NBER WORKING PAPER SERIES

THE HEIGHTS OF AMERICANS IN THREE CENTURIES: SOME ECONOMIC AND DEMOGRAPHIC IMPLICATIONS

Kenneth L. Sokoloff

Working Paper No. 1384

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
June 1984

This paper was originally prepared for presentation at the 1982 meeting of the Social Science History Association. The author wishes to thank Georgia Villaflor for her care in assembling the data on U.S. Army recruits from 1850 to 1855, and to acknowledge many helpful discussions with her, Robert Fogel, and Robert Margo. 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 #1384
June 1984

The Heights of Americans in Three Centuries: Some Evidence and Demographic Implications

ABSTRACT

This paper discusses the potential usefulness of anthropometric measurements in exploring the contributions of nutrition to American economic growth and demographic change. It argues that although the value of height-by-age data to economic historians will ultimately be resolved in the context of investigating specific issues, the early results of the NBER Project on Long-term Trends in Nutrition, Labor Productivity, and Labor Welfare have been encouraging. Among the most significant findings to date are: (1) that by the time of the Revolution, Americans had attained a mean final height (and net nutritional status) that was very high, one that European populations did not generally reach until the twentieth century; (2) that the variation in stature across occupational classes was much less in the U.S. than in Europe; (3) that natives of the South have been taller than those from other regions of the U.S. since the middle of the eighteenth century, and that their absolute height increased during the antebellum period while mortality was declining there; and (4) that natives of large antebellum cities were much shorter than their countrymen born in rural areas or in small cities. The paper also examines, in a preliminary fashion, how a newly available data set bears on the hypothesis that a cycle in U.S. final heights began during the antebellum period. The theory might continue to be sustained, but a sample of U.S. Army recruits from 1850 to 1855 does not seem to provide much support for it.

Kenneth L. Sokoloff
Department of Economics
405 Hilgrad Avenue
University of California
Los Angeles, CA 90024
(213) 825-4249

Over the last few years, the NBER Program in the Development of the American Economy has been pursuing an exploratory study of the usefulness of anthropometric measurements for the estimation and analysis of levels of nutrition, labor productivity, and labor welfare in historical populations. The Nutrition Project, whose principal goal is to investigate the contribution of nutrition (as a component of human capital) to mortality decline and economic growth in the U.S., has in its initial stages devoted the bulk of its resources to the retrieval of large bodies of anthropometric data and the linkage of them to other sources of socioeconomic information. However, a set of papers based on preliminary analysis of the data collected through 1981 has appeared in a special issue of <u>Social Science History</u>.[1] This paper is intended to review the methods and goals of the project, and to critically evaluate its major findings to date. It will conclude with a discussion of how a newly available body of evidence bears on some of the issues raised by the papers in the special issue.

II.

The Project's reliance on height-by-age data as the principal means of estimating levels of nutrition seems to have a solid basis in the physiological literature. Many biologists, anthropologists, and physiologists have studied the effects of nutritional deficiencies, disease, and other environmental conditions on physical development through observational studies of human populations and laboratory experiments.[2] Their work has led to the conclusion that anthropometric measures provide reliable indexes of the extent of malnutrition among sub-groups of particular populations that "reflect accurately the state of a nation's public health and the average nutritional status of its citizens."[3]

The construction of indexes of nutritional status from height-by-age data rests on intensive study of the pattern of human growth between infancy and maturity. Three statistics are particularly useful: the age at which the adolescent growth spurt peaks, the age at which full height is attained, and the final height achieved. Short periods of malnutrition or prolonged spells of moderate malnutrition, during childhood, merely delay the onset of the adolescent growth spurt. Severe, prolonged malnutrition may completely erode the typical growth-spurt pattern and cause permanent stunting. If malnutrition is sustained over an extended period, growth will continue beyond the age at which it normally ceases in well-fed adolescents. Hence, the age at which growth terminates can also be a valuable indicator of nutritional status. There is a clear pattern of "catching-up" after periods of malnutrition; but the longer the periods and the more severe the malnutrition, the more likely the terminal height of an individual will fall below what it would have been under conditions of good nutrition.[4]

Nutritional conditions are not the only influences affecting height-by-age profiles. The actual record of growth observed for any individual or population reflects the interaction of genetic and environmental factors. On the level of individuals, differences in genetic endowment account for most of the variation in stature across them (after allowing for age). Among most contemporary, well-fed populations, however, there is no significant variation in mean final heights that physiologists consider attributable to genetic factors. Although there are a few ethnic groups whose genetic potential for final height seems to differ significantly from the West European standard, they have historically represented an extremely small proportion of the U.S. population.

Other environmental conditions, besides nutrition, also play a role in determining the pattern and record of physical growth. It is important, in this regard, to emphasize that anthropometric measures of nutrition resemble net rather than gross measures of nutrition. Height is influenced not only by the gross intake of nutrients, but also by the claims of other metabolic processes that compete with those of physical development for those nutrients and the efficiency with which that gross intake is utilized. The amount of nutrients that a body allocates to growth and development, from a given intake, may vary with such conditions as climate, clothing and shelter, the level of physical activity (i.e., work), and the incidence of disease. How the body allocates nutrients among the competing claims is complex and not well understood. Thus, while height-by-age data might provide accurate indexes of the amount of nutrients made available for sustaining or promoting physical growth, they do not alone indicate whether variation in net nutritional status is due to differences in the consumption of food, in the claims on the food intake, or in the efficiency with which food is converted into outputs.

The general issue of whether indexes of net nutritional status are useful for studies of the development of the American economy is a question that will ultimately be resolved in the context of grappling with specific problems. Granted that the opinion may be premature, however, there seem to be good reasons to be optimistic about the value of anthropometric measurements to economic historians. Nutrition has figured prominently in many hypotheses concerning the development of the American economy. It has been treated both as a component of human capital, which generates increases in labor income through greater strength or vitality, better health and lower mortality, and as a component of material welfare (or the standard of living). Despite the recognized importance of nutrition as a variable, study of it has been hampered by the difficulty of obtaining accurate measures.

With anthropometric measurements providing indexes of nutritional status, there are a number of ways in which the return to better nutrition can be estimated. One approach is to estimate the relationships between height and wage rates, height and slave prices, and height and income over cross-sectional data. Bodies of evidence that contain the information necessary for this approach have been located and begun to be retrieved.[5] Another method of estimating the return is to link several sources of information on individuals, at different points in their lives, making it possible to examine the relationship between height and occupational mobility or height and accumulation of wealth, after controlling for the other characteristics of the individuals. Still another method of evaluating the return would involve estimating the relationship between height and mortality or life expectancy.[6]

Height-by-age data might also prove useful as indicators of standard of living, particularly in underdeveloped economies for which per capita income or real wage series are not available. In such economies, food consumption and health are likely to be major components of the standard of living.[7] Even for those historical populations where per capita income or real wage series exist, the data are frequently not sufficiently rich to distinguish the standard of living of one sub-group of the population from those of others. Because military records that include height-by-age data and various socioeconomic information typically encompass a significant proportion of a society's population of young males, and extend back over several centuries are available for a large number of countries, there would seem to be great potential for employing anthropometric measurements as indicators of material welfare.

The measure of nutritional status provided by height-by-age is not one of gross food intake (which is presumably what economic historians have previously had in mind). It might be argued, however, that such a net index of nutrition should be preferred to a gross index in some cases because a population's requirements for nutrients and energy (a diet that would be nutritionally adequate) cannot be defined without reference to the population's level of physical activity, disease environment, etc.[8] In general, neither type of index seems likely to dominate the other, and they will often supply complementary information. How valuable one is relative to the other will vary with the problem and context being addressed. When comparing levels of nutrition between two populations that have vast differences in disease environment, for example, net measures (which reflect the nutrients devoted to growth after some have been consumed in fighting disease) might provide a better indicator of the difference between populations in the amounts of human capital in nutrition than gross measures. On the other hand, if one is studying the importance of improvements in nutrition on the decline in some population's mortality rate, a gross measure might be more useful than an index of net nutrition. In any case, the use of indexes of net nutritional status based on height-by-age data may lead to measures of the gross that are more accurate than the conventionally employed alternatives.[9]

III.

The initial stages of the Project have been devoted to the identification and collection of bodies of evidence that bear on the issues of concern, and the development of appropriate statistical procedures.[10] Thirteen samples of data containing information on height-by-age and various socio-economic variables which cover the period from 1750 through 1937 for the United States and several other countries have been located and retrieved (or begun to be). Six of the samples are drawn from U.S. military records between

1750 and 1910, and some of these are in the process of being linked to additional sources which contain information on the mortality experience, wealth holdings, etc. of individual recruits (or their families) at other points in their lives. Investigation of many of the central aspects of the relationship between height and economic behavior await the completion of this task. Nevertheless, preliminary analysis of the data in hand has already yielded striking findings regarding secular trends and cross-sectional variation in heights, and in the economic and demographic implications of these patterns.

Perhaps the most interesting results to date concern the vast differences between the patterns of variation in heights of native-born U.S. whites prior to 1910 and that of most European populations. Whereas the records of Britain and other European countries seem to conform to the expectation of a positive secular trend in stature, with possibly some cycles, extending back to the eighteenth century, the heights of Americans exhibit virtually no trend between the American Revolution and World War II. The lack of a secular trend in the stature of U.S. whites is due to their early achievement of nearly modern heights (a mean of 68.1 inches) by the end of the colonial period. The Revolutionary War level of 68.1 inches roughly approximates the 68.5 inch figure estimated for U.S. whites at the Civil War and the 68.2 figure during World War II.[11] It is also one to four inches greater than the mean final height of males reported for several European countries during the eighteenth century. Most of the European countries seem not to have achieved the heights observed in the U.S. until the twentieth century.

The major differences in stature between the U.S. and European populations give compelling testimony to the gap in net nutritional status of the average man that existed between the two regions. These differences in stature presumably reflect disparities in income levels, but may also stem partially from discrepancies in relative prices, tastes, disease environment, the level of energy-utilizing activities, and other factors. From a human capital perspective, it is clear that Americans, on average, were able to accumulate much higher levels of nutrition than were the Europeans. The contrast is dramatized when one finds that the heights of the European working classes of the late eighteenth and early nineteenth centuries were roughly equal to, or lower than, the levels prevailing in many developing countries today.[12]

Our analysis of the height-by-age data is supported by data on food consumption in Massachusetts discovered by McMahon.[13] Wills deposited in Middlesex County between 1654 and 1830 indicate a sharp rise in the average amount of meat annually allotted to widows for their personal consumption. Between 1675 and 1750, the average allotment increased from approximately 80 to approximately 165 pounds per annum. Such a level of average meat consumption (especially important to nutrition because of it being rich in protein) appears not to have been achieved in Europe until well into the twentieth century.[14]

One of the limitations of utilizing anthropometric measures as indicators of standard of living is illustrated by the trend over time in U.S. heights. As mentioned above, there was virtually no secular trend in mean final heights between the Revolution and WW II, although there is some evidence of cycles in stature during the late nineteenth and early twentieth centuries and during the early nineteenth century (perhaps confined to urban areas).[15] If there were no genetically imposed constraints (or plateaus) on the human potential for growth and physical development, meaning that increases in the consumption of protein, calories, vitamins, etc. would perpetually yield additional increments in stature, then this result would yield the peculiar implication that there was no improvement in the American standard of living over more than one and a half centuries. We know, however, that there are limits to how well nourished an individual can be, and there may also be substantial plateaus over which additional gains in nutritional status do not yield increases in physical stature. Such considerations seem relevant to a consideration of the record over time of the heights of U.S. native-born white, and imply that anthropometric measures will perform better as indicators of standard of living in underdeveloped economies with low per capita incomes or poor disease environments, in economies in which protein and food in general is relatively costly, or in economies where income is distributed in a very unequal fashion.

None of this discussion is meant to suggest that further investigation of the height-by-age data available for the U.S. would be uninformative about variation in the standard of living. On the contrary, we have uncovered evidence of a number of cases in which anthropometric measures may shed light on issues concerned with the physical welfare of various segments of the U.S. population. Included among these are instances of secular trends in the stature of certain groups, of cycles in stature during this period of no long-term change in U.S. mean final heights, and of significant variation over time in how stature was related to variables like occupational status and urbanization. The possibility of cycles is particularly intriguing since the circumstances that generated them would have had to have been quite severe. But the study of the changing pattern of variation in height over socioeconomic variables is also of great interest because it may contribute to our understanding of the environmental costs associated with industrialization and urbanization, or of shifts in the distribution of income and wealth.

The increase in the gap between the heights of rural- and urban-born observed in the first half of the nineteenth century is an example of such a change over time in the relationship between height and socioeconomic variables. It appears to have resulted primarily from a decline in the stature of natives of major urban centers, one that was of a substantial magnitude. During the colonial period, natives of the relatively small cities that existed then were marginally, if any, shorter than their rural-born countrymen.[16] By the middle of the nineteenth century, natives born in cities with populations of over 25,000 were 0.6 to 1.8 inches shorter than those born in rural areas (see Table 2 below). The emergence of this discrepancy between rural and large urban centers is consistent with the claims of some scholars that many antebellum cities suffered from deteriorating environmental conditions (i.e., sanitation, housing, disease pool) and rising mortality as they experienced rapid growth (or simply achieved large city size).[17] But the decline in urban heights may also reflect the influx of foreign-born immigrants into those areas or the spread of a more energy-intensive work regime associated with the factory system of production. Further investigation of this very low level of stature (by U.S. standards) in large cities may help to identify the chief sources of environmental stress.

There have also been significant shifts over time in the relationship between occupational status and stature. What had been minor differences in final heights between farmers and other occupational groups during the colonial period widened to sizable disparities by the time of the Civil War.[18] Utilizing a sample of recruits from that conflict, Margo and Steckel have recently estimated that blue collar recruits were 0.5 to 1 inch shorter than farmers or white collar workers, after adjusting for urban/rural status and region of birth.[19] These occupational differences in stature seem impressive when compared to those prevailing in the colonial period, but are dwarfed by the 2 to 3 inch height differentials that existed between the British white collar and manual classes during the nineteenth century.[20] This relative equality in American stature across occupational classes, as opposed to the European experience, may reflect both greater equality in the standards of living enjoyed by the lower and upper classes in the U.S., as well as one of the conditions that worked to maintain that relative equality. To the extent that occupational differences in stature represent disparities in human capital accumulation across classes, the narrower American differentials would imply, if all other conditions were equal, that greater income equality and social mobility would be observed in the U.S. than in Britain (or Europe). Further investigation of the economic returns to increments in height should help us to better understand the consequences of the U.S. having a relatively equal distribution of the components of human capital reflected in anthropometric measurements (as well as of the taller stature of Americans generally).

Analysis of the variation in stature across place and time may also yield substantial implications for the study of the secular and geographic patterns in U.S. mortality rates. Nutrition has often been identified as a potentially important variable in accounting for eighteenth and nineteenth century declines in death rates, and the evidently high level of nutrition in America may well provide a partial explanation of the low mortality rates which characterized the U.S. during this period relative to Europe. However, nutrition may not play as significant a role in accounting for the regional pattern of U.S. mortality during the period, or the pre-1850 decline in national mortality rates. The late eighteenth and early nineteenth centuries were marked by the narrowing of interregional differences in mortality rates between New England and the South, with the initially higher crude mortality rates in the latter region declining from about 50 per thousand to 25 per thousand, while the New England rate was roughly stable in the 15 to 25 per thousand range.[21] Southern stature has been found to have exceeded that of northerners throughout this period, suggesting that the higher mortality rates in the South were not due to poorer levels of nutrition in that region. Instead, southerners appear to have enjoyed superior nutritional conditions, which may have operated to close the gap between regional death rates by counteracting factors that served to increase mortality in the South (climate, disease pool, etc.).

IV.

During the early stages of the Nutrition Project, investigators detected evidence of several cycles in American final heights. The first of these was estimated to have occurred during the first half of the nineteenth century, by examining the heights of the different birth cohorts represented among Civil War recruits. This apparent rise through the early 1820s and the subsequent decline in mean terminal height have been interpreted as perhaps indicating that a decline in net nutritional status (or health) accompanied the rapid industrialization and urbanization of the second quarter of the century. The existence of the cycle remains open to question, however. Questions have been raised as to whether older recruits were likely to be representative, in regard to their physical condition, of their birth cohorts, and whether the socioeconomic composition of the Union Army deteriorated over the course of the Civil War, leading to an unrepresentative (shorter) set of men serving near the end of that conflict.[22]

A newly available, randomly-drawn sample of U.S. Army recruits who enlisted between 1850 and 1855 makes it possible to independently test for the existence of a cycle in mean final heights affecting the birth cohorts of the 1820s and 1830s.[23] As shown in Table 1, the computation of a mean final height for white, native-born males from the 1850-1855 data yields a figure of 68.3 inches, which slightly exceeds the 68.1 inch estimates calculated for both the Revolutionary War period and the years 1815-1820. The 1850-1855 figure suggests that Americans, on average, experienced modest growth during the first half of the nineteenth century. This view receives further support from the data on Civil War recruits reported by Gould; regional mean final height estimates based on his information,

Table 1

Mean Final Heights of Native-Born American Males
1755-1945
As Estimated from Military Recruits

	REGION OF BIRTH				
	Middle Atlantic	New England	South	Middle West/ West	U.S.
French and Indian War Aged 24-35	67.7 in. (636)	--	67.9 in. (131)	--	--
American Revolution Aged 24-35	68.0 (275)	67.8 in. (301)	68.3 (392)	--	68.1 in. (968)
U.S. Army, 1815-1820 Aged 24-35	67.9 (1,018)	68.0 (668)	68.3 (477)	--	68.1 (2,163)
U.S. Army, 1850-1855 Aged 24-35	67.6 (1,421)	67.8 (455)	68.9 (517)	68.7 in. (273)	68.3 (2,666)
Civil War Aged 24-34	68.0 (86,928)	68.2 (47,003)	68.9 (31,005)	68.8 (82,382)	68.5 (247,318)
World War II	--	--	--	--	68.2 (119,443)

Note:

The estimates for the period 1850-1855 and for the Civil War have been computed from the information contained in the samples of the muster rolls of the U.S. Army for 1850-1855, and in Benjamin Apthorp Gould, Investigations in the Military and Anthropological Statistics of American Soldiers (Cambridge, MA, 1869), p. 104. The other estimates are drawn from Kenneth L. Sokoloff and Georgia C. Villaflor, "The Early Achievement of Modern Stature in America," Social Science History 6 (Fall 1982), and Robert W. Fogel, et al., "Changes in American and British Stature Since the Mid-Eighteenth Century: A Preliminary Report on the Usefulness of Data on Height for the Analysis of Secular Trends in Nutrition, Labor Productivity, and Labor Welfare," NBER Working Paper No. 890 (1982). The regional mean final height estimates, for the first four periods, have been computed by the Quantile Bend method to adjust for shortfall on the left tails of the distributions. For a discussion of the Quantile Bend method, and alternative procedures for correcting for shortfall on the left tails of distributions, see Kenneth W. Wachter and James Trussell, "Estimating Historical Heights," Journal of the American Statistical Association 77 (June 1982), pp. 279-293. The U.S. mean final height estimates for the American Revolution, 1815-1820, 1850-1855, and the Civil War were calculated by weighting the regional means by the shares of the white population residing in the respective regions at the time of the most recent census. This procedure tends to bias the estimates upward slightly, since the net migration of native-born was from the regions with shorter stature to regions with taller stature. The numbers of observations on which estimates are based appear with parentheses.

after weighting them by population shares so as to adjust for the underrepresentation of southerners in the Union Army, yield a national estimate of 68.5 inches. The hypothesis of a cycle marked by declining heights during the late 1820s and the 1830s seems contradicted by these estimates that the mean final height in 1861-1865 exceeded that prevailing in 1850-1855.[24]

Of course, not all sub-groups of the American population had records over time that conformed to the national average. The regional mean final height estimates presented in Table 1, for example, reveal significant variation around the U.S. trend. Southerners are a regional group whose record of growth seems to correspond well with the national average. While the U.S. final height rose from 68.1 inches at 1815-1820 (and at the Revolution) to 68.3 at 1850-1855, and to 68.5 at the Civil War, the southerners grew at a slightly more rapid rate from 68.3 inches at 1815-1820 (and at the Revolution) to 68.9 at 1850-1855 (and maintained to the later date). New England also appears to have experienced net growth in stature during the antebellum period, but the magnitude of the estimated increase depends on the selection of the beginning year. Mean final height in that region seems to have fluctuated in the 67.8 to 68.0 range between the Revolution and 1850-1855, before advancing to 68.2 inches at the Civil War. Registering the same mean final height at the Revolution and the Civil War (68.0), the Middle Atlantic appears to be the only major region that realized no increase in stature. With the 67.6 mean final height estimate for 1850-1855, it is also the region that seems most likely to have experienced a prolonged cycle in stature prior to the Civil War, but one in which a decline in heights was followed by a recovery rather than the reverse.[25] The regions of the Middle West and the West, which have been grouped together here, exhibit mean final heights nearly equal to those of the South, but data for them do not extend back long enough to adequately assess their record over the entire antebellum period.

One of the most interesting findings to emerge from Table 1 is that the regional differential in height observed for the Revolutionary period, with southerners being significantly taller than either natives of the Middle Atlantic or New England, widened during the antebellum period. The difference in stature thus moved in the opposite direction from that of the regional per capita income differential between the Revolutionary and Civil Wars.[26] the increase in the regional differential resulted from the more rapid growth in southern heights, one plausible theory is that improvements in the southern environment (whether man-made or otherwise) led to a decreased incidence of disease and hence taller stature. This view is consistent with the initial conditions of higher mortality and greater heights in the South than in the Northeast, and with the evidence of a significant absolute decrease in mortality in the former region during the period. Another possible explanation is that Southern heights continued to increase with per capita income (and associated gains in food intake and health), while the effects of deterioration in in their physical environment, or of increases in the energy intensity of their daily activities worked to prevent the stature of natives of the Northeast from rising much with per capita income. Such unfavorable developments might have accompanied the rapid progress of industrialization and urbanization in the Northeast during the period. This hypothesis receives support from the finding that mean final heights in the Middle West/West were approximately equal to those in the South at 1850-1855 and the Civil War. A third possibility is that the estimated mean heights for the Middle Atlantic and New England were depressed relative to those of other regions because a disproportionate number of the children of foreign immigrants were born in those areas.[27]

One way of further examining these theories of why the height differential between the South and the Northeast widened during the early nineteenth century is to compute estimates for more narrowly-defined socioeconomic classes within regions. Each of the hypotheses contains implications for the relative movements in the mean final heights of these finer sub-groups. If, for example, the increase in the southern-northeastern differential was due solely to exogenous improvements in the South's disease environment, then (if all else were equal) one would expect to observe virtually no change in the mean final heights of groups in other regions. On the other hand, to the extent that the failure of stature to increase as much as in the Northeast as it did in the South was attributable to the adverse effects of industrialization, one should find that the heights of northeasterners born in rural areas or of non-industrial occupations rose significantly during the period (both absolutely and relative to those of the urban-born or of industrial workers).

Estimates of mean final heights for various socioeconomic classes within regions in 1850-1855 are presented in Table 2. They suggest that the differences in stature across occupational or urban-rural class, within regions, were generally larger than had been the case during the colonial period.[28] However, these discrepancies must be considered small when compared to the gap between the Northeast and the rest of the country. That farmers and professionals in the South are estimated to have been 1.6 inches taller than their counterparts in the Middle Atlantic dramatizes how the regional differences in mean final height cannot be accounted for by regional variation in occupational mix or urbanization.

Perhaps it is no surprise that the estimates in Table 2 provide some support to each of the leading theories of the increase in the Northeast-South height differential. The principal evidence suggesting the unfavorable conditions associated with industrial development and urbanization were contributory factors consists of the extremely low final heights (by American standards) of natives of cities with populations greater than 25,000 (67.1 inches for such cities in

Table 2

Mean Final Heights of Native-Born White Recruits
in the U.S. Army, 1850-55: Aged 24-35
By Place of Birth and Occupational Class

	REGION OF BIRTH			
Occupational Class	Middle Atlantic	New England	South	Middle West/ West
Farmers and Professionals	67.9 in. (158)	--	69.5 in. (146)	--
Artisans, Factory-Workers, and Laborers	67.5 (1,223)	67.7 in. (360)	68.5 (365)	68.6 in. (214)
Place of Birth				
Rural Area	67.7 in. (657)	68.0 in. (206)	68.9 in. (438)	68.6 in. (220)
Small Urban Area (2500<Pop<25,000)	67.7 (252)	67.5* (249)	--	--
Large Urban Area (Pop ≥ 25,000)	67.1 (512)	--	--	--

*This estimate is based on recruits from all urban areas, rather than small urban areas.

Note: All of the mean final height estimates have been computed from the 1850-55 U.S. Army sample using the Quantile Bend method to adjust for shortfall on the left tails of the distributions.

the Middle Atlantic), a slight widening of the height differential between farmers and non-farmers, and the near equivalence of heights in the largely non-agricultural Middle West/West with those in the South. This hypothesis, however, does not seem consistent with the implication of the 1850-1855 data that the mean terminal height of farmers in the Middle Atlantic had not increased since the Revolutionary War. Since this group presumably experienced gains in per capita income and was not substantially affected by environmental deterioration due to industrialization or urbanization, the theory would have predicted the stature of such farmers to have increased.[29]

The findings that neither the heights of farmers in the Northeast nor the occupational differentials increased much during the antebellum period seem to correspond with the hypothesis that the principal source of the widening of the gap between southern and northeastern mean final heights was whatever change led to the substantial advance in Southern stature. Such a region-specific alteration in conditions is made plausible by the dramatic decline in absolute and relative levels of mortality in the South (which seems to have had higher mortality and net nutritional status at the beginning of the period) during the first half of the nineteenth century. Those conditions that initially accounted for the higher mortality in the South, despite the region's evidently superior level of net nutritional status, could have been alleviated, leading to decreases in the incidence of disease and growth in heights. In this view, stature may have remained roughly stable in the Northeast because at the standard of living its population enjoyed, heights might not have been sensitive to further increases in variables directly related to per capita income. Not that industrial development and urbanization can be rejected as contributors to the increase in the height differential between the Northeast and the South. If the relatively tall stature of southerners was entirely due to southern-specific factors, why were recruits from the Middle West and West nearly as tall? Moreover, the very short stature of natives of large cities, the emergence of which was closely related to the above-mentioned processes, indicates that these developments did play some role.

Although they may not play a major role in accounting for the regional differences in stature, the low heights observed among natives of large cities are nevertheless of interest. Economic historians have long speculated about the types and magnitude of environmental deterioration associated with rapid industrial development and urbanization in nineteenth-century America, and the small stature of the urban-born may be reflecting such non-pecuniary factors. One possible explanation of this small stature in large cities is that the great influx of both foreign and native migrants into these urban centers led to overcrowding, significant declines in sanitary conditions, and a worsening of the disease pool -- environmental decay in general. This view posits that the physical growth of the urban population was stunted by an increased incidence of disease, and is consistent with evidence that mortality in large urban areas rose during the period.[30] Another hypothesis concerns the inter-generational effects of malnutrition. Although the magnitude of such effects may not be large, researchers have determined that the malnutrition of mothers can adversely affect the physical development of their future offspring.[31] If a large fraction of those born in the large American cities were children of foreign immigrants, then the existence of such an effect could partially account for the short stature observed. This biological mechanism could have been reinform foreign immigrants earned low incomes and found it difficult to provide for their native-born children. A third possibility is that males born in large urban areas were more likely to enter the labor force at tender ages than their peers born elsewhere. Hence, their short stature might reflect a higher level of energy-utilizing activities that they engaged in prior to their reaching full maturity.

Although the short stature of the natives of large urban areas may not indicate low levels of per capita food consumption, this possibility cannot yet be ruled out. These rapidly growing cities may have attracted members of the poorer classes who sought opportunities for advancement there, yet continued to earn low incomes and provide their families with meager levels of food consumption. The swift growth of these cities between 1820 and 1860 may have led to severe shortages in urban housing, and accordingly to a sharp rise in the cost of shelter. It is thus conceivable that an index of consumer prices that included the cost of shelter would show that the real wages of urban laborers in these cities declined over part of the antebellum period. Moreover, if the income and price elasticities of the demand for shelter by urban laborers were sufficiently low, sharp rises in the cost of shelter could have led to decreases in the amount of food consumed, particularly in the consumption of relatively expensive and protein-rich foods such as meat.

The mean final height estimates reported for various groups in Table 2 were computed in such a way as to adjust for a form of sample selection bias that is frequently evident in military organizations (and particularly in peacetime armies), and is so among the 1850-55 recruits. This sample selection bias is primarily a result of a minimum height requirement being applied to potential recruits. Thus, the distributions of the heights of the fully grown men who enter armies typically resemble truncated normal distributions.[32] This sort of sample selection bias, if unadjusted for, leads to the mean heights calculated from military data being upward-biased estimates of the true means of the underlying populations. For example, those recruits who were farmers will have a higher mean height than that of farmers in general. The problem also tends to produce underestimates of the differences in mean final heights between groups, since the bias associated with the sample means is greater for the shorter groups (because larger proportions of their distributions are subject to truncation). In the context of regression analysis, coefficients will tend to be biased toward zero. Alternative multivariate analysis procedures that correct for this type of sample selection bias and are of low cost are in the process of being developed for the Project, but are not yet available. Hence, the multivariate procedures utilized in the remainder of this paper are confined to regression analysis.

In Tables 3 and 4, regressions estimated over the native-born white recruits from 1850-1855 are reported. Although their usefulness is reduced by their coefficients being biased toward zero, they do provide estimates of the differences in height between occupational classes, places of birth, etc. when all other variables are controlled for (in contrast to the Table 2 estimates, which control for only one additional variable). It is particularly desirable to utilize such a multivariate approach with the 1850-1855 data because of the substantial overrepresentation of the lower occupational classes and the urban-born in the recruits from those years and the high correlations between some of the independent variables.

Notice that while the differences in height between groups implied by the regression coefficients in Table 3 are generally somewhat smaller than those suggested by the estimates presented in Table 2, the qualitative results are quite similar. Holding all other variables constant, the final heights of recruits who were artisans, factory workers, and laborers are estimated to have been between 0.34 and 0.46 inches shorter, on average, than those of farmers. The stature of professionals does not differ significantly from that of farmers, and thus the difference in mean final height between the two groups of occupational classes estimated here is roughly equal to the 0.4 inches estimated in Table 2 for the Middle Atlantic. Similarly, the regression results concerning

Table 3

Regressions with Final Height as Dependent Variable:
Native-Born Recruits from U.S. Army, 1850-1855

Independent Variables	HEIGHT IN INCHES Coefficient	t-statistic
Intercept	67.848	167.05
Years of Age	0.021	1.55
Dummy Variables:		
Artisan	-0.442	-3.32
Factory Worker	-0.459	-2.81
Laborer	-0.339	-2.54
Professional	-0.021	-0.08
Seaman	-0.517	-1.91
Unknown Occupation	-0.936	-1.15
Born in Small Urban Area	-0.103	-0.89
Born in Large Urban Area	-0.289	-2.69
Enlisted in Urban Area	-0.085	-0.95
Born in Middle Atlantic	-0.249	-1.99
Born in South	0.654	4.30
Born in Middle West or West	0.544	3.11
Born in Canada or At Sea	-0.464	-2.11
Migrated Out of State of Birth but Not Out of Geographical Region	0.074	1.41
Migrated Out of Geographical Region	-0.013	-0.10
Migrated from Northeast to Middle West	0.263	1.69
Migrated from Northeast to South or West	0.330	1.99

N = 2823 $R^2 = 0.049$

Note: The regression was estimated over those recruits aged 24 to 35. The intercept reflects the height of a farmer who was born, and resided, in a rural area of a New England state.

the difference in final height associated with birth in small cities, as compared to that in rural areas, correspond well with the figures in Table 2 suggesting that there was no significant disparity (at least in the Middle Atlantic).

Although the regression in Table 3 yields remarkably similar implications about the effects of the above-mentioned variables, its coefficients lead to much lower estimates of the differences in final height across regions of birth or between natives of rural areas and those of large cities than those reported in Table 2. The regression estimate that those born in large cities were 0.29 inches shorter than the rural-born, after controlling for the other variables, is only one-half of the estimate appearing in Table 2 for the Middle Atlantic. Part of the discrepancy is undoubtedly attributable to the regression controlling for variation in the occupational composition across the two groups, and part may be due to the large-city-rural discrepancy being smaller in regions other than the Middle Atlantic, but much of it seems likely to be accounted for by the sample selection bias afflicting the regression coefficients. Not only were the natives of large cities particularly subject to shortfall on the left tail (because of their shorter stature), but because the proportion of recruits who were farmers or professionals did not vary much between the rural-born and the urban-born, and because height did not vary substantially across occupational classes, differences in occupational composition seem unlikely to explain much of the discrepancy between the two estimates.

There are also significant divergences between the estimates of the differences in height associated with birth in the South, or in the Middle West/West, as compared to that in one of the northeastern regions. The regional rankings implied by the regression results are the same as in Table 2, with southerners being tallest, natives of the Middle Atlantic shortest, etc.; but the estimates of some of the differences in stature between the tall-stature regions and the others are lower. Again, the discrepancies between the two sets of estimates are partially due to the regression holding all other variables constant while the approach employed in Table 2 adjusts for only one other variable besides region of birth, and partially attributable to the regression coefficients being biased toward zero. In any case, these discrepancies between the estimates of the regional differentials are small, roughly on the order of 0.2 inches.

The regression also includes a set of independent dummy variables denoting types of migratory status. The estimated coefficients on them indicate that neither inter-state nor inter-regional migrants were generally taller than non-migrants, although northeastern-born recruits who had migrated out of that region seem to have been slightly taller than those who remained behind. This pattern is quite different from that observed in the samples from the colonial period, when inter-state migrants were of significantly greater stature than their more sedentary neighbors. Among the many possible explanations of this apparent shift in migratory patterns is a decrease in the cost of migrating or, more generally, an increase in the return to long-distance migration by lower-class individuals relative to that for individuals from more prosperous backgrounds.

Several regressions that were estimated over data on recruits aged 21 are reported in Table 4. The first of these was estimated with the specification utilized by the regression appearing in Table 3, except that years of age was omitted as an independent variable. The second regression excludes the dummy variable for large urban areas, but includes four additional interaction variables that were given values of zero for recruits whose cities of birth had populations of under 15,000 in 1850. Recruits whose cities of birth had populations greater than 15,000 had the variables set equal to the log of the population of the city in 1850, the ratio of the city's population in 1850 to that in 1830, the proportion of the city's population that was foreign-born in 1830, and the 1850 rate of mortality in the county of birth.

Table 4

Regressions with Height as Dependent Variable:
Recruits Aged 21

	HEIGHT IN INCHES	
Independent Variables		
Intercept	68.127 (380.23)	68.092 (375.85)
Interaction Variables: Non-Zero if population if city of birth ≥ 15,000		
Log (Population in 1850)		-0.048 (-1.64)
Growth of City Population		-0.045 (-1.07)
Mortality		0.008 (0.59)
Percent. Foreign-Born		0.000 (0.02)
Dummy Variables:		
Artisan	-0.291 (-2.26)	-0.289 (-2.23)
Factory Worker	-0.492 (-3.08)	-0.490 (-3.06)
Laborer	-0.239 (-1.77)	-0.231 (-1.71)
Seaman	-0.278 (-1.24)	-0.282 (-1.25)
Born in Small Urban Area	-0.281 (-2.21)	-0.173 (-1.38)
Born in Large Urban Area	-0.565 (-4.63)	
Enlisted in Urban Area	-0.171 (-1.69)	-0.176 (-1.74)
Born in Middle Atlantic	-0.068 (-0.49)	-0.053 (-0.36)
Born in South	0.600 (3.49)	0.617) (3.55)
Born in Middle West or West	0.033 (0.19)	0.081 (0.46)
Born in Canada or At Sea	-0.071 (-0.30)	-0.043 (-0.18)
N =	2190	2190
R^2 =	0.049	0.050

Note:
The intercept represents the height of a farmer who was born, and remained, in a rural area of a New England state. A number of statistically insignificant dummy variables have been omitted from the table due to space constraints. These omitted variables include a set referring to migratory status, all members of which proved insignificant when tested separately or jointly. The "Growth of City Population" interaction variable was defined as the ratio of the city's population in 1850 to that of 1830. The mortality variable was defined as the ratio of one thousand times the number of deaths in the county of birth during the year 1849-1850 (as contained in the 1850 Census) to the population of the county in 1850. The "Percent. Foreign-Born" variable was defined as the proportion of the city of birth's population that was foreign-born in 1830 (as computed from information contained in the 1830 Census). The t-statistics appear within parentheses after the respective coefficients.

These variables were constructed in an attempt to identify which of the features of the large cities was most closely associated with the stature of recruits born in them. It was thought that such an approach might yield clues as to the basis for the short stature of natives of such cities.

Replacing the dummy variable for large urban areas with a continuous measure of city population increases marginally the explanatory significance of the regression, but the other three variables, as apparent, fail to provide any additional explanatory power. Why these latter variables perform so poorly is not clear. It may be that stature was not systematically related to any of these variables, after controlling for city size, but the results could also stem from the suspect quality of the information from which the variables were constructed or from there being insufficient variation in the variables over those cities for which non-zero values were computed. The four additional variables were also included in regressions estimated over recruits aged 24 to 35, as well as over soliders of other ages, but these efforts yielded the same qualitative findings.

The estimates of occupational and regional differentials in height among recruits aged 21 are generally consistent with those for the older age category reported above. Recruits from the South continue to be taller than those from either New England or the Middle Atlantic. The results contrast sharply from the previous ones, however, in that there are no statistically significant differences apparent between the heights of New Englanders and those of natives of either the Middle Atlantic or the Middle West/West. The lack of a statistically significant coefficient on the variable for birth in the latter region is particularly surprising since the coefficient was large and highly significant for recruits aged 24 to 35.

There is also a slight discrepancy between the two sets of recruits in the results concerning occupational differentials. The factory workers among the younger recruits again emerge as the shortest of the occupational groups other than seamen; however, the differences between their heights and those of artisans or of laborers are now statistically significant. In the earlier regression, the final heights of these three groups were estimated to have been roughly the same, all significantly lower than that of farmers. The disparity in qualitative results is puzzling, even if it is no surprise that factory workers were the shortest group. One would expect that factory workers would have entered the labor force at younger ages, and consequently had their physical development stunted, either because children were more effectively utilized under the more regimented organization of work typical of factories, or because, on average, they came from less well-to-do families. Factory workers might also have been shorter because labor in factories placed greater demands on the energy of workers than did other sorts of manual work, or because they came from poorer households and consumed less nutritious diets during their years of growth.

V.

This paper has discussed the potential usefulness of anthropometric measurements in exploring the contributions of nutrition (or changes thereof) to American economic growth and demographic change. It has been argued that although the value of height-by-age data to economic historians will ultimately be resolved in the context of investigating specific issues, the early results of the NBER Nutrition Project have been very encouraging. Among the most significant findings to date are: (1) that by the time of the Revolution, Americans had attained a mean final height (and net nutritional status) for males that was very high, one that most European populations did not reach until the twentieth century; (2) that the variation in stature across occupational classes was much less in the U.S. than in Europe; (3) that natives of the South have been taller than those from other regions of the U.S. since the middle of the eighteenth century, and that their absolute height and their advantage in stature over northeasterners grew during the antebellum period while mortality was declining there; and (4) that natives of large antebellum cities were much shorter than their countrymen born in rural areas or in small cities.

The paper also began, in a preliminary fashion, to evaluate how a newly available data set bears on the hypothesis that a cycle in U.S. final heights occurred during the antebellum period. The theory can continue to be sustained, but samples of U.S. Army recruits from 1850 to 1855 do not seem to provide much support for it. A comparison of regional mean final heights for recruits aged 24 to 35 between the 1850-1855 period and 1861-1865 seems to indicate that if any change occurred during the decade, it was in the direction of further growth. There are not enough recruits in the 1850-1855 sample from birth cohorts in the late 1830s or early 1840s, however, to examine whether heights began to turn down with those cohorts. The only evidence yet uncovered from this new source of information that might seem to bolster the idea of an antebellum cycle is the low stature associated with birth in large cities. As the process of urbanization advanced, more and more Americans were born in such cities and exposed to conditions that could retard their growth; at some point, there may have been a large enough increase in their numbers to pull down the national mean heights.

Footnotes

1. For an early description of the Project and some of the initial results, see Robert W. Fogel, Stanley L. Engerman, Roderick Floud, Richard H. Steckel, T. James Trussell, Kenneth W. Wachter, Kenneth L. Sokoloff, Georgia C. Villaflor, Robert A. Margo, and Gerald Friedman, "Changes in American and British Stature Since the Mid-Eighteenth Century: A Preliminary Report on the Usefulness of Data on Height for the Analysis of Secular Trends in Nutrition, Labor Productivity, and Labor Welfare," NBER Working Paper No. 890 (Cambridge, MA 1982). The papers include Robert W. Fogel, Stanley L. Engerman, and James Trussell, "Exploring the Uses of Data on Height: The Analysis of Long-Term Trends in Nutrition, Labor Welfare, and Labor Productivity"; Roderick Floud and Kenneth W. Wachter, "Poverty and Physical Stature: Evidence on the Standard of Living of London Boys 1770-1870"; Kenneth L. Sokoloff and Georgia C. Villaflor, "The Early Achievement of Modern Stature in America"; Gerald C. Friedman, "The Heights of Slaves in Trinidad"; and Robert A. Margo and Richard H. Steckel, "The Heights of American Slaves: New Evidence on Slave Nutrition and Health". They appear in Social Science History 6 (Fall 1982).

2. See, for example, Phyllis Eveleth and James Tanner, Worldwide Variation in Human Growth (London, 1976); J.M. Tanner, A History of the Study of Human Growth (Cambridge, ENG., 1981); James Tanner, Foetus Into Man: Physical Growth from Conception to Maturity (Cambridge, MA, 1978); J.G. Fleagle, K.W. Samonds, and D.M. Hegsted, "Physical Growth of Cebus Monkeys, Debus Albifrons, During Protein and Calorie Malnutrition," American Journal of Clinical Nutrition 28 (1978), pp. 246-253; M.F. Elias and K.W. Samonds, "Protein and Calorie Malnutrition in Infant Cebus Monkeys: Growth and Behavioral Development During Deprivation and Rehabilitation," American Journal of Clinical Nutrition 30 (1977), pp. 355-366.

3. Eveleth and Tanner, Worldwide Variation in Human Growth, p. 1.

4. Physiologists have not yet worked out a complete accounting of all the effects and their magnitudes. The various effects are difficult to study, as well as to report, because of the interactions between the age of the insult, the severity of the malnutrition, the health of the subject, etc.

5. Among the bodies of evidence that have been located are cost of living surveys from 1934-1937, which contain information on height, age, occupation, wages, wealth, etc. for all members of families, and slave appraisal for Mississippi-born recruits in the Civil War, which contain information on height, age, weight, and value as a slave.

6. Friedman has already done this with his data on Trinidad slaves. See Friedman, "The Heights of Slaves in Trinidad."

7. The usefulness of height-by-age data as an indicator of standard of living should decline with the absolute level of the standard of living, both because of the declining share of income devoted to food as income rises (Engel's Law) and because of the limited genetic potential for height.

8. The basic argument here is that the contribution of a given food intake to an individual's health should be judged in the context of his total energy requirements. Thus, a worker performing arduous physical labor who receives the same food intake as an ordinary cliometrician should be judged less well nourished.

9. There exist modern data sets with precise information on the kinds and amounts of food consumed, but scholars who study historical populations have often had to turn to crude proxies for food consumption such as the price of a particular grain or food. See Andrew Appleby, "Nutrition and Disease: The Case of London, 1550-1750," Journal of Interdisciplinary History 8 (Summer 1975), pp. 1-22.

10. See Fogel, et al., "Changes in American and British Stature Since the Mid-Eighteenth Century...".

11. The Revolutionary War figure is computed in Sokoloff and Villaflor, "The Early Achievement of Modern Stature in America." The World War II figure is computed in Fogel, et al., "Changes in American and British Stature Since the Mid-Eighteenth Century...". This latter source also reports estimates of the mean final height at the Civil War of 68.2 inches. The 68.5 figure for the Civil War reported below seems to differ from the previous estimates, because it is computed over a different age group (more comparable to the age groups referred to in other years) and an adjustment was made for the overrepresentation or underrepresentation of various regions. This latter procedure consisted of weighting the regional mean final height estimates by population shares in 1860.

12. See Floud and Wachter, "Poverty and Physical Stature...," and J.M. Tanner, A History of the Study of Human Growth, for estimates for the heights of boys and men from the European working classes. See Eveleth and Tanner, Worldwide Variation in Human Growth, for estimates of heights in contemporary developing societies.

13. Sarah F. McMahon, "'Provisions Laid Up for the Family': Toward a History of Diet in New England, 1650-1850," Historical Methods 14 (Winter 1981), pp. 4-21.

14. U.S. Department of Agriculture, Meat Supply and Surplus, George K. Holmes (ed.), Bureau of Statistics, Bulletin No. 55 (Washington, D.C., 1907).

15. The antebellum cycle was first estimated to have included a period of increasing final heights up to birth cohorts of the early 1820s, followed by a period of declining stature through cohorts born in the late 1830s. The discussion of the cycle in Fogel et al., "Changes in American and British Stature Since the Mid-Eighteenth Century...," was based on this chronology. This paper also presents the evidence for the existence of a cycle in the late nineteenth and early twentieth centuries. More recent work has suggested that there was no significant decline in mean final heights until the

birth cohorts of the late 1830s. Thus, the discussions in the Robert A. Margo and Richard H. Steckel, "Heights of Native-Born Northern Whites During the Antebellum Period," and Fogel, Engerman, and Trussell, "Exploring the Uses of Data on Height...," refer to this new dating of the cycle.

16. Sokoloff and Villaflor, "The Early Achievement of Modern Stature in America...," find no statistically significant evidence that the urban-born were shorter than the rural-born during the colonial period. However, they observe a significant differential by the second decade of the nineteenth century. See Margo and Steckel, "Heights of Native-Born Northern Whites During the Antebellum Period," for further discussion of the urban-rural differential estimated from data on Civil War recruits.

17. For evidence (as well as discussion) of increases in urban mortality during the antebellum period, see Yasukichi Yasuba, Birth Rate of the White Population in the United States, 1800-1860: An Economic Study (Baltimore, 1962).

18. Although there were some small occupational differences among recruits serving during the French and Indian War, no statistically significant differentials were found among Revolutionary soldiers. See Sokoloff and Villaflor, "The Early Achievement of Modern Stature in America."

19. Margo and Steckel, "Heights of Native-Born Northern Whites During the Antebellum Period."

20. See Floud and Wachter, "Poverty and Physical Stature: Evidence on the Standard of Living of London Boys 1770-1780," and Tanner, A History of the Study of Human Growth, p. 179.

21. Robert W. Fogel et al., "The Economics of Mortality in North America, 1650-1910: A Description of a Research Project," Historical Methods 11 (Spring 1978), pp. 75-108; and Maris A. Vinovskis, "Mortality Rates and Trends in Massachusetts Before 1860," Journal of Economic History 32 (March 1972), pp. 184-213.

22. As discussed in footnote 15, the most recent study of the antebellum cycle in final heights (Margo and Steckel, "Heights of Native-Born Northern Whites During the Antebellum Period") found that a significant drop in stature did not begin until the birth cohorts of the late 1830s. As Margo and Steckel note, this finding might be an artifact due to a form of sample selection bias. Some contemporaries argued that during the final stages of the Civil War, the ranks of the Union Army were being filled by a lower class of recruit. Even after adjusting for occupational status, these recruits may have been shorter on average than earlier enlistees (who were from earlier birth cohorts).

23. This new data set, collected by Georgia Villaflor, does not allow for a direct test of whether the birth cohorts from the late 1830s and early 1840s were shorter than the preceding ones, because it does not contain information on many recruits from those birth cohorts. However, it does so indirectly, because it provides data on recruits from slightly earlier birth cohorts, and thus a reference group with which Civil War recruits of the same age, etc. can be compared.

24. The word "contradicted" may be a bit strong here, as a record of increases over time (i.e., birth cohorts) in stature, followed by a period of decreases beginning about 1840 could be consistent with the evidence presented here. This point is strengthened when one considers that socioeconomic classes with shorter heights were overrepresented among the 1850-1855 recruits, as compared to the soliders who served during the Civil War.

25. This apparent cycle in Middle Atlantic heights might also be partially attributable to the overrepresentation of individuals born in large cities, or of non-agricultural occupations, among the 1850-1855 recruits.

26. This claim is based on the implication of Alice Hanson Jones' work that southern per capita income at 1774 was equal to or greater than per capita income in the northern colonies. See her Wealth of a Nation to Be: The American Colonies on the Eve of the Revolution (New York, 1980). For comparisons of regional per capita income during the late antebellum period, see Richard A. Easterlin, "Regional Income Trends, 1840-1950," in Robert W. Fogel and Stanley L. Engerman (eds.), The Reinterpretation of American Economic History (New York, 1971).

27. Laboratory experiments with rats have suggested that offspring of poorly nourished parents might be smaller than offspring of well-nourished parents, even if both groups of offspring are raised under identical conditions. See R.K. Chandra, "Antibody Formation in First and Second Generation Offspring of nutritionally Deprived Rats," Science 190 (1975), pp. 289-290.

28. Sokoloff and Villaflor, "The Early Achievement of Modern Stature in America."

29. Slightly less than 25% of the native-born farmers among the 1850-1855 recruits were born in urban areas.

30. Yasuba, Birth Rates of the White Population in the United State, 1800-1860.

31. See footnote 27.

32. Because enforcement of height restrictions seems to have seldom been enforced strictly, the distributions of the heights of recruits are characterized by "shortfall" at the lower heights, or fewer recruits than one would observe if the distribution of the heights of recruits were normal, rather than complete truncation at all heights below the intended minimum height.