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# Underperformance in affluence: the remarkable relative decline in American heights in the second half of the 20th-century

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John Komlos und Benjamin E. Lauderdale:

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# Underperformance in Affluence: the Remarkable relative decline in American Heights in the second half of the 20th-Century *

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Data and coding information is available upon request.

Objective: We use the complete set of NHES and NHANES data collected between 1959 and 2004 in order to construct trends for the physical stature of the non-Hispanic white and black US adult population and compare them to those of Western- and Northern-Europeans. Method: Regression analysis is used to estimate the trend in US heights stratified by gender and ethnicity holding income and educational attainment constant. Results: US heights have stabilized at mid-century and a perio0d of stagnation set in with the birth cohorts 1955-74, concurrent with continual rapid increases in heights in Western and Northern Europe. The American population had been the tallest in the world for two centuries until World War II, but by the end of the 20$^{th}$ century fell behind many of their European counterparts. Only since the most recent birth cohorts 1975-83 is some gain apparent among whites but not among blacks. The relationship between height and income and between height and educational attainment has not changed appreciably over time for either men or women. Conclusion: We conjecture that the American health-care system, as well as the relatively weak welfare safety net might be the reason why human growth in the United States has not performed as well in relative terms as one would expect on the basis of income. The comparative pattern bears some similarly to that of life expectancy insofar as the US is also lagging behind in that respect.

## Introduction

Prior to reaching adulthood, the physical stature of children and youth is determined by the balance between the intake of nutrients and expenditure of energy, called net nutritional status. Final adult height is reached by the early 20s and after about age 50 people begin to shrink. Hence, height provides a historical record of nutritional status until early adulthood. It is influenced by nutritional intake which, in turn, is determined by such economic variables as real family income and food prices. However, nutritional status is also affected by the claims on nutrient intake such as work during adolescence, frequency, length and severity of endemic or epidemic diseases. Hence, growth is basically affected by food intake and by the availability, effectiveness and accessibility of medical care. The cost of medical services are therefore important as well as how the medical sector is organized, because that affects transaction costs, entitlements to health services as well as externalities, thereby determining quality and quantity of care. The distribution of income within a society also matters to height insofar as that has an impact both on the ability to acquire nutrients and to obtain medical care and medicine. Thus, the political economy of the health care system, education, transfers to the poor, and government policy toward equality (hence taxation policy) all matter. Genetics have a large effect at the individual level, but tend to be unimportant in the aggregate as long as the ethnic composition of the population examined is held constant (Fogel 1994, Tanner 1978, 1986; WHO, 1995). Hence, height is a measure of the biological well being of children and youth, whereby conditions in utero, in infancy, and during adolescence are particularly salient.

We estimate for the first time the long-term trends in the height of the US population stratified by gender and ethnicity using the National Health Examination Surveys (NHES, 1959-62) and the National Health and Nutrition Examination Surveys (NHANES, 1970-74, 1976-80, 1988-94, 1999-2004). Heights in the survey are actual measurements, not self-reported values. Insofar as people reach final height generally in their early 20s and begin shrinking at the end of their 40s,

the analysis of adult cohort trends using cross-sectional data is limited to this roughly 25-year window during which individual adult heights are stable. Longitudinal samples would be better to estimate long-term trends of the height of a population but are unfortunately rarely available. Because one of the most important contributions that trends in height can add to our understanding of biological welfare historically is its ability to allow cross-temporal comparisons, it is imperative to combine the results of cross-sectional surveys to evaluate long-term trends.

Two previous studies based on limited evidence suggested that US heights essentially remained stable after World War II (Komlos and Baur 2004, Komlos and Lauderdale 2006). After being the tallest population in the world for at least two centuries, Americans have lagged behind their European counterparts. The current study has the advantage of being based on a much larger number of observations and covers almost the whole 20$^{th}$ century (the birth cohorts of 1910-1983). While the trend in the weight of the US population has been extensively reported that of height has been *almost* neglected (Ogden et al. 2004), even though it is a useful overall measure of the biological well being of a population and correlates negatively with all-cause mortality risk until about 185 cm among men and 170 cm among women (Waaler; 1984).

That income and education are correlated with height has consistently been observed, in all samples studied, but references to the extent to which such relationships have changed over time have been few. Such effects might well vary over time: as there is more information about proper childhood nutrition, and as income increases allow food consumption to reach levels of satiation, education might become more important than income in determining long-term nutritional status, i.e., adult height.[1] Additionally, we ought to see such variation if social mobility changes in a society, greater social mobility leading to adult height being less strongly correlated with adult income or education as the latter two variables become more weakly correlated across generations.

We have evidence on the income and education of the adults in the sample, but we do not have information on the socio-economic characteristics of their parents which affected their well-

being during childhood. While it is true that the social status of persons in the sample is by no means a perfect proxy for that of their parents, or the resources available during childhood, we note that the results obtained do not depend crucially on controlling for income and education. We do the analysis in two ways. After stratifying by race and gender we calculate the trends in height with and without controlling for education and income. Ideally we would want to have education and income of the subject's parents, because those are salient during the time the child is growing. Not having information on the subject's socio-economic characteristics during childhood we use his/her income and education in adulthood as a proxy variable. In any event, there is a high correlation between father's and son's socio-economic status. Only 9% of sons whose fathers were in the lowest quartile of the income distribution ended up in the top quartile during the second half of the 20th century (Blanden, 2005; Perruci and Wysong, 2003; Wysong and Perrucci, 2006) and intergenerational social mobility has diminished over time (Schmitt, 2005). Hence, it is not so far-fetched to include the subject's own income in the regression as a proxy variable for parental socio-economic status.

**Methods**

The NHES and NHANES data sets collected by the United States National Center for Health Statistics (NCHS) contain information on a cross section of the U.S. population collected over the period 1959 to 2004).[2] While the surveys were conducted separately under different guidelines, they nonetheless provide a unique opportunity to estimate trend in the physical stature of the US-born population for most of the 20th century.

One difficulty in the analysis is that the three variables of interest—birth cohort, age, and survey iteration—are inherently correlated. Thus, all individuals present in the sample from the birth cohorts of the 1910s were sampled in the earliest surveys when they were already in middle age while all individuals sampled from the birth cohorts of the 1970s and 80s were very young at sampling. To best eliminate the influence of age effects on our ability to isolate differences

between birth cohorts, we limit our analysis for the raw (but weighted) mean height series to ages 23-47, which for both men and women are the ages at which height is stable at the individual level (column 2, Tables 1-4).[3] In the regression we control for education and income and extend the analysis to ages 20-50 by including dummy variables for ages 20-22 and 45-50. We use the survey weights for each NHANES survey, normalized so that each individual data point has equal weight on average, independent of survey. We limit our analysis to non-Hispanic white and black individuals born in the U.S.;[4] this leaves a sub-sample of nearly 26,000 observations across the five surveys.

To consider relationships between height and income or education across the different surveys presents a methodological challenge. We use household income because it has the most stable definition over time. Ideally, to achieve a parameter that allows meaningful cross-survey comparison, we would consider income quantile/percentile, allowing us to examine the magnitude of relationships on the scale of the population. However, because the measures of income are top-coded at five times the poverty income in several of the surveys, such a comparison is problematic. Therefore, we use the poverty income ratio (PIR) which is available from NHANES I onward and is imputable for NHES.[5] This variable adjusts for family size and inflation and allows a relatively stable comparison across the four decades of measurement. For education, which is reported only categorically (using different categories for each survey), the possible analyses are even more limited. Consequently, we consider the height premium for completing more than a high school education, the only criterion distinguishable across all five surveys.

Komlos and Lauderdale (2006) found a strong negative association between height and local population density among whites even after controlling for social status.[6] Hence, ideally we would hold population density constant; however this information is unavailable in the public release version of these data.[7] The possibility that such association exists, but cannot be controlled for, raises the specter of omitted variable bias if the sampling of the surveys has changed in

urban/rural composition significantly over time or if it is associated with age of participant. The survey sample weights are designed by NCHS to account for such variation, which is some assurance that such bias ought to be minimal.

**Results**

The analysis is stratified by race and sex throughout. Weighted simple averages of height by birth cohort are shown in columns 2 of Tables 1-4 as well as the coefficients of separate regressions of height on five-year birth cohorts in columns 3 controlling for income and education. The levels of height implied by these coefficients is calculated at the mean level of education and of income and are shown in columns 5 (Tables 1-4) and in Figures 1-2. Figure 3 shows a comparison of unadjusted cubic spline fits for the individual surveys to the overall trend for white men and women.[8] The trends of the individual surveys generally track well with the overall trend, with some small discrepancies in height for a given birth cohort between surveys. We attribute this to small sample size and possible slight differences in sampling procedure between surveys; there is little evidence that either differential mortality by height or post-adolescent growth could have an appreciable effect on population height.

[Tables 1-4 and Figures 1-3 about here]

The long term trends for white men indicate that heights increased rapidly until the 1930-34 birth cohorts (Figure 1). To be sure that NHES surveys are less reliable for the early period under discussion because of small sample size,[9] it is reassuring therefore that the early positive trends depicted here are supported by previous work on the height of the residents of Pittsburgh[10] (Wu 1994). This might suggest that the late-19th and early-20th century advances in public health and nutrition were initially more available to whites. The increases in the height of white men all but came to a halt during the Great Depression and even declined slightly during World War II. It increased thereafter briefly in the early 1950s but then stagnated for two decades between c. 1955 and 1974. Growth then resumed most recently between 1975 and 1983 increasing

by c. 1.55 cm (Table 2 and Figure 1). Black men began the century shorter than white men by more than a cm but grew markedly faster and caught up by the early 1960s.[11] However, they grew very little in the subsequent two decades: merely 0.3 cm until the end of the period under consideration, but are again shorter than white men by c. 1 cm among the most recent birth cohorts (1980-83) (Figure 1 and Table 4). Admittedly, the estimates of the most recent cohorts are based on few observations and are likely to change as more data become available.

The height of white women increased slower than that of men in the first half of the century and stagnated almost completely between c. 1940 and 1974 (Figure 2). The change in these three decades was a miniscule 0.16 cm, but as for white men during the last eight years of the period under consideration (1975-83) heights increased among white women by about 1.42 cm (Table 1). Again, these are based on a few numbers of observations and are not statistically significant, so they might well have to be reassessed in future research. Black women have experienced only 0.46 cm of growth since the birth cohorts of the mid-1930s (Figure 2). The height of black females caught up to that of their white counterparts in the early 1920s, much earlier than did that of men, and then they deviated little from the height of white women for most of the remaining period under consideration until very recently (Table 3). The height of black females increased in the early 1970s but has declined since then, so that in 1980-83 they were again shorter than white women by one cm (Table 3 and Figure 2).

These trends are in stark contrast to several countries in Western- and Northern-Europe, where increases in height continued through the birth cohorts of the 1960s and 1970s at a rapid pace. After two centuries of being the tallest in the world, Americans began to see this advantage vanish by World War II, (Figure 4). In the subsequent decades, however, Dutch heights greatly outstripped all other groups and Norwegian heights grew faster than American heights as well.[13] Danish and German heights surpassed American height by the 1950s birth cohorts and, along with Norwegian heights, appears to have reached a plateau more recently at around 180 cm

while white American men are 0.75 cm and black American men 1.8 cm shorter. Dutch men are 4.9 cm and women are 5.9 cm taller than their US counterparts.

PIR (income) and the education dummy variables affect the time trends very little[14] (Tables 1-4). The comparisons across the four race/gender groups suggest that the magnitude of the income premium among men both black (0.4 cm/per one unit increase in PIR) and white (0.4 cm) is greater than for women (0.1-0.2 cm) (Tables 1-4). There may be some reverse causation working here, as taller people have higher earnings (Heineck 2005; Persico et al. 2004). Hence, we do not mean to imply the direction of causation with the height-income association.

The education premium beyond a high school degree is greatest among white men (1.6 cm) followed by white women (1.4 cm), black men (0.9 cm) and black women (0.4 cm) (Tables 1-4). The most notable discrepancy is the large difference in the magnitude of the education height premium between whites and blacks, the premium for whites being roughly 2-3 times greater. This may be due to the relatively recent expansion in higher education among blacks; just 9% of the black sub-sample in the NHES survey has greater than high school education. If most black individuals with high school education have parents with lower attainment, then the normal generational correlation of parental education and child education that yields an observable correlation between adult height and adult education in the white population would be greatly weakened even if the actual benefit of growing up in a household with more than a high-school education were the same across groups.

Table 5 about here

To assess possible changes in the relationship between height, income and education over time, we repeat the regressions adjusted for PIR and the education dummy variable for each survey individually (Table 5). There is insufficient data for blacks to support a strong conclusion based on individual surveys other than the general observations with respect to the absolute level of the correlations available from the general regression. For whites, the magnitudes of income

affects are rather stable but greater historically among men than women. That the most recent data indicates parity in the height-income correlation (Table 5) between white men and women may be the product of increasing rates of female employment, which makes men's and women's incomes a more comparable measure of their status. The magnitudes of the education effect on height are stable for white females at c. 1.3 cm and declining among males from 2.3 to 1.3 cm within the limitations imposed by the statistical error. The height premium for exceeding a high school education has remained remarkably stable among white women despite a rapid increase in general educational attainment. The multicollinearity between income and education makes these parameters more difficult to disaggregate and increases the error in their estimation, which may obscure any changes in these coefficients over time.

We also plot height for three PIR groups (0-1.5, 1.5-3 and 3+; Figures 5-6) which generally supports the linear model used in the regressions. The shape of the trends has not changed significantly for either white men or white women and height increases have been comparable across all income levels.

[Figures 5 and 6 about here]

**Discussion**

As Tanner suggested some time ago, the way humans grow is a "mirror" reflecting the socio-economic conditions of the society (1986). There is widespread agreement that nutritional intake, the incidence of diseases and the availability of medical services have a major impact on human size (Bogin, 2001, p. 74; Costa, 1993; Komlos and Cuff 1998; Komlos and Baten 2004; Waaler, 1984). However, the recent evolution of the physical stature of Americans as well as the disparity in height between Europeans and North Americans has been challenging to explain in those terms, given the increasing economic prosperity experienced on both sides of the Atlantic.

Yet, American physical stature does not fully reflect American affluence. While on paper America is still among the wealthiest of countries, its population has become shorter than West-

ern- and Northern-Europeans physically and also live shorter lives.[16] The primary finding of this paper is that height of the US population tended to remain stable after mid-century even as affluence increased substantially. For example, the height of black men, the most rapidly growing group until 1964, hardly changed since then. Black females have fared even worse. While their height did increase for a while, they also experienced serious reversals so that their height is not much different than what it was at the outset of World War II. This is obviously somewhat of a mystery given the substantial advances of blacks in the labor market and is by no means commensurate with their social, legal, and political gains. Another adverse development is that in recent times both black male and black female heights are again one cm below their white counterparts as they were at the beginning of the century.

Whites have also not fared much better except for the most recent birth cohorts, 1975-83, when their heights once again began to show signs of improvement. To be sure the results pertaining to the youngest birth cohorts, both white and black are not on a solid evidential basis, as the numbers of observations are small, especially among blacks (Tables 1-4). Nonetheless the data pertaining to whites they are sufficient to intimate, even if not conclusively, that the stagnation among whites might well have finally ceased. The stagnation lasted for an extended period of time. Among white men heights stagnated between c. 1935 and 1949 which is understandable given the adversities of the Great Depression and World War II, but that it remained practically unchanged again between c. 1955 and 1974 is not easily explained in socio-economic terms given the substantial increases in income and medical knowledge during those two decades. Among white women the stagnation in heights reached back even further in time as it have remained practically unchanged between 1940 and 1974.

The trends reported here substantiate, in the main, earlier findings using much smaller samples reported in Komlos and Baur (2004) and Komlos and Lauderdale (2005), but contrast with those of Ogden et al. (2004, p. 2), who assert that between the early 1960s and 2002 “mean height

increased approximately 1 inch" (2.54 cm). The discrepancy arises primarily because their results are for the average adult population rather than by birth cohort and the shorter pre-1950s birth cohorts are an increasingly smaller fraction of the U.S. adult population as time progresses. Their own evidence indicates that heights stagnated or even declined among the 20-39 year age group between those measured c. 1978 and c. 2001 (Ogden et al. 2004, p. 11).[20]

Tallest in the world between colonial times and the middle of the 20th century, Americans by the 21st century are much more affluent but have become shorter (and fatter) than West- and Northern-Europeans. In fact, the US population is currently at the bottom end of the height distribution in advanced industrial countries. Even native-born US white men are shorter than their counterparts in Norway, Sweden, Denmark, Czech Republic, Belgium and Germany and black men are even shorter than that. There is a marked gap of 4.9 cm between US white men and Dutch men[21] (Fredriks 2000; Sunder 2003) (Figure 4). US white women are 5.9 cm shorter than their Dutch counterparts. Even though a century and a half ago Americans were taller than the Dutch by even a larger margin. Thus, this is a complete reversal of the 19th century pattern.

This reversal is rather salient insofar as height is indicative of how well the human organism thrives in its socio-economic environment. It is a general marker for such aspects of biological well being as life expectancy. Hence, Americans' laggard performance in physical stature is noteworthy insofar as it captures socio-economic effects on the human organism in utero, infancy, childhood and in adolescence that also find expression in infant mortality and life expectancy in general. Because physical growth is a function of net nutritional status before adulthood, which, in turn depends on nutritional supply on the one hand and disease encounters on the other, we conjecture that the differences between American and European physical stature can be attributed primarily to these two factors (Tanner, 1978).[22] Why American heights declined in relative terms remains a conundrum, a topic for future research, but even at this stage of our knowledge we can conjecture that there are differences in the diet of US and European children that could effect

human growth. For example, American children might consume more meals prepared outside of the home, more fast food rich in fat, high in energy density and low in essential micronutrients, than European children (Bowman et al., 2004; Paeratakul, 2003; Skinner et al 1999; USDA 1999).

Moreover, consideration of the differences in the socio-economic institutions of Europe and the US might help in at least beginning to resolve this paradox. Without claiming to propose a comprehensive answer to this quandary, we propose the hypothesis that there are several crucial differences between the West- and Northern-European welfare states and the more market-oriented economy of the US that might well shed further insights into this paradox. This includes greater

socio-economic inequality and more extensive poverty in America[23] (Smeeding 2005; Thomas, 2003; Wilkinson and Marmot, 2003, OECD, 2001). Furthermore, the European welfare states provide a more comprehensive social safety net including universal health care coverage while the share of those who have no health insurance in the United States is about 15 % of the population (Decker and Remler, 2004, Richmond and Fein 2005; Sunder, 2003). Is it possible that the West-European welfare states are able to provide better health care to children and youth than the more market-oriented American one (Navarro and Shi, 2001; Navarro et al., 2006)? Or is there something about the quality of health care that is responsible for these results (Asch et al., 2006; McGlynn et al., 2003; Schoen, 2005)?[25]

These factors are also related to the reasons why Americans have a lower life expectancy compared to other populations in advanced industrial countries. For example, the Canadian life-expectancy that had been above US levels throughout the 20$^{th}$ century exceeded even that of white Americans for the first time about 1970 (Kunitz and Pesis-Katz, 2005), just as Americans born after the war were reaching adulthood and were beginning to fall behind in height. Furthermore, the US infant mortality rate is the highest among the advanced industrial countries – twice that of Sweden (WHO 2002), and Swedish life expectancy exceeds that of the US by 1.9 years (Human Development Report 2000, p. 157). Germans evaluate their own health status more positively than

Americans do (Komlos and Baur, 2004). In brief, “the United States today is less healthy, compared to other rich nations, than it was 50 years ago” (Banks et al. 2006; Bezruchka. 2006). Thus, falling behind in height corresponds to falling behind in other dimensions of biological welfare as well.

Consider, in addition, that among the advanced West- and Northern-European countries mentioned above there is a significant negative correlation between functional illiteracy of the population and male height -0.64 ($p<0.02$) and between income inequality as measured by the Gini coefficient and male height -0.50 ($p<0.04$). The results with female heights are similar: -0.60 ($p<0.04$) and -0.56 ($p<0.02$). Among females the number of doctors per capita was also associated significantly with height +0.62 ($p<0.01$). In other words, the greater is the inequality and lower is educational attainment, the shorter is the population (UNDP 2004, pp 150, 188).

The lagging US height performance is not caused by a long left tail in the height distribution. Heights are normally distributed and the whole American height distribution is shifted to the left (Komlos and Baur 2004; Komlos and Kriwy 2003). In other words, rich Americans are shorter than rich West-Europeans and poor white Americans are shorter than poor West-Europeans. One can calculate the height of high earners (income equals to four times the poverty income ratio) with more than a high school education on the basis of the coefficients in Tables 1-4 (born 1975-79). They are as follows: white men: 180.1 cm, black men 179.7 cm, white females: 165.8 cm, black females: 162.9 cm. Thus, upper-class white American men are still shorter than the Dutch and Danish average, just about as tall as the Swedish and Czech average, and just slightly taller than the Norwegian average. Moreover, upper-class black-American men are shorter than the Belgian mean. At the same time, American upper-class women, both white and black, are still shorter than their Dutch, Danish, Swedish, Czech, Norwegian, German, Belgian, Finn, and Austrian counterparts. Compared to white upper-class American height of 180.1 and 165.8 cm for males and females, German upper-class heights are 182.0 and 168.6 cm

respectively. At the same time poor Americans (PIR=1) without a high school degree are 177.2 and 163.6 cm tall compared to 178.4 cm and 165.6 cm for the German poor. That is to say, well educated and high income white Americans are 1.9 and 2.8 cm shorter than their German counterparts, while poor and poorly educated white Americans are 1.2 and 2.0 cm shorter than their poor German counterparts. Thus, at both ends of the socio-economic spectrum Americans are shorter than Germans, though women tend to be relatively shorter than men. It is uncanny for a population that is on paper wealthier than Western Europeans to be shorter even by such small amounts. In fact, we presume that genetically Americans could be as tall as the Dutch. After all, in 1850 they were 6.5 cm taller than the Dutch, the Germans and most other Europeans (Komlos and Baur 2004).

Could genetic factors play a role in the US's falling behind in physical stature? While this possibility cannot be ruled out with the data set under consideration, this factor is unlikely to be the explanation for the patterns reported above, because we have all but eliminated those born outside of the US and, moreover, Hispanics and Asians are also excluded from the analysis. Admittedly, this does not rule out second-generation immigrants from the data set, but there are several reasons to think that this is not very likely to be the cause of the patterns reported here. If this were the main reason for the US falling behind, one would expect to find that at least African-Americans, among whom immigration has been small (under 1% of the total in the 1950s (U.S. Department of Justice, 2002)), would have kept pace with European developments. Furthermore, one would expect that the rich Americans at least would be as tall as the rich Europeans. Yet, neither is the case. In addition, Americans were still the tallest in the world at the turn of the 20$^{th}$ century, at a time when immigration rates had been very high for some time, particularly from the poorer and shorter, populations of Eastern and Southern Europe. Apparently this did not matter in the early-20$^{th}$ century, why would it then matter at its end?

We do not claim to have provided conclusive evidence for Americans' unusual height evolution. Yet, there does seem to be an uncanny similarity in the US falling behind the other developed nations of Europe in height, subjective evaluation of health, and longevity at the outset of the 21st century that certainly needs further investigation. The more opulent US economy has underperformed relative to its west- and northern-European counterparts in several dimensions of biological welfare including physical stature. That is the case although US population spends more on health care, so one would think that they would be healthier. The US per capita expenditure on health is more than $4,000 per annum - twice as much as the OECD (Organization for Economic Co-operation and Development) average. In stark contrast, Sweden spends $1,700 per annum. Mysteriously, the wealthiest are by no means the tallest or the healthiest, and therefore, we should pay more attention to differences in height among industrialized countries as an overall indicator of how well the human organism is performing relative to its biological potential. In developed societies where caloric and protein intake is rarely limited by family income, height reflects less the economic output of a community and more its political, personal, and social choices that influence overall health during childhood development. Thus, the observed discrepancy between material welfare (standard of living) of a society and biological welfare (particularly of children and youth in this paper) has helped to motivate the development of a distinct concept of a biological standard of living (Komlos 1989).

Our findings here suggest that the relationship of height to education and income has been remarkably consistent over the last 40 years, despite economic growth and higher average educational attainment. The mechanisms underlying these findings remain unclear; however, continued work in these areas is a promising avenue for connecting contemporary correlations in height at the societal level to causal mechanisms in early life. While we are unable to pinpoint the causal pathways of this laggard performance in the US, perhaps the West- and Northern-European welfare state with its universal socio-economic safety net is able to provide a higher biological

standard of living to its children and youth than the more free-market oriented US economy is, which at least in this important measure – as well as in life expectancy - has underperformed in affluence. This is not much more than a hypothesis at this point, but is worth following up with further research rather than being largely ignored as it has been up to now.

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**Table 1:** Height of white females, 5-year birth cohorts for the pooled NHES and 6 NHANES data sets

| Birthyear | N | Height (cm) | Coeff. | t-stat | Height (cm) | Height (in.) |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1910-14 | 132 | 160.51 | **-3.84** | -9.32 | 160.53 | 63.20 |
| 1915-19 | 340 | 160.66 | **-3.42** | -9.02 | 160.94 | 63.36 |
| 1920-24 | 361 | 161.60 | **-2.63** | -8.49 | 161.74 | 63.68 |
| 1925-29 | 849 | 162.60 | **-1.70** | -6.96 | 162.67 | 64.04 |
| 1930-34 | 1,323 | 162.69 | **-1.66** | -7.53 | 162.71 | 64.06 |
| 1935-39 | 1,273 | 162.97 | **-1.33** | -6.15 | 163.03 | 64.19 |
| 1940-44 | 1,293 | 163.47 | **-0.89** | -4.38 | 163.48 | 64.36 |
| 1945-49 | 1,728 | 163.42 | **-1.19** | -6.40 | 163.17 | 64.24 |
| 1950-54 | 859 | 163.73 | **-1.06** | -5.94 | 163.31 | 64.29 |
| 1955-59 | 554 | 164.79 | Ref. | - | 164.37 | 64.71 |
| 1960-64 | 537 | 164.05 | **-0.71** | -3.49 | 163.65 | 64.43 |
| 1965-69 | 483 | 164.06 | **-0.69** | -3.34 | 163.67 | 64.44 |
| 1970-74 | 326 | 164.14 | **-0.73** | -2.87 | 163.63 | 64.42 |
| 1975-79 | 236 | 164.71 | 0.21 | 0.71 | 164.57 | 64.79 |
| 1980-53 | 98 | 164.70 | 0.69 | 1.49 | 165.05 | 64.98 |
| > HS EDU | | | **1.44** | 14.44 | | |
| PIR | | | **0.24** | 6.89 | | |
| Age 20-22 | | | -0.14 | -0.87 | | |
| Age 45-50 | | | -0.04 | -0.31 | | |
| Constant | | | **163.19** | 947.89 | | |
| Total N | 10,392 | | 11,242 | | | |
| $R^2$ | | | 0.04 | | | |
| F | | | **28.59** | | | |

Note: Column 1: number of observations refers to the ages 23-47 used to calculate weighted means in col. 2. Coefficients in Column 3 are obtained using ordinary least squares regression using observations weights. Number of observations differs from those reported in column 1 in so far as ages 20-22 and 48-50 are included in the regression but those for whom education or income information is missing are excluded. Coefficients that are significant at the 5% level are in bold-faced type. Height values in column 5 have been standardized for average level of education (>HS ED = 0.3735) and average income levels (PIR=2.6889).

**Table 2:** Height of white males, 5-year birth cohorts for the pooled NHES and 6 NHANES data sets

| Birthyear | N | Height (cm) | Coeff. | t-stat | Height (cm) | Height (in.) |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1910-14 | 102 | 173.16 | **-3.01** | -6.04 | 174.58 | 68.73 |
| 1915-19 | 309 | 173.33 | **-3.53** | -8.23 | 174.06 | 68.53 |
| 1920-24 | 341 | 174.62 | **-2.50** | -7.27 | 175.09 | 68.93 |
| 1925-29 | 633 | 175.58 | **-1.52** | -5.31 | 176.08 | 69.32 |
| 1930-34 | 890 | 176.69 | **-0.73** | -2.72 | 176.86 | 69.63 |
| 1935-39 | 824 | 176.94 | **-0.74** | -2.81 | 176.85 | 69.62 |
| 1940-44 | 798 | 176.59 | **-1.06** | -4.35 | 176.53 | 69.50 |
| 1945-49 | 1,125 | 177.16 | **-0.81** | -3.75 | 176.78 | 69.60 |
| 1950-54 | 787 | 177.96 | 0.05 | 0.24 | 177.64 | 69.94 |
| 1955-59 | 508 | 177.91 | Ref. | - | 177.59 | 69.92 |
| 1960-64 | 467 | 178.25 | 0.31 | 1.37 | 177.90 | 70.04 |
| 1965-69 | 349 | 177.94 | 0.31 | 1.32 | 177.90 | 70.04 |
| 1970-74 | 222 | 178.20 | 0.11 | 0.41 | 177.70 | 69.96 |
| 1975-79 | 164 | 179.39 | **1.05** | 3.16 | 178.64 | 70.33 |
| 1980-53 | 97 | 179.09 | **1.65** | 3.23 | 179.25 | 70.57 |
| > HS EDU | | | **1.62** | 14.29 | | |
| PIR | | | **0.41** | 10.26 | | |
| Age 20-22 | | | -0.14 | -0.69 | | |
| Age 45-50 | | | **-0.50** | -3.13 | | |
| Constant | | | **175.76** | 885.83 | | |
| Total N | 7,616 | | 8,263 | | | |
| $R^2$ | | | 0.06 | | | |
| F | | | **31.8** | | | |

Note: Column 1: number of observations refers to the ages 23-47 used to calculate weighted means in col. 2. Coefficients in Column 3 are obtained using ordinary least squares regression using observations weights. Number of observations differs from those reported in column 1 in so far as ages 20-22 and 48-50 are included in the regression but those for whom education or income information is missing are excluded. Coefficients that are significant at the 5% level are in bold-faced type. Height values in column 5 have been standardized for average level of education (>HS ED = 0.41522) and average income levels (PIR=2.8071).

**Table 3:** Height of black females, 5-year birth cohorts for the pooled NHES and 6 NHANES data sets NHANES

| Birthyear | N | Height (cm) | Coeff. | t-stat | Height (cm) | Height (in.) |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1910-14 | 19 | 160.5 | **-5.20** | -4.99 | 158.54 | 62.42 |
| 1915-19 | 42 | 158.91 | **-4.59** | -4.09 | 159.14 | 62.65 |
| 1920-24 | 71 | 160.99 | **-2.09** | -2.89 | 161.65 | 63.64 |
| 1925-29 | 188 | 162.77 | -1.02 | -1.81 | 162.72 | 64.06 |
| 1930-34 | 266 | 162.94 | -0.93 | -1.81 | 162.81 | 64.10 |
| 1935-39 | 250 | 163.38 | -0.56 | -1.07 | 163.18 | 64.24 |
| 1940-44 | 259 | 162.68 | -0.68 | -1.37 | 163.05 | 64.19 |
| 1945-49 | 470 | 163.21 | -0.80 | -1.77 | 162.93 | 64.15 |
| 1950-54 | 395 | 163.05 | **-0.89** | -2.05 | 162.85 | 64.11 |
| 1955-59 | 454 | 163.87 | Ref. | - | 163.74 | 64.46 |
| 1960-64 | 420 | 163.48 | -0.53 | -1.06 | 163.20 | 64.25 |
| 1965-69 | 364 | 164.19 | 0.32 | 0.64 | 164.05 | 64.59 |
| 1970-74 | 124 | 163.79 | 0.57 | 0.98 | 164.30 | 64.69 |
| 1975-79 | 96 | 163.07 | **-1.43** | -2.10 | 162.31 | 63.90 |
| 1980-53 | 71 | 163.16 | -0.09 | -0.10 | 163.65 | 64.43 |
| > HS EDU | | | 0.43 | 1.57 | | |
| PIR | | | 0.12 | 1.32 | | |
| Age 20-22 | | | **-0.92** | -2.49 | | |
| Age 45-50 | | | 0.25 | 0.70 | | |
| Constant | | | **163.43** | 437.01 | | |
| Total N | 3,489 | | 3,832 | | | |
| $R^2$ | | | 0.02 | | | |
| F | | | **4.15** | | | |

Note: Column 1: number of observations refers to the ages 23-47 used to calculate weighted means in col. 2. Coefficients in Column 3 are obtained using ordinary least squares regression using observations weights. Number of observations differs from those reported in column 1 in so far as ages 20-22 and 48-50 are included in the regression but those for whom education or income information is missing are excluded. Coefficients that are significant at the 5% level are in bold-faced type. Height values in column 5 have been standardized for average level of education (>HS ED = 0.26097) and average income levels (PIR=1.7061).

**Table 4:** Height of black males, 5-year birth cohorts for the pooled NHES and 6 NHANES data sets NHANES data

| Birthyear | N | Height (cm) | Coeff. | t-stat | Height (cm) | Height (in.) |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1910-14 | 10 | 171.55 | **-5.35** | -3.83 | 171.74 | 67.61 |
| 1915-19 | 37 | 172.54 | **-4.15** | -3.24 | 172.94 | 68.09 |
| 1920-24 | 54 | 173.05 | **-3.17** | -3.55 | 173.92 | 68.47 |
| 1925-29 | 93 | 173.86 | **-2.77** | -3.44 | 174.32 | 68.63 |
| 1930-34 | 111 | 175.04 | **-1.72** | -2.20 | 175.37 | 69.05 |
| 1935-39 | 100 | 175.17 | -1.44 | -1.90 | 175.65 | 69.15 |
| 1940-44 | 158 | 176.08 | -1.23 | -1.83 | 175.86 | 69.24 |
| 1945-49 | 295 | 176.26 | -0.86 | -1.42 | 176.23 | 69.38 |
| 1950-54 | 301 | 177.39 | -0.05 | -0.09 | 177.04 | 69.70 |
| 1955-59 | 376 | 177.20 | Ref. | - | 177.09 | 69.72 |
| 1960-64 | 332 | 178.15 | 0.83 | 1.36 | 177.92 | 70.05 |
| 1965-69 | 274 | 177.31 | 0.03 | 0.05 | 177.12 | 69.73 |
| 1970-74 | 103 | 178.77 | 0.68 | 0.93 | 177.77 | 69.99 |
| 1975-79 | 68 | 177.58 | 1.28 | 1.56 | 178.37 | 70.22 |
| 1980-53 | 61 | 177.53 | 1.13 | 0.99 | 178.22 | 70.17 |
| > HS EDU | | | **0.87** | 2.41 | | |
| PIR | | | **0.39** | 3.40 | | |
| Age 20-22 | | | -0.45 | -0.87 | | |
| Age 45-50 | | | 0.23 | 0.48 | | |
| Constant | | | **176.03** | 369.32 | | |
| Total N | 2,373 | | 2,605 | | | |
| $R^2$ | | | 0,05 | | | |
| F | | | 7.00 | | | |

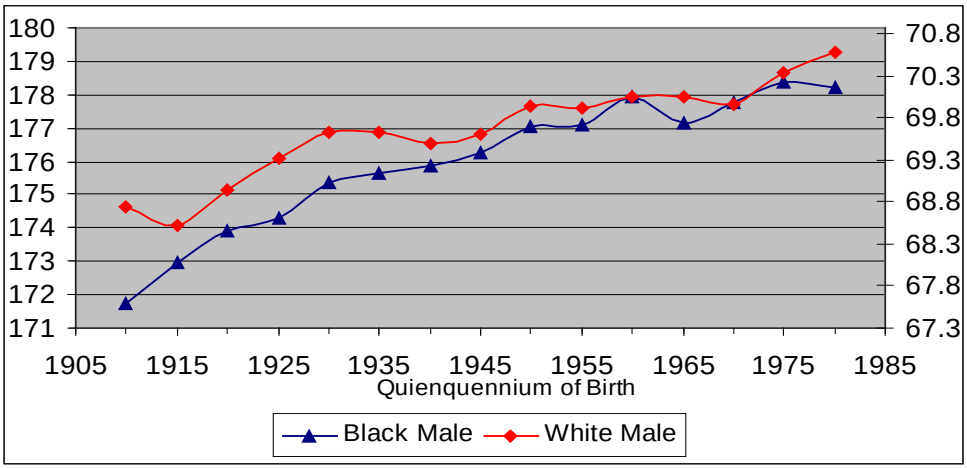
Note: Column 1: number of observations refers to the ages 23-47 used to calculate weighted means in col. 2. Coefficients in Column 3 are obtained using ordinary least squares regression using observations weights. Number of observations differs from those reported in column 1 in so far as ages 20-22 and 48-50 are included in the regression but those for whom education or income information is missing are excluded. Coefficients that are significant at the 5% level are in bold-faced type. Height values in column 5 have been standardized for average level of education (>HS ED = 0.28794) and average income levels (PIR=2.0945).

**Table 5:** The height premiums (cm) for exceeding a high school education and for higher income in each individual NHANES survey, adjusted for birth cohort. The fractions of the population exceeding the cutoff for the education dummy variable are also shown.

| "Survey" | PIR | Std. Error | > HS Ed. | Std. Error | Frac. > HS Ed. |
|---|---|---|---|---|---|
| **Black Female** | | | | | |
| NHES | -0.47 | 0.41 | -0.69 | 1.46 | 0.09 |
| NHANES I | 0.12 | 0.19 | 0.83 | 0.73 | 0.11 |
| NHANES II | 0.03 | 0.33 | 1.11 | 1.03 | 0.21 |
| NHANES III | 0.09 | 0.15 | 0.83 | 0.44 | 0.33 |
| NHANES 1999-2004 | 0.22 | 0.19 | 0.02 | 0.58 | 0.48 |
| **Black Male** | | | | | |
| NHES | 0.56 | 0.53 | 0.1 | 2.6 | 0.06 |
| NHANES I | -0.08 | 0.36 | 1.55 | 1.4 | 0.15 |
| NHANES II | 0.70 | 0.42 | -1.3 | 1.11 | 0.28 |
| NHANES III | **0.50** | 0.17 | 0.73 | 0.51 | 0.34 |
| NHANES 1999-2004 | 0.06 | 0.22 | 1.26 | 0.69 | 0.41 |
| **White Female** | | | | | |
| NHES | **0.29** | 0.12 | **1.31** | 0.38 | 0.24 |
| NHANES I | **0.35** | 0.09 | **1.17** | 0.25 | 0.32 |
| NHANES II | 0.16 | 0.12 | **1.69** | 0.3 | 0.42 |
| NHANES III | 0.13 | 0.14 | **1.47** | 0.39 | 0.56 |
| NHANES 1999-2004 | **0.31** | 0.11 | **1.39** | 0.38 | 0.68 |
| **White Male** | | | | | |
| NHES | **0.45** | 0.14 | **2.33** | 0.42 | 0.25 |
| NHANES I | 0.25 | 0.14 | **2.02** | 0.39 | 0.37 |
| NHANES II | **0.59** | 0.13 | **2.12** | 0.33 | 0.47 |
| NHANES III | **0.53** | 0.17 | **1.01** | 0.45 | 0.54 |
| NHANES 1999-2004 | **0.33** | 0.14 | **1.32** | 0.44 | 0.60 |

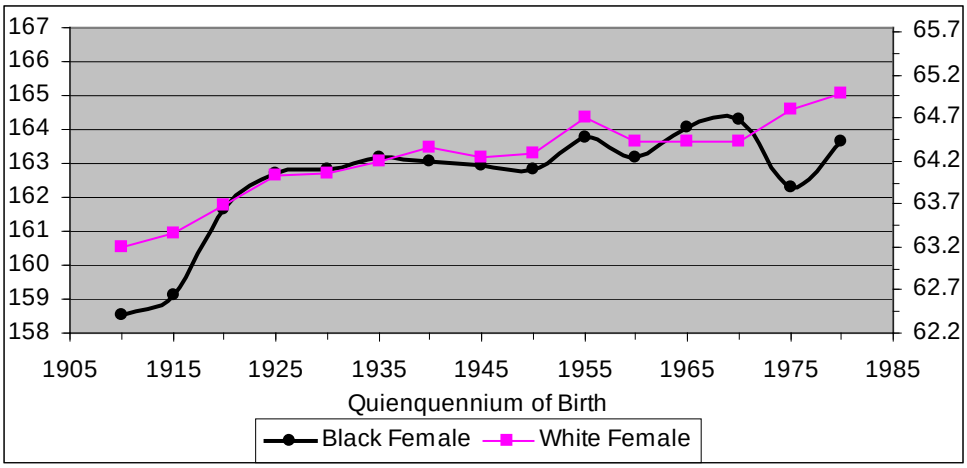
Note: Coefficients significant at the 5% level are in bold face type. PIR coefficients indicate change in height for a one unit increase in the PIR value. The above regressions were also controlled for the quinquennium of birth not reported here.

Figure 1: Height (cm and inches) as a function of birth cohort for white and black, U.S. born Men aged 23-47.



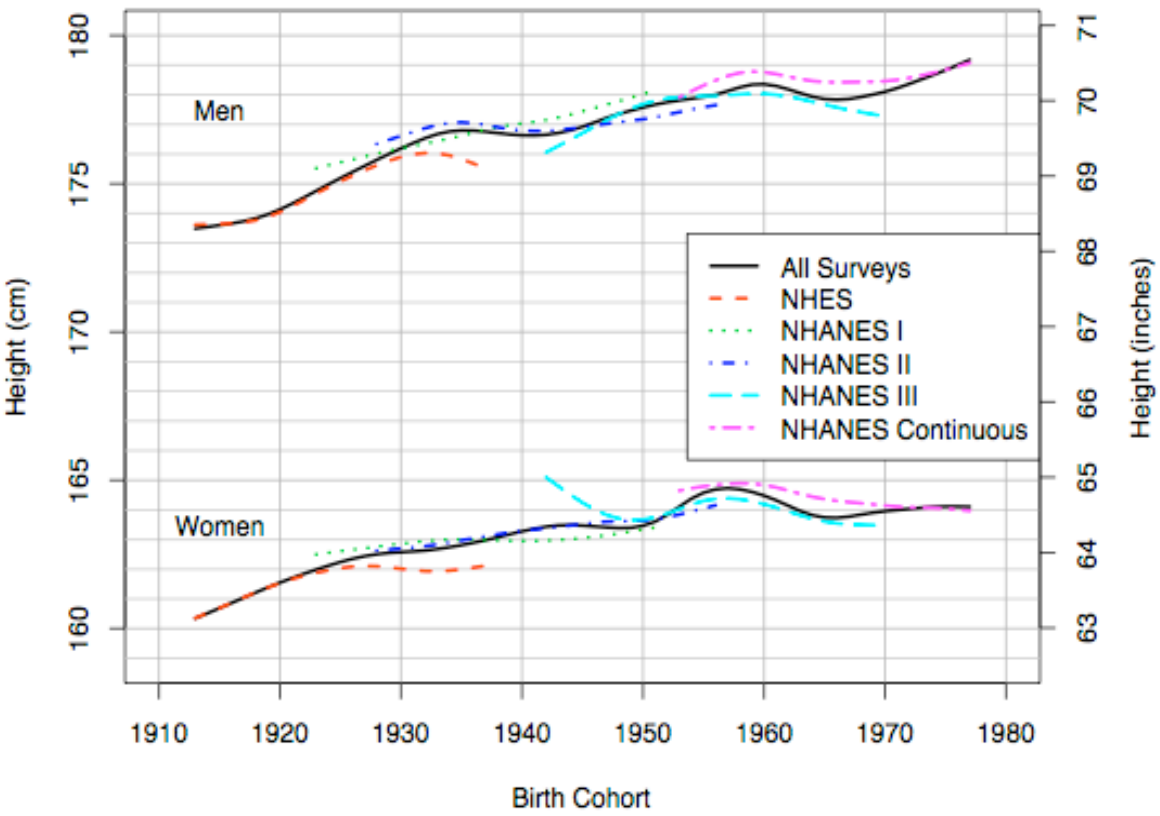

Note: level of height is standardized at average education and average income for the period.

**Figure 2:** Height (cm and inches) as a function of birth cohort for white and black, U.S. born Women aged 23-47.



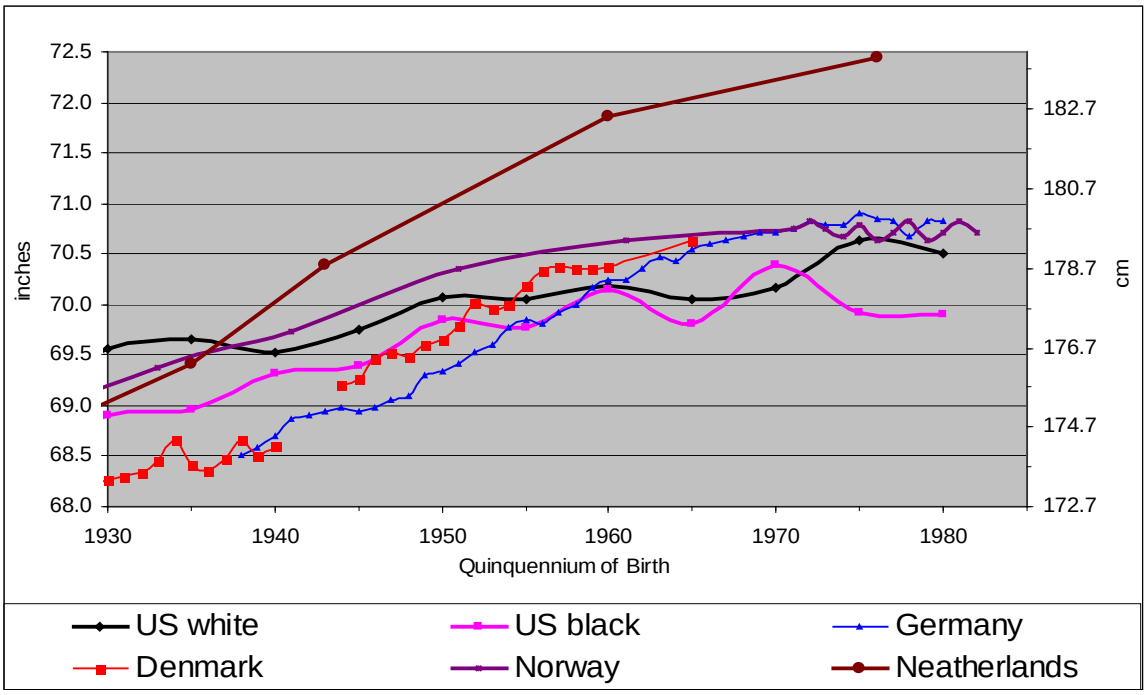

Note: level of height is standardized at average education and average income for the period.

**Figure 3:** Cubic spline fits for each individual survey overlaid on pooled spline fits, for the height (cm and inches) of white men and women. While there are some discrepancies at the tails of individual surveys, this is attributable to the general problem of large errors on curve fits at the edges of their domain.



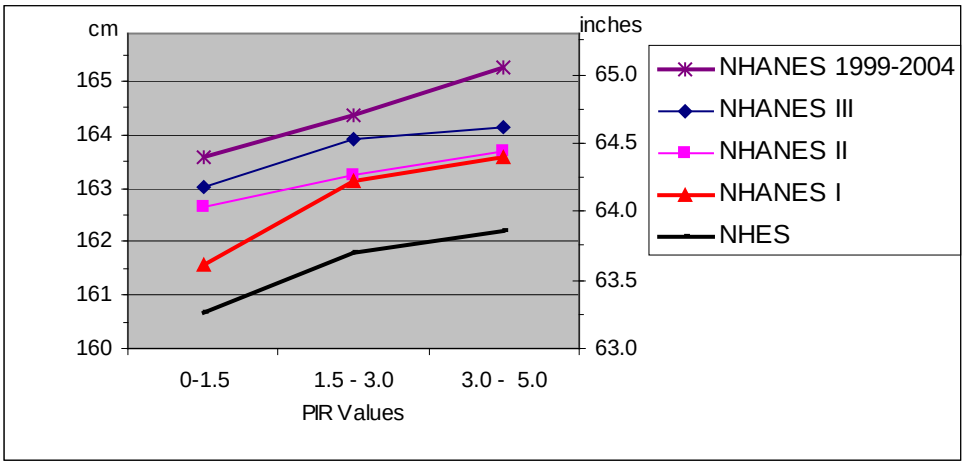

Note: Data for Nhanes 2003-2004 are not included in this graph.

**Figure 4:** Comparison of the Trend of the Height of Men in some Industrialized Countries



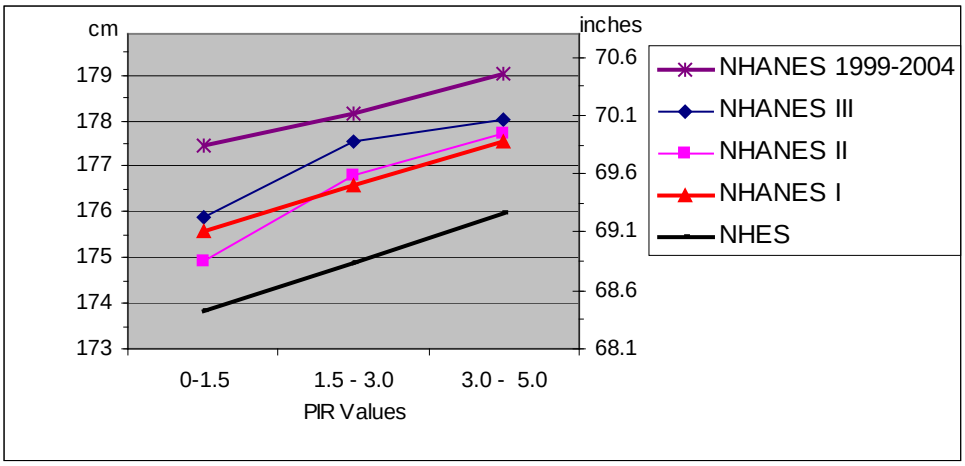

Note: Sources of US height is Coumn 2 of Tables 2 and 4 insofar as the European data are also not standardized for income or education.

**Figure 5:** White female height age 23-47 as a function of income (PIR Values in categories of 0-1.5, 1.5 – 3.0, and 3-5) in each NHANES Survey.




Note: These values are not controlled for birth cohort effects.

**Figure 6:** White Male heights, ages 23-47 as a function of income (PIR Values in categories of 0-1.5, 1.5 – 3.0, and 3-5) in each NHANES Survey.




Note: These values are not controlled for birth cohort effects.

[1] Admittedly, it would be more desirable to have information on permanent household income rather than contemporaneous income. In absence of such information the income variable captures only with error access to resources in childhood. However this is the best we can do with the data at hand, and the results are not affected by the income variable, as the results are similar if the income variable is left out of the regression.

[2] Data compiled from http://www.cdc.gov/nchs/nhanes.htm

[3] There is some evidence that height of populations may be influenced by the correlation of height with mortality, however this effect appears to be small over a 25-year span for modern mortality rates (Yan 1999).

[4] Information on place of birth is not available in the NHES sample and consequently the full sample is used. Hence, the earliest estimates include non-US born individuals as well and therefore lead to an underestimate of the true mean height of the US-born population.

[5] PIR adjusts for family size through the dependence of the poverty income on family size. Imputation for the early surveys was done using the categorical income ranges provided combined with data on family size and the poverty incomes by family size at the middle year of the survey.

[6] The sample used for that analysis is not a random sample but a convenience sample used for commercial purposes by the textile industry. While we are unable to provide a convincing answer for the phenomenon, the findings might indicate, nonetheless, the influence of urban disamenities on height, such as pollution (poorer quality of air) and the quicker spread of contagious diseases. There are also negative neighborhood externalities in “inner city” neighborhoods. Moreover, urban life styles associated with a fast-food consuming culture, more stressful living – a fast-paced life that might lead to the disregard of children’s needs, and thereby affect children’s growth (Phelps, 2003, 104). In other words, there might be net negative health effects of urban living compared with small towns and suburbs even after controlling for individual social status. While urban areas have better access to health-care facilities, the residents might not be as keen on using those opportunities. The data set did not have sufficient number of observations on black and Hispanics to test the population density/height hypothesis for those ethnic groups.

[7] The first three surveys (NHES, NHANES I, NHANES II) include an 8 category variable for municipality size that, though an imperfect indicator of population density, might have been useful if it were available

for the later surveys, however NCHS does not release location information for privacy reasons in the public-release version of the NHANES data.

[8] A cubic spline is an interpolated curve constructed so as to connect points smoothly with piecewise third-order polynomials. These flexible (smoothed) curves allow features of the data to appear that might not be clear in the regression models, providing a check that pooling the survey results is not obscuring differences across surveys. NHANES 2003-04 is not included in this figure as it became available too late.

[9] This is particularly the case insofar as this early part of the sample also includes those individuals who were born outside of the United States.

[10] That the absolute levels of the NHES and the Pittsburgh results differ is probably due to the upward bias on height of both self-reporting and the registered voter sub-population reported by Wu. The fact that the NHES sample also includes foreign born is an additional factor in this regard.

[11] The heights of Pittsburgh registered voters also corroborate a white-black height gap for men of approximately 1cm at the beginning of the century (Wu 1994). It is not at all clear why the height of blacks had caught up to that of whites, given the health and wealth disparity between the two groups. This issue remains for future research to be resolved.

[12] It is not at all clear why the height of blacks has caught up to that of whites, given that health and wealth disparity between the two ethnic groups. This issue remains for future research to be resolved.

[13] It by no means obvious what combination of factors has led to the Dutch to be taller than the population of the surrounding countries with extensive social safety net. In addition to an excellent medical system and many social services the Dutch anthropometric advantage also might be based on the lower labour force participation rates of females, which has enabled mothers to provide a more propitious environment for the new-born than those prevailing in day-care centers. “In addition, starting with the beginning of the 20$^{th}$ century the expanding welfare state supported Dutch mothers from all social classes to participate in a public health monitoring system. The so-called *consultatiebureaus* played a key role, especially after World War II. Mothers could obtain advice about infant-feeding, child nutrition and hygiene from a paediatrician; assessment of the health status of the children was part of the routine” (de Beer, 2004). The extensive character of this system is unique in the Netherlands.

[14] The small increases in adjusted $R^2$ after the inclusion of these covariates indicate that only small amount of the increase in height is linked to those variables (results not shown).

[15] This is true regardless of the mechanism for height's correlation to income. If the mechanism is through correlation with parent's income which determined early life biological welfare, then household income has been doubly abstracted from the causal mechanism by generation and by choice of spouse whereas male income has only abstracted by generation. Alternatively, if the mechanism is a benefit in the job marketplace for being tall (Persico et al. 2004), we would expect this to be more applicable to men than to women.

[16] Disparity between life expectancy of Asian-American men and urban African-American men is c. 16 years, about the difference between the life expectancy in Iceland and Bangladesh (Muray et al. 2005).

[17] Genetic aspects are not likely to be the primary factor in the American-European height differences, as non-Hispanic white Americans are essentially of European descent and moreover, Americans have been taller than Europeans until the mid-20th century.

[18] This is particularly the case insofar as this early part of the sample also includes those individuals who were born outside of the United States.

[19] That the absolute levels of the results differ is probably due to the upward bias on height of both self-reporting and the registered voter sub-population.

[20] They also did not select those born in the United States and do not examine the effects of income or education.

[21] Not all of these countries are depicted in Figure 3.

[22] Genetic aspects are not likely to be the primary factor in the American-European height differences, as non-Hispanic white Americans are essentially of European descent. In addition, childhood obesity might be an independent factor that leads to shorter final attained adult heights (Sandhu et al., 2006). This result needs to be considered tentative as they do not control for social status and because He and Karlberg do not find any such association (2001).

[23] That there is till hunger in the land of plenty is indicated by the fact that 25 million people receive emergency food rations per annum. (O'Brien and Torres 2006). http://www.mathematica-mpr.com/publications/PDFs/finalhungerexecsumm.pdf

[24] (http://www.census.gov/hhes/hlthins/historic/hihistt1.html) Accessed November 4, 2002.

[25] "…the United States is an outlier for financial burdens on patients and patients forgoing care because of costs. Half of sicker adults in the United States said that they did not see a doctor when sick, did not get recommended treatment, or did not fill a prescription because of cost" (Schoen, 2005).

[26] (Accessed November 5, 2002) http://workforcesecurity.doleta.gov/unemploy/content/chartbook/images/chta11.gif).

[27] We obtained similar results after eliminating those who do not speak English at home in NHANES III, where this distinction is available.

[28] In addition, the height of army personnel also failed to show any increases after c. 1960 even after controlling for foreign-born parents (Komlos 2006).