldwide Variation in Human Growth (Cambridge, 1976); Norton Sydney Ginsberg, Atlas of Economic Development (Chicago, 1961); Robert Summers, Irving B. Kravis, and Alan Heston, "International Comparisons of Real Product and its Composition, 1950-77," The Review of Income and Wealth 26 (March 1980), 19-66; UNESCO, World Illiteracy at Mid-Century (New York, 1957); and World Bank, World Development Report (Washington, 1980).

Table 2 (con't)

a. The countries represented for adolescents are Argentina, Egypt, German Democratic Republic, Hong Kong, India, Japan, Republic of Korea, Lebanon, Malaysia, New Zealand, Spain, Sudan, Taiwan, United States, Uruguay, and Yugoslavia. The countries represented for adults are Egypt, France, Hong Kong, India, Republic of Korea, New Zealand, Taiwan, Thailand, Turkey, United Kingdom, and the United States. Several countries have more than one height study.

TABLE 3

Estimated Relationship Between

Average Height and Per Capita Income

Per Capita Income (1970 U.S. $)	Boys Aged 12	Girls Aged 12	Adult Men	Adult Women
150	137.1	137.2	160.9	149.7
250	138.9	139.0	162.7	151.4
500	141.4	141.5	165.1	153.9
1000	143.8	143.9	167.5	156.3
2000	146.3	146.4	169.9	158.7
3000	147.7	147.8	171.4	160.1
4000	148.7	148.8	172.4	161.1
5000	149.5	149.6	173.1	161.9

Source: Calculated from Table 2, assuming a national study for a population with European ancestors; the Gini coefficient is evaluated at the sample mean.