NBER WORKING PAPER SERIES

THE TALL AND THE SHORT OF THE RETURNS TO HEIGHT

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Working Paper 26325
http://www.nber.org/papers/w26325

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
September 2019

We thank Matthew Schwartzman for excellent research assistance, and Jonathan Beauchamp, Dwayne Benjamin and Gary Solon for helpful discussions. Workshop participants at Buffalo, McGill and the 2019 SOLE meetings and NBER Summer Institute provided helpful comments. Baker gratefully acknowledges the research support of a Canada Research Chair at the University of Toronto. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

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NBER Working Paper No. 26325
September 2019, Revised May 2020
JEL No. I3,J24

ABSTRACT

We present evidence of height profiles which are common to socioeconomic outcomes ranging from childhood cognitive scores to adult poverty in the US. For males there is little to no variation with height above the mean, but substantive variation below. For females there is also greater variation below mean height, but also in the upper 10 percent of heights. Birthweight and parental height have independent, mediating impacts on the variation of age 7 cognitive scores with adult height. However, the majority of the significant variation of male scores at heights below the mean remains a topic for future research.

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1. Introduction

Variation in social, health and economic outcomes by adult height is studied in the humanities, medicine, public health and the social sciences. This research reports that taller people have advantages ranging from higher wages and educational achievement through higher overall life satisfaction, but face higher probabilities of certain morbidities (e.g., Deaton and Arora 2009). A focus of economic research on this topic is how variation in cognitive (e.g., Case and Paxson 2008) and non cognitive (e.g., Persico et al. 2004) skills with height can explain corresponding variation in wages. These skills are viewed as markers, or the result, of the underlying determinants of a reward to height. The determinants include the social license or dominance that taller people enjoy which enhances the development of these skills, or the different endowments of taller people which interact with the environment to similar effect. Of course, another explanation is discrimination, but given evidence that measures of social and cognitive skills can account for correlations of wages with height, it has received less attention.

In this paper we present evidence from US and UK data that a common profile characterizes the association between height and many determinants (completed education, teenage and early childhood cognitive scores, occupational skills) and correlates (poverty and self-reported health) of earnings. For males this profile is highly non-linear and asymmetrical around mean height. At heights above the mean there is little to no variation in these outcomes with stature. At heights below mean height the variation is substantive. For females the profile is more moderately non linear through mean height. There is also an importance difference from the male profile: at the upper 10 percent of heights the (positive) variation of some of these outcomes with stature rivals the variation below mean height.

While there is some previous evidence (reviewed below) that the variation of earnings or wages with height is non linear, to our knowledge the evidence that a common, non linear profile characterizes the association of height with so many related outcomes is new. In fact, some might argue that our findings are expected given evidence of a non linear height/earnings relationship, but the previous evidence (reviewed below) is mixed.

These results are primarily empirical but they point to a potentially important and neglected source of inequality in the US. We show that for a number of socioeconomic outcomes the differences experienced by the bottom 10-15 percent of heights rivals the differences across markers of inequality based on race/ethnicity.

We next evaluate the contributions of cognitive and non cognitive skills to the variation of labor market wages/earnings with height in the US and the UK, when specifying a non linear wage/height profile. The majority of previous evaluations of these factors have been made specifying a linear wage/height profile. The more recent (e.g., Lundborg et al. 2014, Schick and Steckel 2015) argue their contributions are roughly equal. More importantly, in those cases where a non linear wage/height profile has been specified, the corresponding height profiles in cognitive and non cognitive skills are clearly linear. For males, evidence that measures of childhood and teenage cognitive skills exhibit the common non linear adult height profile, while measures of non cognitive skills do not, underpins the findings of this analysis. Specifying a non linear height profile in wages reveals that these cognitive skills account for substantively more of the variation of wages with height than non cognitive skills. For females there are more symmetric contributions of the cognitive and non cognitive, consistent with previous research.

We conclude with some exploratory analysis of the antecedents of these non linear height profiles. Its pervasiveness suggests a common source. We present some initial evidence that low birthweight births vary non linearly through mothers' mean height. Given assortative mating on height, this presents the possibility that the incidence of low birth weight is disproportionately among the shorter statured. However, we also present evidence that measures of family background (parental education) and birth outcomes (birthweight) do not account for the substantial variation of childhood cognitive scores with adult height below the mean. Adding parental height to the analysis, we find that its explanatory account spans that of parental education. However, it again has limited traction accounting for the variation in childhood scores below average height. As a result, markers of the variation in childhood cognitive scores below adult mean height, especially for males, remain an important topic for future research.

In the next section we review previous studies that offer evidence of non linearities in the height profiles of labor market earnings and in other outcomes. Section 3 provides a description of the data and our empirical framework. In sections 4 and 5, we document the pervasiveness of a common non linear height profile in socioeconomic outcomes. In Section 6 we show how the variation in these outcomes below mean height compares to their variation by race/ethnicity. In Section 7 we investigate how measures of cognitive and non cognitive skills can account for variation of wages with height. Section 8 contains an analysis of how the adult height profile in childhood cognitive scores is associated with family background variables, birth outcomes and parental height. Section 9 contains discussion and conclusions.

2. Previous Evidence of Non Linear Height Profiles

Earnings/Wages

Many previous studies of labor market wages or earnings adopt a linear specification of the height profile. In cases where non linear profiles have been specified, they are often of a fairly parametric form. Heineck (2009a) provides evidence of a quadratic relationship between wages and height in the British Household Panel Survey. Less parametric specifications (e.g., quintile dummy variables) are suggestive but the estimates are mostly statistically insignificant. Schick and Steckel (2015) also present evidence of a non linear height profile for male earnings using data from the British National Child Development Survey (NCDS). They identify the flattening in the male height profile at 72" of height, from a specification that divides males' heights into 5 intervals. Hubler (2009) investigates polynomial and spline specifications of the height profile of German wages. He concludes that the height effect is largest for relatively tall men (75").[1]

Our preferred specification of the height profile is as single inch dummy variables. We are aware of two studies that have adopted comparable profiles in studies of earnings. Lundborg et al. (2014) specify centimetre fixed effects and show that in Sweden, conditional on age, the earnings[2]/height profile for males is "slightly concave", but also that, "most of the action occurs at the lower part of the height distribution" (p. 159). Refining the inference using a piecewise linear specification they conclude that the variation of earnings per 10 cm (3.94 inches) of height is 7.9 percent just below mean height and 4.1 percent just above, and by 188 centimeters (just over 74 inches) the association is positive but small and statistically insignificant.

Closest to the evidence we present, in terms of the specific shape of the height profile, is Kim and Han (2017). They show (figure 1) that the unadjusted relationship between height and monthly wages of Korean males plateaus at the mean height in their sample. This finding is of particular interest here because the average height of Korean males, the point of the start of the plateau, at 67", is considerably less than of the American males we analyze (70"). They

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[1] Sohn (2015) makes a similar finding for Indonesian males using a polynomial specification.

[2] The measure of earnings includes earnings from work, self-employment income and social insurance benefits.

parameterize the height profile in 5 centimetre (roughly 2 inch) intervals and conclude that conditioning on a variety of demographic and economic characteristics, the estimates for males indicate that the increase of earnings with height exhibits "…leveling-off at approximately the average height" (p. 16).[3]

Other Outcomes

To be clear, our primary focus is not actual labor market earnings or wages. It is instead the determinants of earnings and other measures of socioeconomic status which are related to earnings. To our knowledge, there is little evidence that the height profiles in these outcomes are non linear. If the evidence reviewed above is considered definitive, that the association of height with wages is non linear, then it is directly of interest to discover if well studied determinants of earnings exhibit a similar non linearity, and perhaps surprising if they don't. Furthermore, outcomes such as completed education are more permanent markers of economic status than cross sectional measures of income. Also, they are available for the entire population rather than just those who work. This is potentially important if employment varies systematically with height.

Most of the previous evidence of the association between height and these other outcomes reveals a linear relationship, although in many cases this is by specification.[4] For example, Case and Paxson (2008) estimate the relationship between childhood cognitive scores and childhood height using American and British data, and Schick and Steckel (2015) estimate the relationship between childhood and teenage cognitive and non cognitive measures and height

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[3] The non parametric estimates of the wage/height profile for males in figure 2 of Case and Paxson (2008) also suggest some flattening out of the weekly earnings/height profile for males above mean height, but they conclude that the earnings height "…association is not driven by lower earnings of unusually short people, but instead is observed throughout the range of heights." (p. 500).

[4] Komlos (1987 and 1990) presents historical evidence of a positive relationship between height and occupation or social class.

using British data, both specifying a linear profile. Lundborg et al. (2014) present the raw associations of height with age 18 measures of cognitive skills, non cognitive skills and handgrip strength among Swedish males. Each of the relationships are roughly linear, with a positive slope (p. 153).

An exception to this conclusion is Heineck (2009b). He examines the relationship between height and two cognitive test scores administered at age 16 or later in Germany. Quadratic and quintile specifications of the height profile for males indicate concave relationships between height and these cognitive measures, with maximums at about 179 centimetres (just over 5 feet 10 inches). The profiles for females are not as simply summarized although those in the lowest height profile score less than their mid quintile counterparts.[5]

3. Data and Empirical Framework

To examine various socioeconomic outcomes by height we use data from the National Health Interview Survey (NHIS). This is a national, representative survey of the American population with a primary focus on health outcomes. For our purposes it captures self reported height; highest level of education; race/ethnicity; in some years 3-digit occupation; self reported health; and the poverty status of the household. Much of our evidence is based on the 1990-1994 NHIS. These are survey years that offer detailed occupational coding and match well with the 1991 edition of the Dictionary of Occupational Titles and 1990 census, which we use in some of the occupational analysis. It is also a period in which the response rate to the NHIS averaged near 95 percent (Lucas et al. 2006, Moriarity and Dahlhamer 2012). We also obtain evidence from other years of this survey; for example, the 2010-2013 surveys to examine stability in the height profiles over time. However, it is important to note that response rates in the NHIS have

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[5] Evidence for other countries is available in Vogl (2014) (Mexico) and Lafave and Thomas (2017) (Indonesia).

fallen over time, dropping by more than 10 percentage points between the mid 1990s and 2010 (Czajka and Beyler 2016). Except where noted, we select samples of adults aged 25-59. This is to be more certain that formal human capital investments are complete and adult height has been obtained, and to avoid sample selection problems in some of the outcomes due to retirement.

The NHIS surveys record self reported height. Doctor or interviewer recorded height would be preferable because validation studies have revealed error in the self reports of this variable. As explained below we also examine data from the National Health and Nutrition Examination Survey (NHANES) to discover if the self report of heights in the NHIS is materially affecting our results.

We also use data from the 1979 National Longitudinal Survey of Youth (NLSY79) to investigate the contributions of cognitive and non cognitive skills to the non linear profiles of economic outcomes in stature. The NLSY79 first surveyed a sample of 14-21 year olds in 1979, with follow-ups annually until 1994 and every two years thereafter. Each wave asks questions about completed education and earnings. Because there is sample attrition over time, we use a relatively early wave – 1990 – for our analysis. This is the earliest year in which all respondents are at least 25 years of age, which helps ensure that we are measuring completed education. To maximize sample size, we follow Lang and Manove (2011) and use a 3 year average of earnings from 1989, 1990 and 1991 to calculate wages. This procedure allows us to include individuals who do not report earnings in 1990. Self-reported height is available in the 1981, 1982 and 1985 waves, and every survey year from 2006-2014. We use the 1985 wave because it is the year closest to the time when our earnings and education variables are measured. The NLSY79 also contains each respondent's Armed Forces Qualification Test (AFQT) score (recorded in 1981), as well as a wide variety of personality and attitudinal measures.

We also use the NCDS. The NCDS has been a workhorse of research on the wage returns to height. It has followed almost an entire cohort of children born in a particular week in 1958 from birth to adulthood. While its sample sizes are quite small, and it is for a different country, the NCDS offers cognitive testing at much younger ages than the NLSY79 and direct observations on both adult height and some birth outcomes.

Finally, we use the US public use Natality Files to examine the relationship between poor birth outcomes and mother's height. Starting with the 2003 revision, US birth certificate data records mother's height. We use the data from 2011, the first year the height variable appears in the codebook, and also a year that is both proximate to the time of our other surveys and has the information on mother's height for the majority of births.[6]

Our parametrization of the height profile, where sample sizes allow, is at the same level of detail as the responses in the surveys. Specifically, we regress, by sex, various outcomes on single inch height dummy variables and a minimal set of controls.

$$ED_i = \alpha + H\gamma + X\beta + \varepsilon_i \quad (1)$$

where, for example, ED_i is a measure of completed education, H is a vector of (single inch) height dummy variables (the dummy for mean height is excluded), and X includes age (single year), region, race/ethnicity (African American, Hispanic, "other"), foreign birth and indicators for survey year (where necessary).

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[6] The height variable first appears in the NBER sourced public use birth certificate data in 2009, but does not appear in the codebook. We use the 2011 data as this is the first year the variable is officially recorded in the codebook, and the rate of non response/missing data is smaller than in the previous years. In 2011, data on mother's height is not available for Alabama, Alaska, Arizona Arkansas, Connecticut, Hawaii, Maine, Massachusetts, Minnesota, Mississippi, New Jersey, Rhode Island, Virginia and West Virginia. Non response is relatively high in Washington DC (11.5%) and Georgia (17.9%). Height is observable for just under 84% of births in our selected sample (see below).

For the analyses of surveys with smaller samples, and also as a means of summary, we also estimate a regression with a linear specification of the height profile allowing a slope break at heights below the mean.

(2) $$ED_i = \theta + \pi H_i + \rho SH_i + \varphi H_i \cdot SH_i + X\tau + \omega_i$$

where SH_i is a dummy variable for individuals with heights below mean height. For this specification we rescale the height variable to have zero mean to facilitate the interpretation of the *SH* dummy variable as capturing any discontinuity in the height profile at mean height.

4. The Height Profile in Completed Education and Occupational Choice

In table 1 we report summary statistics, by sex, for the self reported heights reported in the NHIS data. Average height is 70" for males and 64" for females. For males, the interquartile and 90/10 percentile ranges are +/- 2 and 4 inches from the mean. For females there is a similar progression above mean height, but the 25th and 10th percentiles are one and three inches below mean height, respectively.

We begin the analysis with, perhaps, the most studied determinant of labor market earnings—formal education. In figure 1 we graph the height profile (estimates of γ), with 95 percent confidence intervals,[7] for years of completed education in the 1990-94 NHIS. We specify a full set of height dummy variables in the estimation, but report estimates for the height ranges 63" though 76" for males and 59" though 70" for females in the figures.[8] In both cases this omits about 4 percent of the distribution of heights. Note that the markers for 70" (males)

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[7] We estimate robust standard errors.

[8] While the 1990-94 NHIS include all heights reported, the 2010-13 NHIS only reports height between 63" and 76" for males and 59" and 70" for females. Furthermore, other heights are not observed if the individual reported a weight that was outside bottom coding and top coding for this variable. Adding controls for weight (single pound) does not substantively change the height profiles of completed education.

and 64” (females) are located at 0 and have no confidence interval indicating the omitted category.

The results for males in the first panel exhibit three distinct features. First, there is little statistically or economically significant variation in completed education at heights above the mean. Second, and in contrast, the variation below mean height is both statistically and economically significant. At one inch below the mean it is almost one half a year, and at the 10th percentile of height (66”) it is over one year. Third, there is a remarkable asymmetry directly around mean height—the difference in completed education is much greater one inch below the mean than one inch above.

Hispanics are shorter on average than many other groups in the US population and also have lower average educational attainment. We allow the height profiles to vary by an intercept shift for ethnicity, but it is possible that our estimates simply capture the unequal distribution of the different ethnic groups across the height profile. To see if this is true we also report the height profile omitting African Americans and Hispanics from the sample. The results, also reported in figure 1, show that while the educational deficits at shorter heights are smaller making this omission, the substantial and significant non linearity at mean height remains.

There are also cohort effects in height so the variation in education by height in figure 1 might simply reflect the fact that older cohorts are shorter and have less education on average. In fact, the variation in average height by age across our 25 to 59 year old sample is only 0.59 inches. Also, estimates of separate height profiles (not reported) for the 25-40 and 41-59 age intervals display similar patterns, as do the height profiles from the 2010-13 NHIS (see appendix A).

Finally, another possible confounding factor is weight. However, the height profile estimated conditional on single pound weight dummy variables (not reported) is again very similar to the one reported in figure 1.

Because it is not obvious how differences in completed years of education map into degrees and diplomas, we have also estimated these profiles for significant milestones of educational attainment (not reported).[9] Each displays similar non linearity. For example, at a height just one inch below the mean, the "no high school diploma" rate is almost one-third higher than at average height, which was 11 percent (or 10 percent for non-Hispanic whites) in 1990-94 (see also figure B2 in appendix B). At two inches below mean height, the 4 year college degree or higher rate is more than 18 percent lower than at mean height, while at two inches above mean height it is roughly the same.

In the second panel of figure 1 is the profile for females. Here many of the educational differences by height are smaller than for males, but there is still significant variation below, and asymmetry around, mean height.[10] What is new here is the positive variation in completed education within the upper 10 percent heights. Excluding African Americans and Hispanics from the sample again makes little difference to this inference. In profiles not shown, the estimates for no high school diploma at heights 61" through 63" are more than twice, in absolute value, the estimates at heights 65" through 67". At 3 inches below mean height college attainment is lower by almost 5 percentage points or 22 percent, while at 3 inches above the mean it is just over 1 percentage point higher.

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[9] These results are available on request. The profiles for not completing a high school diploma from the 2010-13 NHIS are reported in appendix B.

[10] For females, conditioning on weight the differences by height are marginally larger and the profile retains the same shape as in figure 1.

As noted, the NHIS height variable is self reported. In appendix B we briefly summarize some previous studies of error in self reported height. We also compare the height profiles for the no high school diploma outcome[11] from the NHIS and NHANES, and within the NHANES by self reported height and examination recorded height. As noted there, we observe that the non linearities documented in the NHIS data are also present in both the self reported and exam recorded height profiles in the NHANES. While there is no doubt some error in the self report of height, it does not appear to affect our inference of substantial non linearities in the height profiles of educational attainment at mean height.[12]

Previous research indicates that occupational choice is a primary intermediary between cognitive or non cognitive skills and labor market outcomes. Case et al. (2009) demonstrate that in a wage regression the estimated coefficient on height is significantly attenuated when additional controls for educational attainment and occupational fixed effects are added as control variables. Likewise, Lundborg et al. (2014) demonstrate that occupational fixed effects attenuate the association between height and earnings at shorter heights, indicating that very short people sort into lower paying occupations.

We next demonstrate that this sorting of individuals into lower or higher paying occupations by height in the US exhibits a very similar height profile to the association of height with completed education. We also show that underlying this result is sorting on measures of occupational skills by height which again exhibits a very similar height profile.

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[11] Years of completed education are not available in the public use NHANES.

[12] Persico et al. (2004) come to a similar conclusion for their inference comparing self reported and exam recorded heights in the NCDS.

To investigate occupational earnings, we take advantage of the fact that the 1990-94 NHIS provides information on respondents' detailed (3 digit) occupation.[13] We calculate average annual earnings at this occupational level by sex, using a similarly selected sample from the 1990 US census. We next assign these averages to NHIS respondents based on their reported occupations. We then estimate equation (1) using the log of these averages as the dependent variable.

The results are reported in figure 2.[14] For males we observe a sharply non linear profile, which is very similar to the profile for completed education (figure 1). There is effectively no advantage in this component of earnings for individuals with heights above the mean. For heights below the mean the deficit is substantial—an earnings deficit of 10 percent or more for the bottom 20 percent of heights. For females the orders of magnitude are smaller, but the profile exhibits the greater variation below mean height, the asymmetry around the mean, and the variation in the upper 10 percent of heights, as seen in figure 1. Visually roughly half of the earnings deficits below mean height for males can be accounted for by the corresponding non linearities in the educational investments.[15] For females, education accounts for part of the variation below the mean height, and most of the variation in the upper ten percentiles.

We next rank occupations by their skill level. To do this we merge Dictionary of Occupational Title (DOT) data (1991 edition) to our 1990-94 sample. We construct the different routine and non routine task constructs as proposed by Autor et al. (2003). We then standardize each task to have 0 mean and unit standard deviation and then assign the task content of NHIS

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[13] The 1990-1994 NHIS contains a detailed occupation variable with coding that corresponds to the 1990 Census occupational classification.

[14] Excluding African Americans and Hispanics from the sample does not substantially change the inference (estimates not shown). We cluster the standard errors by occupation.

[15] The control is years of completed education.

respondents' employment based on their reported 3-digit occupation. These estimates of occupational task content then serve as a dependent variable in (1).[16]

By these definitions, Autor and Price (2013) show that non routine analytical and interpersonal skills are in the ascendency in the American labor market over the past four to five decades, while manual and routine cognitive skills are in the decline. In figure 3 we report the results for Non Routine Interpersonal skills and Routine Cognitive skills, the skills that saw the largest increase or decline over the period 1960 through 2010. For males, there is significant non linear variation around mean height. There is effectively no variation in these skills for the majority of males of mean height or taller. However, at a height of two inches below the mean (the 25th percentile) the content of Non Routine Interpersonal skill is 10 percent of a standard deviation lower, and the content of Routine Cognitive skill just over 5 percent of a standard deviation higher, than at mean height. The estimates for those in the bottom quartile of height are substantially larger with the deficit in Non Routine Interpersonal skills ranging from over 20 percent to over 40 percent of a standard deviation. For females the differences are smaller than for males. However, the estimated height profile shows the same features as for the previous outcomes, including greater variation below mean height, asymmetry around the mean, and for non routine interpersonal skills, variation over the top 10 percent of heights.

One might argue that taller people have an advantage in interpersonal skills so the profiles in figure 3 are to be expected. However, the profile for Non Routine Analytic skill for males (not reported), the other task in ascendancy over the period, is similar to that for Non

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[16] Excluding African Americans and Hispanics from the sample produce does not substantially change the inference (estimates not shown).

Routine Interpersonal, but it spans a larger interval (for males over 30 percent of a standard deviation) at shorter heights.[17]

5. The Height Profile in Poverty and Self Reported Health

The stylized facts of the association of socioeconomic status and height are typically based on inference from a linear specification of the height profile in earnings. For example, that the estimated returns for hourly earnings range from one to more than two and half percent per inch. This implies that earnings variation over the interquartile range of male height (4 inches) is equivalent to just under one to up to two years of schooling (e.g., Schick and Steckel 2015). The implications of a non linear height profile are not so often, or easily, summarised. For example, in Lundberg et al (2014) the earnings return to 10 cm (roughly 4 inches) of height just below mean height for Swedish males is just over 7 percent, while just above mean height it is over 4 percent.

The preceding evidence for completed education and occupational choice suggest that the inference for alternative markers of socioeconomic wellbeing for the full population in the U.S. might be different. For males we might anticipate little to no return to height above mean height, while for females we might anticipate asymmetry in returns around mean height and positive returns at very tall heights. We examine two markers of socioeconomic wellbeing—measured poverty and self reported health—to check this inference.

The height profiles for a measure of household poverty are reported in figure 4.[18] For males the profile mirrors the profiles in completed education and occupational choice. The

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[17] The height profile for routine manual skills is flatter for both sexes.

[18] The measure of poverty is based family size, number of children under 18 years of age and family income using poverty levels derived from the Current Population Survey from the same year. Producing poverty rates from the NHIS comparable to those from other sources is not straightforward (Czajka and Denmead 2008). Here we simply code persons as in poverty as per the survey supplied indicator that the individual's household income is below the poverty line

poverty rate at average height is 5 percent, as it is at most taller heights. At lower heights it rises in excess of 6 percentage points. For females we see the greater variation at heights below the mean, but not so prominently the variation at the very tallest heights. The poverty rate at average height for females is 8 percent.

Because stature is sometimes interpreted as a proxy for physical nutrition and development, the self reported measure of overall health from the NHIS is also of interest. However, this outcome may also capture some part of labor market outcomes. The literature on self reported health teaches that justification bias raises the possibility that causality runs from poorer labour market outcomes through to poorer reported health outcomes.

The height profiles are reported in figure 5 for a 0/1 indicator that the respondent reports either excellent or very good health. The height profile for males displays what are now expected features. Taller individuals report little advantage relative to those at average height, while shorter males are significantly less likely to report better health. The height profile for females shows greater resemblance to the male profile for this outcome. It lacks a strong positive association between height and health at the tallest heights. In figure A2 of appendix A we report the corresponding profiles for self reported health from the 2010-13 NHIS.

6. How Significant is the Variation in Socioeconomic Outcomes Below Mean Height?

The preceding evidence is that a variety of permanent and more transitory measures of economic status within the American population vary with height according to a common, gender specific, non linear profile. Is the resulting variation in status by height economically significant?

The evidence here is that for many outcomes the variation with height is mostly, if not exclusively (i.e., males), below mean height. To provide context for the variation in these outcomes below mean height we compare it corresponding inequality by race/ethnicity. To do this we re-specify the controls for height in our regression equation to be dummy variables for (approximately) the bottom decile, the 10th through the 30th percentiles, and the 30th through 50th percentiles of the height distribution. In table 2 we report estimates of the dummy variables for the shortest two height categories as well as for dummy variables for African Americans and Hispanics from the same regression.

For both females and males, height in the bottom 12-13 percent of the distribution is a marker of lower educational outcomes that is persistent over time and economically significant in its magnitude. It is comparable in magnitude to the outcomes for African Americans. Height in the next roughly 20 percentiles is again a persistent indicator of lower educational attainment, but the estimates are roughly half of those for the bottom decile.

The estimates for the employment rate for the bottom decile for males sit amidst the estimates for African Americans and Hispanics, while for the shortest females the inference is more period specific. For excellent or very good health, among males the estimate for the shortest 12 percent of height is similar to those for African Americans and Hispanics, while for females it is negative but about half as large.

7. Can the Non Linear Profile Help Distinguish the Antecedents of the Correlation Between Height and Socioeconomic Outcomes?

We next investigate whether the inference of a distinct, common, non linear height profile in many determinants of earnings can provide additional leverage to distinguish among competing accounts of why height matters to this outcome. Previous research has mostly approached this question within the context of a linear specification of the height/earnings gradient. For example, Schick and Steckel (2015) report that in British data cognitive skills and non cognitive skills account for roughly equal proportions of the height/earnings premium for both males and females. For Swedish males, Lundborg et al. (2014) report that family background factors, cognitive skills and non cognitive skills account for roughly one-third, 20 percent and almost 10 percent of the raw height/earnings relationship, respectively.[19] Handgrip strength accounts for a further 11 percent. Almost half the remaining 25 percent is soaked up by occupation fixed effects, a result the authors attribute to very short males (less than 170 centimeters or almost 67 inches) ending up in low paying occupations. They also extend the analysis to a piecewise linear specification with 5 intervals. While harder to summarize, the relative contributions of the various controls appear to roughly hold within each interval except for the tallest (189 centimeters or 74 inches or taller). Also, conditional on the family, cognitive, non cognitive and hand strength factors, earnings vary with height only below the mean. Against this background our investigation is informed by a particular, common, non linear profile in important determinants of earnings, especially for males. In contrast, the relationship between height and cognitive or non cognitive skills appears to be linear in Sweden.

We start with data from the NLSY79. The NLSY79 offers information on log hourly wages, but also on some of the outcomes in the NHIS such as completed education.[20] To calibrate this analysis to the results from the NHIS, in table 3 we present estimates of (2) for completed education and for log hourly wages.[21] For both males and females, the results for completed education indicate a sharply steeper height profile below mean height, and a much lower return in the main linear profile.[22] Log wages for males display greater variation with

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[19] Because Lundberg et al. (2014) enter these controls variables in a particular order—family background, cognitive and then non cognitive—it is not possible to infer whether, as in Schick and Steckel (2015), part of the accounts of cognitive and non cognitive skills span each other.

[20] To maximize sample size, we focus on education reports in 1990, when the respondents would have been 25-32 years old; the results are similar if we use the responses from 2014.

[21] Here the base controls are age (single year), region, and race (black and Hispanic indicators.)

[22] We have graphed the single inch height profiles in completed education in the NLSY79. The results echo the patterns observed in the NHIS. The profile for males is clearly non linear at the mean, although the differences at

height below mean height, but females' wages do not. For females the main effect of height is through the linear term, and the statistically insignificant estimate of the interaction term indicates a less steep slope below the mean. Finally, most of the estimates for the *SH* dummy are small and all are statistically insignificant. The additional results in table 3 show that these inferences are robust to restricting the sample to non Hispanic whites.

The primary measure of cognitive skill in the NLSY79 is the AFQT. As measures of non cognitive skills we follow research that has used the NLSY79 (i.e., Persico et al. 2004). These are variables capturing participation in social activities during high school and the Rosenberg index of self-esteem.[23] To preview our inference, in figures 6 and 7 we plot estimates of the single inch height profiles from (1) for AFQT and high school social participation, respectively. The male height profile for AFQT percentiles (figure 6) strongly echoes the height profiles for the outcomes in the NHIS. It is sharply non linear, asymmetric around the mean and there is little to no return to height above the mean. Individuals in the bottom decile of heights score almost 30 percentiles lower than men of mean height. For women the height profile of AFQT scores displays less distinct variation below the mean and in the upper 10 percent of heights than was evident in the NHIS.

In figure 7 are the height profiles for high school social activities. The profile for males is different than the profiles for the other outcomes. There is no sharp break at mean height, and

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shorter heights are smaller and the decline more gradually than in the NHIS. Each inch of height below the mean adds about 0.2 years of education, but there is little association between education and height above the mean. For females the non linearity is more modest, but again the decline at shorter heights is smaller than in the NHIS. Moving from being very short to average height is associated with about a 0.7 year increase in educational attainment, which is very similar to the change when moving from average height to being very tall.

[23] Social participation, "activities", is measured as the number of organizations or other extra-curricular activities the respondent participated in in high school. Self-esteem is measured using the Rosenberg self-esteem scale, which is a measure that runs from 0 to 40 with higher values indicating higher self-esteem. Self-esteem was measured in 1987, when the respondents were 22-29 years old.

no monotonic decline in activity in the lower percentiles. In contrast for females there is systematically lower activity at the shorter heights.[24]

Estimates of (2) for each of the measures of cognitive and non cognitive skills are presented in table 4 to summarize this inference. For males it is the estimates for the Rosenberg measure of self esteem and AFQT that indicate a steeper slope below mean height. For high school social activities, the main correlation with height is through the linear term. For females the estimate for the linear term is statistically significant for each measure. While there is also some evidence of a steeper slope below mean height, it is only consistently statistically significant across samples for high school social activities.

We next investigate how these measures of cognitive and non cognitive skills mediate the correlation between wages and height. In the first panel of table 5 we regress males' log wages on various specifications of the height profile, alternatively adding controls for cognitive (AFQT) skills, non-cognitive (social participation and self esteem) skills and their combination.

In the first row we specify a linear height profile. On their own cognitive and non cognitive skills account for 35 percent and 22 percent of the correlation of height with wages. Together the account is almost 39 percent. The relatively equal contributions here are roughly comparable to the inference in Schick and Steckel (2015).

In the next two rows, we report the estimates when we instead specify the height profile according to (2). Here cognitive skills can account for over half the greater slope of wages in

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[24] We have also examined an array of other measures of non cognitive skills that were collected at older ages (in 2014). These include: two personality traits related to emotional stability (calm/emotionally stable and anxious/easily upset), two traits related to responsibility (dependable/self-disciplined and disorganized/careless), and four traits related to social skills (extraverted/enthusiastic, sympathetic/warm, reserved/quiet, and critical/quarrelsome.). Each is measured using participants' self-assessed ratings of pairs of personality traits on a scale of 1 to 7. The majority of the height profile estimates from (2) for these traits are economically and statistically insignificant.

height below mean height, but little of the main linear profile. Non cognitive skills have greater traction for the main linear profile, but a relatively diminished role—roughly 25 percent—for the variation below mean height. Also, conditional on cognitive skills, non cognitive skills make little contribution for the variation below the mean.

The corresponding results for females are in the bottom panel of table 5. Here cognitive skills play the larger role when the height profile is linear. Specifying a non linear profile does not significantly change this inference as the interaction terms are all statistically insignificant and of reasonably similar magnitude across the columns. Recall that the height profile in female wages does not exhibit a significant break at mean height (table 3).

Therefore, when we specify a non linear wage/height profile, for males cognitive skills play the larger relative role for the substantial variation of wages below mean height. Note also, that for males AFQT exhibits the same non linear profile in height (figure 6) as for other outcomes. The power of AFQT to account for differences in adult wages has precedence in other literatures and its interpretation is not straightforward (e.g., Neal and Johnson 1996, Lang and Manove 2011). Nominally a measure of skills, there has been much debate whether the skills captured are innate or acquired, and if the latter how they are affected by environment.

In appendix C we investigate the impact of environmental factors on the relationship between height and AFQT to help sharpen its interpretation.[25] There we show that neither controlling for family income or measures or school quality significantly changes the non linear relationship between this measure of skills and height for males.

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[25] Because each of these investigations involves restricting the sample, we present estimates including observations for African Americans and Hispanics to maintain sample sizes. The estimates (available on request) excluding these observations are qualitatively similar but less precise.

Perhaps the more telling criticism, however, is that many of the NLSY79 respondents competed the AFQT close to, or after, completing their education, and so the test might be viewed as an alternative measure of completed education rather than of prior cognitive skills.[26] In this case the results in tables AFQT are simply revealing the "completed education" is related to wages. To address this point, we next use data from the NCDS which offers cognitive and non cognitive scores from much earlier ages. As noted above, data from this British data set has figured prominently in past research on the relationship between height and wages.

Estimates of the relationship between log wages and measures of cognitive and non cognitive skills from the NCDS, corresponding to the NLY79 results, are reported in table 6. The wage measure is from age 33,[27] while we use standardized math and reading scores from age 7 to measure cognitive skills,[28] and a standardized teacher reported index of behavior, the Bristol Social Adjustment Guide,[29] also for this age as a measure of non cognitive skills.

The results for males, in the first two rows of the top panel, support the inference from the NLSY79, with the exception that the measure of non cognitive skills has less leverage. To investigate whether the measure of non cognitive skills is from too young an age, in the next row we substitute age 16, teacher reported variables capturing the child's impulsiveness, temper, aggression, rigidity, withdrawal and industriousness, on a five point scale. This substitution

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[26] See, for example, Lang and Manove, (2011) for a discussion of this issue.

[27] We restrict the sample to "Euro-Caucasians" who are paid employees, and also, following the literature (Persico et al 2003, Schick and Steckel 2015), to full time workers. For males this latter restriction makes little difference as few within this ethnic group work part time. For females the qualitative story remains the same but the main linear term is larger in the specification following (2).

[28] The tests are the Southgate Reading Test and the Problem Arithmetic Test. See http://doc.ukdataservice.ac.uk/doc/5805/mrdoc/pdf/CognitiveAssessmentVariables.pdf accessed September 10, 2019.

[29] This Guide canvases children's behaviors, including withdrawal, depression, anxiety, hostility towards adults, restlessness, and nervousness. We use the survey provided total score for all "syndromes".

makes little difference to the inference.[30] It is important to note that these NCDS measures of behaviour are not irrelevant to the earnings outcomes. The estimates for these variables are precisely estimated and comparable in magnitude to the estimates for the math scores.

The results for females, reported in the second panel, again echo the inference from the NLSY79. Cognitive skills substantively attenuate the slope in the linear specification, although again the measures of non cognitive skills do not get much traction. In the non linear height specification, the main message is that, like in the NLSY79, this non linearity is not a significant component of the variation of females wages with height. Estimates for both the *SH* dummy variable and its interaction with height are small and statistically insignificant.

These results from the NCDS indicate that the age 7 measures of cognitive skills have a similar impact on the relationship between wages and height in the NCDS as AFQT has in the NLSY79. The adult height profiles of these math and reading scores from (1), reported in figure 8, suggest why this is true. For males we observe the familiar non linearity at mean height (69”), especially in reading scores. For females while the non linearity at mean height is attenuated relative to the evidence in previous figures, there is evidence of higher scores at the tallest heights. The estimates of (2) for each of these outcomes reported in table 7 confirms this inference.

To summarize, measures of teenage and childhood cognitive skills from US and British data display the distinctive non linear, gender specific, height profiles observed for a number of socioeconomic outcomes in the NHIS data. For males there is a sharp non linearity at mean

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[30] Each variable is specified as dummy variables capturing the five categories. We have also built up a standardized total behaviour score from teacher reports, at age 16, of 24 dimensions of the child’s behavior on a 3 point scale, obtaining similar results. We note that Schick and Steckel (2015) who also use the NCDS find that non cognitive skills play a larger role. They use a variety of social indicators available in the survey; teacher, parent and self reported. They also use measures from ages 11, 16, 23 and 33, leading to a much smaller sample size than the ones here.

height, with little to no return to height above the mean. Almost all the substantive variation is below mean height. For females the "trend break" at mean height is less pronounced and there is an increase in slope at the tallest heights. Taking these findings to the question of how cognitive and non cognitive skills mediate the relationship between height and wages in US and British data, we find an enhanced role for cognitive skills for males. We attribute this finding to the fact that childhood and teenage measures of cognitive skills exhibit the same distinctive non linear height profile we document for other socioeconomic outcomes.

8. What are Antecedents of the Non Linear Adult Height profile in Childhood Cognitive Scores?

The preceding evidence that the common, gender specific height profiles are also present in age 7 cognitive scores suggests their source may lie in early childhood and/or birth outcomes. In the final part of our investigation we provide some exploratory analysis of the antecedents of the height profiles in childhood cognitive scores.

There is now a large literature on the effects of birth outcomes such as low birth weight on adult outcomes. One reason to suspect these outcomes might vary with adult height is that recent research has identified a genetic link between fetal growth and postnatal growth (Horikoshi et al. 2013). Also, there is some evidence that outcomes such as low birth weight vary with mother's height. In a meta study Han et al. (2012) report that in unadjusted data, shorter women have a higher risk of both premature and low birth weight births, while taller women have a decreased risk. However, these relationships do not always hold controlling for possible confounders.[31] The hypothesized reasons shorter stature should be associated with these outcomes include (Zhang et al. 2015) that it a) imposes a physical constraint on the intrauterine

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[31] Notably many of the studies they survey are of births at selected hospitals or within specific ethnic groups rather than the nationally representative data we use in the following analysis.

environment, b) is a marker of the mother's lifetime social and nutritional condition and c) represents a genetic association between polymorphisms that influence both maternal height and pregnancy fetal outcomes. The strong heredity of height would provide a pathway from mother's stature and poor birth outcomes to children's realized height.

We provide direct evidence on the variation of selected birth outcomes by mother's height taking advantage of the addition of mother's height to US birth certificates in the 2003 revision. We focus on three birth outcomes that have been related to later life outcomes such as educational attainment (e.g., Oreopoulos et al. 2008, Figlio et al. 2014): birth weight, five minute APGAR and gestational age. We draw samples of singleton births for non Hispanic whites from the 2011 public use sample to abstract from the higher rates of certain birth outcomes among multiple births and in certain ethnic/racial populations.

In table 8 are estimates of the mothers' height profile from (2) for measures of low birth weight, very low birth weight, low five minute APGAR and premature birth, not conditioning on any other characteristics of births or mothers. For each outcome and both sexes, greater height is associated with better outcomes and the return to height is significantly greater at heights below the mean.

Estimates of the height profile from (1) for low birth weight, presented in Figure 9, indicate that the summary estimates in table 9 are not misrepresenting the data. The mean rate of low birth weight births at mean height (64") is 5.7 percent for female births and 4.8 percent for male births. Therefore, at the 25th percentile of maternal height (62") the rates of low birth weight are 25% (males) to 31% (females) higher than at mean height.[32]

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[32] A secondary question here is whether the height profile in, for example, low birth weight, reflects a "pure" effect of height or whether it is partly a result of correlated factors. Low birth weight and prematurity are related as the latter is cited to be a cause of the former. To investigate this possibility we have estimated the height profile for

Height is largely heritable—up to 80 percent of height is estimated to be attributable to inherited DNA sequences.[33] However, the higher rates of poor birth outcomes of mothers of lower heights needn't imply higher rates for below average height offspring, if the hereditary link is "undone" by how adults partner on height. That is, if shorter women tend to systematically mate with taller men, they wouldn't systematically have shorter offspring.

To provide evidence on the consequences of partnering by height for the heights of any offspring, we use data from the 1995/96 NHIS.[34] We match opposite sex married partners and compare their adult heights. We find a find that shorter (below mean height) individuals are more likely to match with each other, they are relatively less likely to match with average height individuals than above average height individuals, and they are relatively less likely to match with taller individuals.[35]

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low birth weight from (2) conditioning on the child's parity and gestational age at birth (gestational age is coded into 10 categories ranging from under 20 weeks to 42 weeks or older entered as dummy variables), the mother's age and education, and dummy variables indicating the mother smoked during pregnancy, was in receipt of Special Supplemental Nutrition Program for Women, Infants and Children (WIC) benefits (see Currie and Rajani (2015) and Sonchak (2016) on this factor) started prenatal care in the first trimester and was underweight as indicated by her pre pregnancy BMI (underweight is defined as BMI<18.5; while mother's weight is related to the incidence of low birth weight, past research identifies the slight stature as the primary risk factor). The unconditional estimates for the slightly smaller sample with non missing values of these control covariates (not reported) match well the estimates in table 8. The additional controls attenuate but do not eliminate the height profile in low birth weight, and the returns to height remain asymmetrical around the mean.

[33] See, for example, https://ghr.nlm.nih.gov/primer/traits/height (accessed July 24, 2018).

[34] We use these two years of data because matching partners within households is relatively straightforward in these years and they are in a period with relatively high response rates. We match opposite sex married adults by family type and household ID. With the 1997 redesign of the NHIS adult height is collected for only one sample adult in each surveyed family.

[35] We calculate the local log odds ratio of opposite sex married matches across various groupings of heights. If we define two height groups, *S* and *T*, then the local log odds is $\ln\frac{(n_{SS}*n_{TT})}{(n_{ST}*n_{TS})}$, where n_{ST} is the number of matches in the data between *S* height males and *T* height females. Roughly speaking, this measure is the ratio of the frequency of within group matches to across group matches. If matching was random the value of this log odds would be zero. More positive values indicate a preference for within group matches over across group matches. We divide males and females into three groups *S*, *M* and *T*, where M is 70" for males and 64" for females. The local log odds of SM matches are 0.39, of MT matches is 0.22 and of ST matches is 0.88.

We next simulate the heights of any children of these couples using Tanner's (target height) TH formula:[36] the predicted adult height of offspring is midparent (the average of parents') height plus 2.5 inches for males and minus 2.5 inches for females.[37] For each female height we then calculate the proportion of male partners of females of this height in the data who would produce a male or female offspring of below average height by this formula. These calculations indicate that 84% of the male offspring, and 63% of the female offspring, of women of stature 63" or less will attain below average adult height. Alternatively, 60% of the below average height male offspring and 72% of the below average height female offspring predicted in this way have mothers who are of below average height. Therefore, there is reason to expect that the higher rates of poor birth outcomes for shorter females are disproportionately associated with offspring of below average adult height.

Direct evidence on the relationship between low birth weight and adult height is available from the NCDS. Estimates of the height profile following (1) for males and females are presented in figure 10. For males we observe some non linearity below mean height, although it is confined to the lower 25 percent of the height distribution, and the confidence intervals are large. The rate of low birth weight at average height is 4%, so the differences at the shorter heights are substantive. For females the variation in the rate below mean height is a little larger than above mean height. The low birth weight rate at mean height here is 4.7%.

There is also a large literature on how family background variables mediate children's outcomes. For example, controlling for parental education might capture the financial resources

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[36] See, for example, van Dommelen et al. (2012).

[37] While this method of prediction has its limitations relative to methods that use more detailed measurements of the child at young ages, it has the advantage of feasibility given the (pre birth) data at hand. The mean predicted adult height of male offspring using this method is 70" and of female offspring is 64". However, the distribution of heights is more compressed then we observe in our NHIS samples. We round all fractional predictions downwards (e.g., 66.5" is coded as 66") to match the whole number recording of heights in our surveys.

a child has access to in childhood and/or the support and encouragement s/he receives to pursue education. The NCDS does not provide direct informational on parents' educational attainments, but information on the age at which each left full time education by single year ranging from aged 13 or less through age 23 or more. There is also information on parents' and grandfather's "social class".[38]

Either birth outcomes, such as birthweight, or parental background variables could capture some inherited endowment from parents to offspring, or latent background variables. Black et al. (2007), however, argue that for longer term outcomes, within twin estimates of the impact of low birth weight compare favourably to estimates from across families, suggesting birthweight has an effect independent of these confounders.

In table 9 we present estimates of (2) using the age 7 cognitive scores as the dependent variable and alternatively controlling for birthweight, parental education or both. We enter birthweight as a quadratic to allow a more nuanced effect than a dummy variable for low birth weight.[39] We specify parents' school leaving age as single age dummy variables.

In the first panel are the results for males. If we specify a linear height profile, then the variation of reading scores with height is lower by roughly a fifth controlling for either parental education or birthweight, and almost by half controlling for both. This would suggest that these

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[38] Making use of these variables, however, changes the sample in potentially significant ways. For example, the information on parents' education was collected in the age 16 wave, and in the (smaller) male sample which has valid observations on both the age the mother and father left full time education and age 33 wages, there is little evidence of a non linear relationship between height and wages. The sample is almost 700 observations smaller than the one used in the first two rows of table 7, and the estimates of the linear height term and the height interaction term are 0.013 (0.007) and 0.013 (0.020), respectively (standard errors in parentheses). This problem is attenuated somewhat in the following analysis as while respondents must have valid observations on age 33 height to be included in the analysis sample, we do not condition on valid observations of age 33 wages.

[39] Specifying a cubic in birthweight leads to very similar inference. The estimates using a dummy variable for low birth weight indicate a marginally smaller contribution of birthweight. The specification of birthweight as a polynomial is consistent with evidence in Oreopoulos et al. 2008 that the effects of lower birth weight are not discrete.

factors can account for a non trivial part of the cognitive score/height gradient. Furthermore, because the impacts are additive in combination, any omitted factors they proxy for do not appear to be common.

Specifying the height profile more appropriately as non linear (row 2) tempers this inference. The substantive and additive impact of these two factors remains for the main linear effect, but the linear term represents the minority of the variation of reading scores with height. Their impact on the variation of scores below mean height is again roughly additive but more modest. At best the variation of scores with height in this part of the distribution within the implied birthweight and parental education cells is 10 percent smaller than it is across the sample.

The results for the age 7 math scores in the next two rows tell a very similar story. When the height profile is specified non linearly, the leverage of birthweight and parental education for the main linear profile is again additive and comprehensive, but their leverage for the interaction term is limited.

The results for females are in the second panel. The results for the reading scores follow the inference for the male results, although for females the variation of scores with height through the main linear effect is relatively larger. For the math scores there is little evidence for a non linear height profile, and the inference from the two specifications is very similar

We have examined alternative specifications of the birth outcome and background variables. For males, controls for premature birth, fetal distress and pregnancy abnormality, as well as for the timing and number of prenatal doctor visits has little effect on the estimates of the interaction effect, as do controls for fathers' class. For females, the controls for father's class have more leverage but not as much as the controls for parents' education.

Given the evidence in other research of the impact of low birth weight on socioeconomic outcomes, one might conclude from table 9 that it plays some role in the variation of test scores with height. Interpretation of the results controlling for parental education is less clear, however, due to the possibility that it captures relevant genetic inheritance from parents. Furthermore, as the relationship between completed education and height documented in figure 1 appears persistent over time, parental education may not only proxy for factors such as family income and parental encouragement to pursue education, but also for parental height and whatever genetic and other environmental factors that work through that channel.

To provide greater clarity on this point, we next add measures of mother's and father's heights as additional control variables. This further restricts the analysis sample to children who have valid observations for both these measures.[40] An implication is that any evidence of a non linear height profile in females' reading scores is not present in this sample so we only present the linear height specification for this group.[41] Also, the estimates for the interaction terms for males are attenuated in this sample.

We specify both mother's and father's height as quadratics,[42] and consider all pairwise additions of the controls so their relative contributions are transparent. The results are presented in table 10. For males, the variation of scores with height is smaller within parental height cells than within parental education cells, and the marginal contribution of parental education

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[40] This is also true in the analysis in table 9 using parents' education (see footnote 42), although the numbers of observations with valid observations for mother's education but not for father's education is relatively small (roughly 100 observations). The number of observations with valid observations of mother's height (collected in sweep 0) but not for father's height (collected in sweep 2) is larger (roughly 550 observations). In both cases, children with missing observations for their father are marginally shorter than those with valid observations.

[41] The estimate of the interaction term is consistently very small and statistically insignificant. Also, the estimates of the main linear term and the impacts of the controls are almost identical in the two specifications.

[42] Specifying linear or cubic profiles in mother's and father's height makes little difference to the results for the linear height profile. For the non linear height profile, a cubic specification of mother's and father's height makes little difference to the results, but a linear specification reduces the contribution of parents' height to males reading scores.

conditional on parental height is very small. In contrast the marginal contribution of parental height conditional on parental education is non trivial. This suggests that whatever information is captured by parental education is spanned by parental height but not vice versa. Also, once again birth weight appears to make a different account of the variation in scores with height as its impact is additive to the account of parents' height. The estimates for females tell a similar story, although there is greater variation residual variation in reading scores conditioning on these three factors.

9. Discussion and Conclusions

We present evidence of gender specific height profiles, which are common to a range of socioeconomic outcomes in the US (and the UK). For males there is little to no "return" to height above mean height, but substantial return below the mean. As such, mean height is a dividing line between individuals who see a return to height and those that don't. For females there is a bend in the profile at mean height but not as distinct as the one for males. Also, females in the top 10 percent of the height distribution see a positive return the height.

These profiles characterize the association of height with outcomes ranging from age 7 cognitive scores to adult self reported health. As a result of these relationships the variation of socioeconomic outcomes below mean height is a substantive marker of inequality in the US.

Within the context of the American and British labor markets, the mediating influence of cognitive and non cognitive skills on the earnings/height relationship for males is sensitive to how the height profile is specified. Specifying a non linear profile leads to a greater role for cognitive skills. The is prima facie true because childhood and teenage measures of cognitive skills exhibit the same nonlinear height profile as adult socioeconomic outcomes.

We provide an exploratory search for antecedents of the non linear adult height profile in childhood cognitive skills. We present evidence that suggests poorer birth outcomes may play a role. We find that low birthweight provides some account of the variation of test scores with height for females, but has limited relevance to the variation of male scores below average height. More salient for both males and females is parental height, a factor that also appears to span any role of parental education in the test score/height relationship.

The non linear height profiles identified here are distinctive for a) the prominent role mean height plays dividing regions with and (mostly) without a return to height, and b) their pervasiveness in outcomes for the American population. As noted above, there is supporting evidence from Korea (Kim and Han 2017) that this is a more general and fundamental finding for the relationship between height and outcome. However, there is also the evidence from Sweden, where teenage measures of cognitive and non cognitive skills display a very different (linear) profile, and the height profile in earnings while non linear is a more moderate quadratic. This may point to important environmental factors that help mould the height profile in the U.S.

Height is strongly heritable. Therefore, it is of interest that the variation in outcomes by height is attenuated controlling for parents' height. This implies that any advantage to being taller only partially transcends the legacy of having shorter parents. However, what that legacy is remains elusive. The systematic and persistent association of social economic outcomes with below average height, which we document in the first part of this paper, will imply corresponding differences in childhood environmental factors that persist over generations. Also, genetic inheritance specific to parts of the height distribution will tend to persist, aided by assortative mating on height. Unpacking the legacy of parental height remains an important topic for future research.

These findings have potentially important implications for research on programs to address economic inequality and on the role of background factors in socioeconomic outcomes. There is little evidence whether height is a significant mediator of social program impacts. Such evidence could inform program design and evaluation, and underline the need to assimilate evidence from other disciplines of how labour market skills and attributes vary with adult height.[43] Also, the systematic association of lower socioeconomic outcomes with adult height below the average, particularly for males, further complicates the interpretation of research on the relationship between family background factors and children's outcomes.

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[43] For example, in addition to the correlations with cognitive and non cognitive skills which have been the focus of economic research, there are documented relationships between height and hearing (Barrenäs et al. 2015, Welch and Dawes 2007), spatial skills (Zhou et al. 2016), sense of feeling (Peters et al. 2009) and (as evidenced by occupational choice) competition and freedom to make decisions (Baker and Cornelson 2018).

References

Autor, D.H., Levy, F. and R.J. Murnane, (2003) "The Skill Content of Recent Technological Change: An Empirical Exploration" *Quarterly Journal of Economics*, 118(4) 1279-1333.

Autor, D.H. and B Price, (2013) "The Changing Task Composition of the US Labor Market: An Update of Autor, Levy, and Murnane (2003)" mimeo.

Baker, Michael and Kirsten Cornelson (2018) "Gender Based Occupational Segregation and Sex Differences in Sensory, Motor and Spatial Aptitudes", *Demography*, 55(5) 1749-1775.

Black, Sandra E., Devereux, Paul J. and Kjell G. Salvanes, (2007) "From Cradle to the Labor Market? The Effect of Birth Weight on Adult Outcomes" *Quarterly Journal of Economics*, 122(1), 1279-1333.

Barrenäs, Marie-Louise., Bratthall, Åsa. and Jovanna Dahlgren, (2005). "The association between short stature and sensorineural hearing loss" *Hearing Research*, *205* (1–2), 123-130.

Case, Anne and Christina Paxson, (2008) "Stature and Status: Height, Ability, and Labor Market Outcomes" *Journal of Political Economy* 116(3) 499-532.

Case, Anne, Paxson, Christina, and Mahnaz Islam, (2009), "Making sense of the labor market height premium: evidence from the British household panel survey", *Economics Letters* 102, 174–176.

Currie, Janet., and Ishita Rajani, (2015). "Within mother estimates of the effects of WIC on birth outcomes in New York city" *Economic Inquiry, 53*(4), 1691–1701.

Czajka, John L. and Gabrielle Denmead, (2008). "Income Data for Policy Analysis: A Comparative Assessment of Eight Surveys" Mathematica Policy Research Inc.

Czajka, John L and Amy Beyler (2016) "Declining response rates in Federal Surveys: Trends and Implications" Mathematica Policy Research, Washington DC.

Deaton, Angus S., and Raksha Arora, (2009). "Life at the top: the benefits of height" *Economics and Human Biology* 7 (2): 133-136.

Figlio, David, Guryan, Jonathan, Karbownik, Krzysztof and Jeffrey Roth (2014). "The Effects of Poor Neonatal Health on Children's Cognitive Development" *American Economic Review* 104(12): 3921–3955

Han, Zhen, Lutsiv, Olha, Mulla, Sohail and Sarah D. McDonald (2012) "Maternal Height and the Risk of Preterm Birth and Low Birth Weight: A Systematic Review and Meta-Analyses", *Journal of Obstetrics and Gynaecology Canada*, 34(8) 721–746

Heineck, Guido (2009) “Too tall to be smart? The relationship between height and cognitive abilities” *Economics Letters* 105(1) 78–80.

Horikoshi, Momoko et al. (2013) “New loci associated with birth weight identify genetic links between intrauterine growth and adult height and metabolism” *Nature Genetics* 45(1) 76-82.

Hubler, Olaf, (2009) “The nonlinear link between height and wages in Germany, 1985− 2004” *Economics and Human Biology* 7 191−199.

Kim, Tae Hyun, and Euna Han, (2017) “Height premium for job performance” *Economics and Human Biology* 26 13-20.

Komlos, John (1987) “The Height and Weight of West Point Cadets: Dietary Change in Antebellum America” *The Journal of Economic History*, 47(4) 897-927.

Komlos, John (1990) “Health and Social Status in Eighteenth-Century Germany” *Journal of Interdisciplinary History* 20(4) 607-621

Lang, Kevin and Michael Manove (2011) “Education and Labor Market Discrimination” *American Economic Review* 101(4) 1467-96.

Lucas, Jacqueline W., Barr-Anderson, Daheia J. and Raynard S. Kington (2006) “Health status of non-Hispanic U.S.-born and foreign-born black and white persons: United States, 1992–95.” National Center for Health Statistics. Vital Health Statistics 10(226). 2005.

Lundborg, Petter, Nystedt, Paul and Dan-Olof Rooth (2014) “Height and Earnings: The Role of Cognitive and Noncognitive Skills” *Journal of Human Resources*, 49(1) 141-166

Merrill, Ray M. and John S. Richardson (2009) “Validity of self-reported height, weight, and body mass index: findings from the National Health and Nutrition Examination Survey”, 2001-2006. *Preventing Chronic Dis*ease 6(4).

Moriarity, Chris and James Dahlhamer (2012) “Adjustment for Unit Nonresponse in the National Health Interview Survey.” Paper presented at the 2012 Joint Statistical Meetings, Session 671, San Diego, CA, USA.

Neal, Derek. and William R. Johnson (1996) “The Role of Premarket Factors in Black-White Wage Differences”, *Journal of Political Economy* 104(5) 869-895.

Persico, Nicola, Postlewaite, Andrew and Dan Silverman (2004) “The Effect of Adolescent Experience on Labor Market Outcomes: The Case of Height” *Journal of Political Economy*, 112(5) 1019-1053.

Peters, Ryan M., Hackeman, Erik and Daniel Goldreich, (2009). "Diminutive Digits Discern Delicate Details: Fingertip Size and the Sex Difference in Tactile Spatial Acuity" *The Journal of Neuroscience*, *29* (50),15756 –15761

Oreopoulos, Philip, Stabile, Mark, Walld, Randy and Leslie L. Roos (2008) "The Short, Medium, and Long Term Effects of Poor Infant Health," *Journal of Human Resources,* 43(1) 88-138.

Sahyoun, Nadine R., Maynard, L Michelle, Zhang, X.L. and Mary K. Serdula (2008), "Factors Associated with Errors in Self-reported height and Weight in Older Adults", *The Journal of Nutrition, Health and Aging*, 12(2), 108-115.

Schick, Andreas and Richard H. Steckel, (2015) "Height, Human Capital and Earnings: The Contributions of Cognitive and Noncognitive Ability", *Journal of Human Capital* 9(1), 94-115

Sohn, Kitae, (2015) "The height premium in Indonesia" *Economics and Human Biology* 16 1-15

Sonchak, Lyudmyla (2016) "The Impact of WIC on Birth Outcomes: New Evidence from South Carolina", *Maternal and Child Health Journal* 20(7) 1518–1525

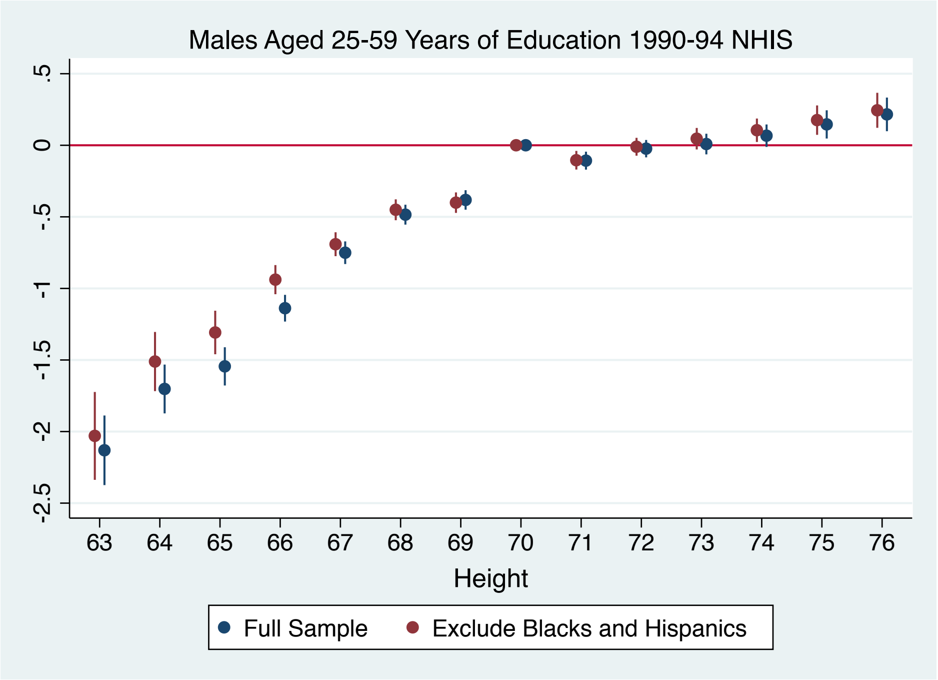
van Dommelen, Paula, Schönbeck Yvonne and Stef van Buuren (2012) "A simple calculation of the target height" *Archives of Disease in Childhood* 97(2),182.

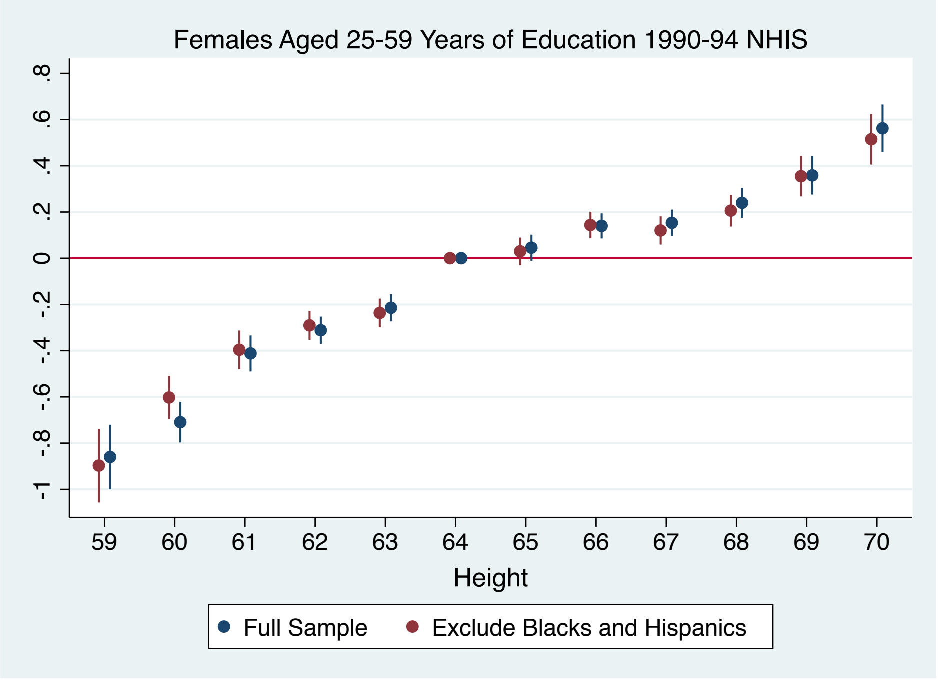
Welch, David and Patrick J.D. Dawes, (2007). "Childhood Hearing Is Associated With Growth Rates in Infancy and Adolescence" *Pediatric Research, 62* (4), 495-8.

Zhang, Ge, Bacelis, Jonas, Lengyel, Candice, Teramo, Kari, Hallman, Mikko. Helgeland, Øyvind, Johansson, Stefan, Myhre, Ronny, Sengpiel, Verena, Njølstad, Pål Rasmus, Jacobsson, Bo, and Louis Muglia (2015) "Assessing the Causal Relationship of Maternal Height on Birth Size and Gestational Age at Birth: A Mendelian Randomization Analysis", *PLoS Med* 12(8): e1001865. doi:10.1371/journal.pmed.1001865

Zhou, Liu, Ooi, Teng Leng, and Zijiang J. He, (2016). "Intrinsic spatial knowledge about terrestrial ecology favors the tall for judging distance" *Science Advances 2* (8), e1501070 DOI: 10.1126/sciadv.1501070.

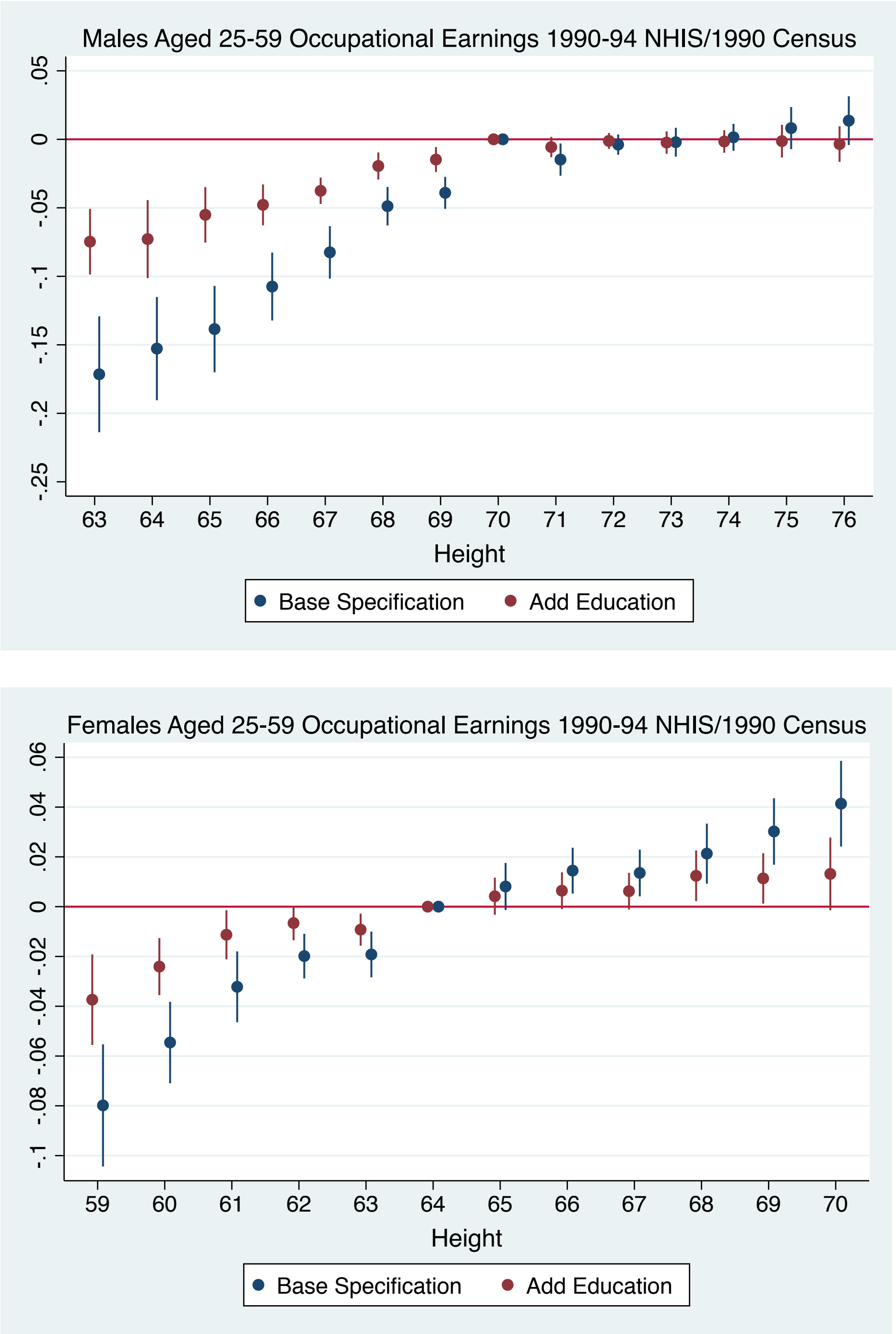
Figure 1: Males' and Females' Years of Educational Attainment by Height, NHIS





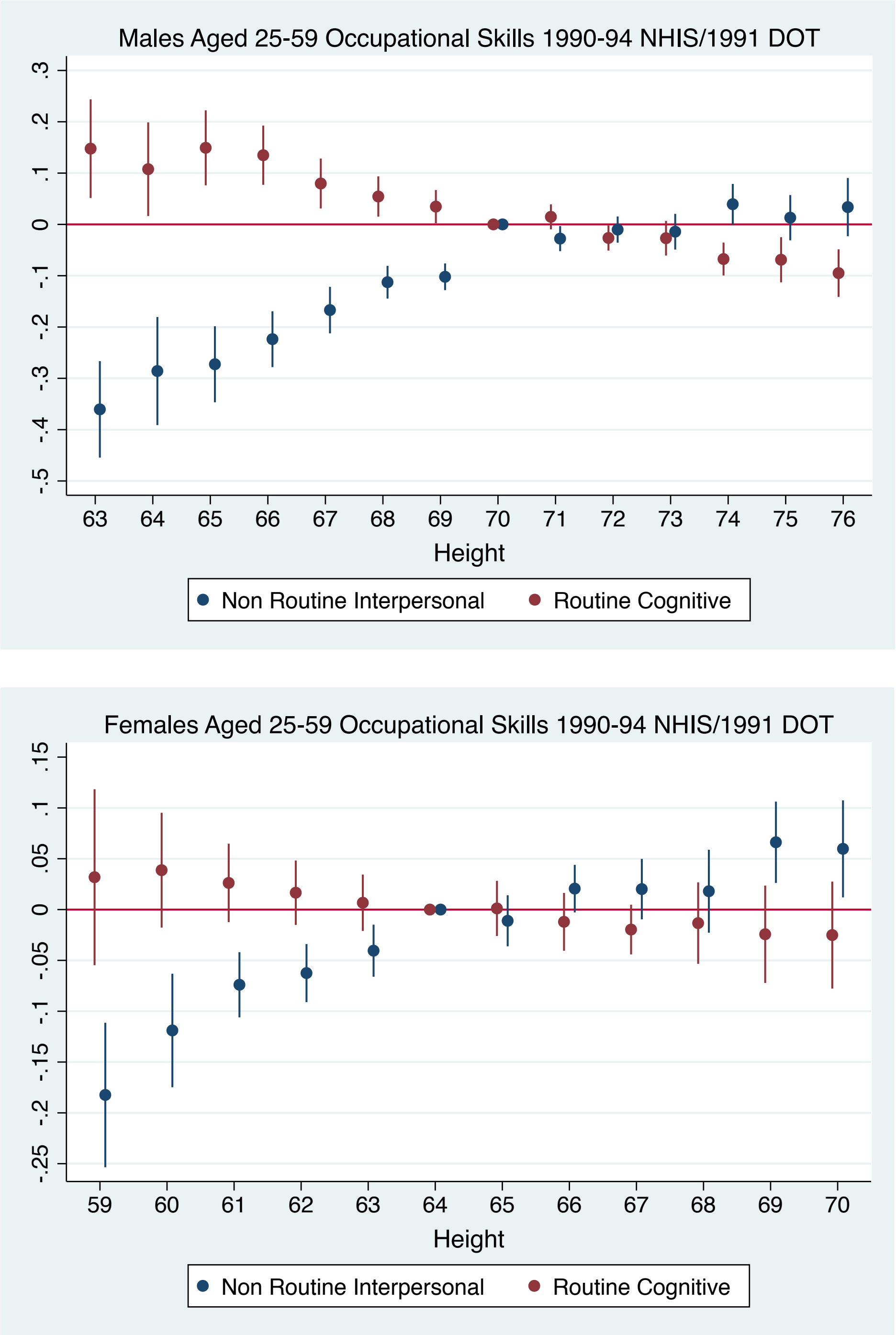
Notes: Authors calculations from 1990-94 NHIS. The reported parameters are estimates of single inch height dummy variables from a regression of the indicated outcome on height, age (single year), region, race/ethnicity (as applicable) foreign birth and indicators for survey year. Mean height (70' males, 64" females) is the omitted category. Robust 95 percent confidence intervals.

Figure 2: Males' and Females' Average Occupational Earnings by Height, NHIS and Census



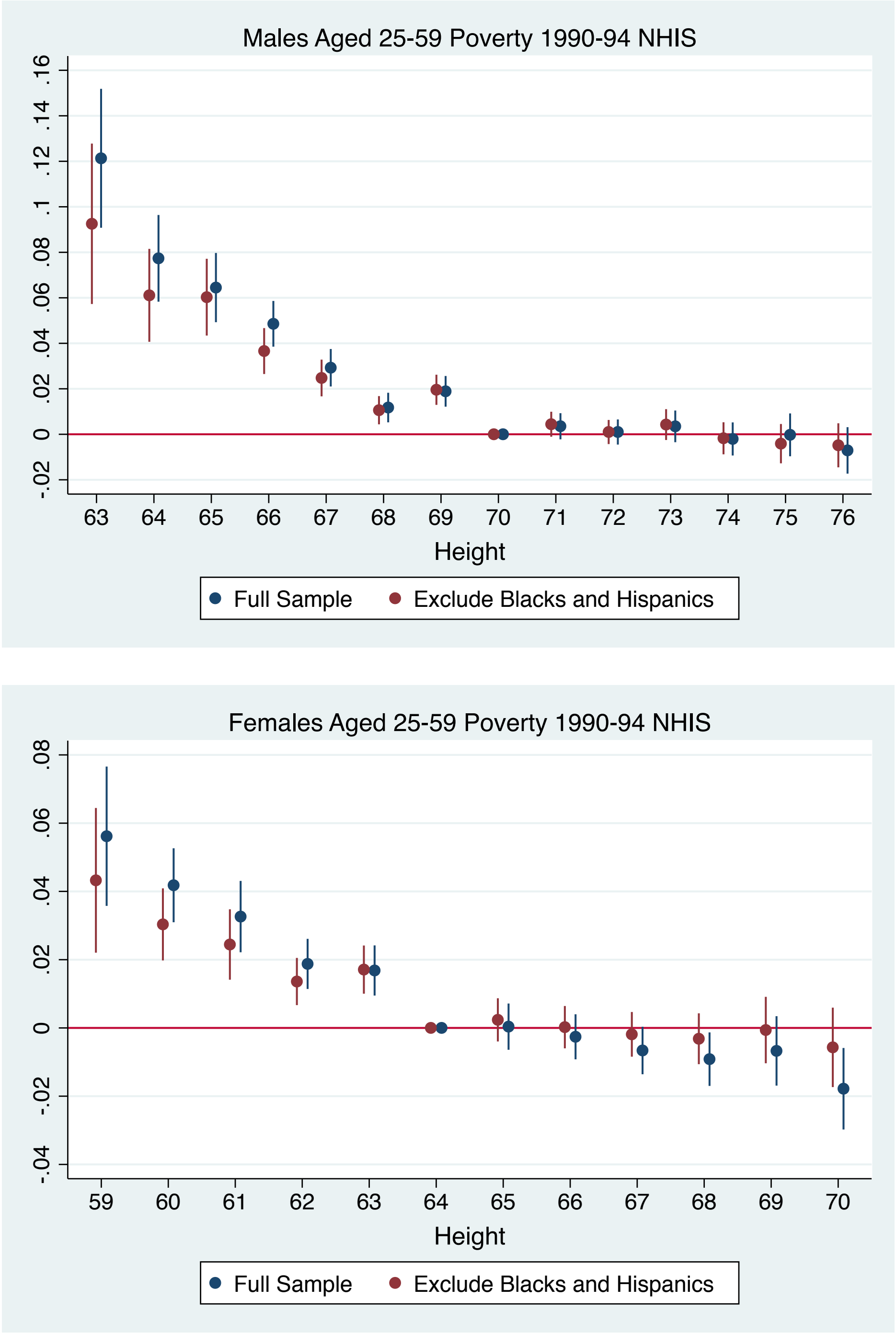
Notes: Authors calculations from 1990-94 NHIS and 1990 Census. The reported parameters are estimates of single inch height dummy variables from a regression of the indicated outcome on height, age (single year), region, race/ethnicity foreign birth and indicators for survey year. Mean height (70' males, 64" females) is the omitted category. Robust 95 percent confidence intervals.

Figure 3: Males' and Females' Occupational Skills by Height, NHIS and DOT



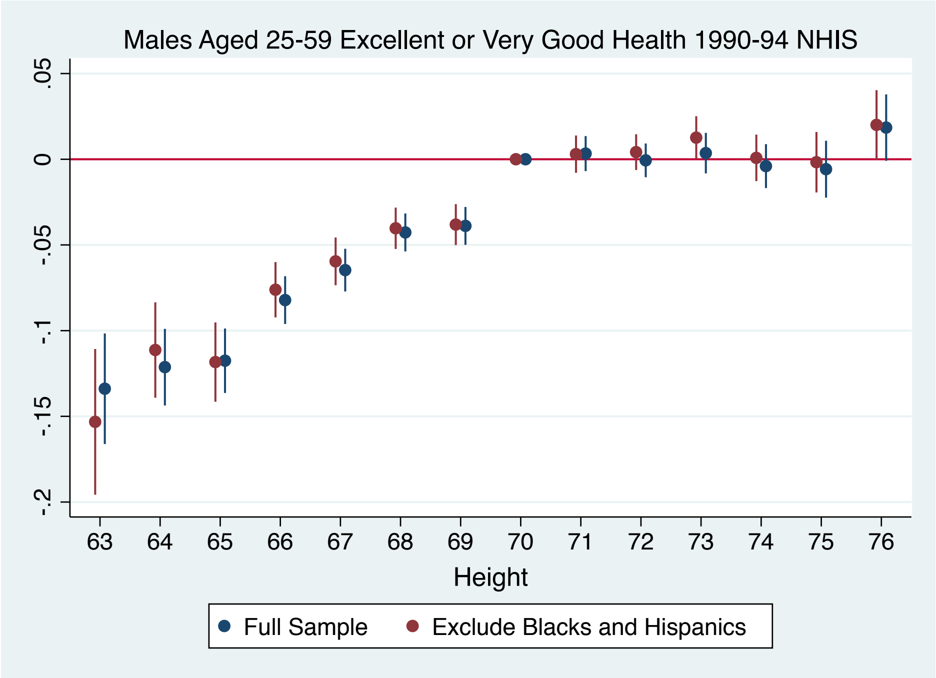
Notes: Authors calculations from 1990-94 NHIS and 1991 DOT. The reported parameters are estimates of single inch height dummy variables from a regression of the indicated outcome on height, age (single year), region, race/ethnicity, foreign birth and indicators for survey year. Mean height (70' males, 64" females) is the omitted category. Robust 95 percent confidence intervals.

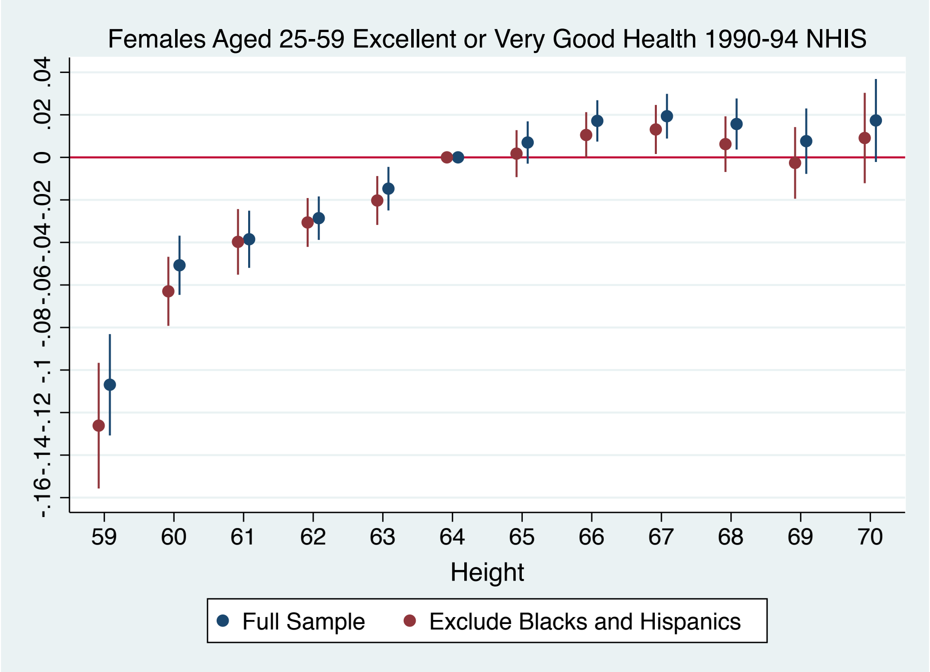
Figure 4: Males' and Females' Household Poverty by Height, NHIS



Notes: Authors calculations from 1990-94 NHIS. The reported parameters are estimates of single inch height dummy variables from a regression of the indicated outcome on height, age (single year), region, race/ethnicity (as applicable), foreign birth and indicators for survey year. Mean height (70' males, 64" females) is the omitted category. Robust 95 percent confidence intervals.

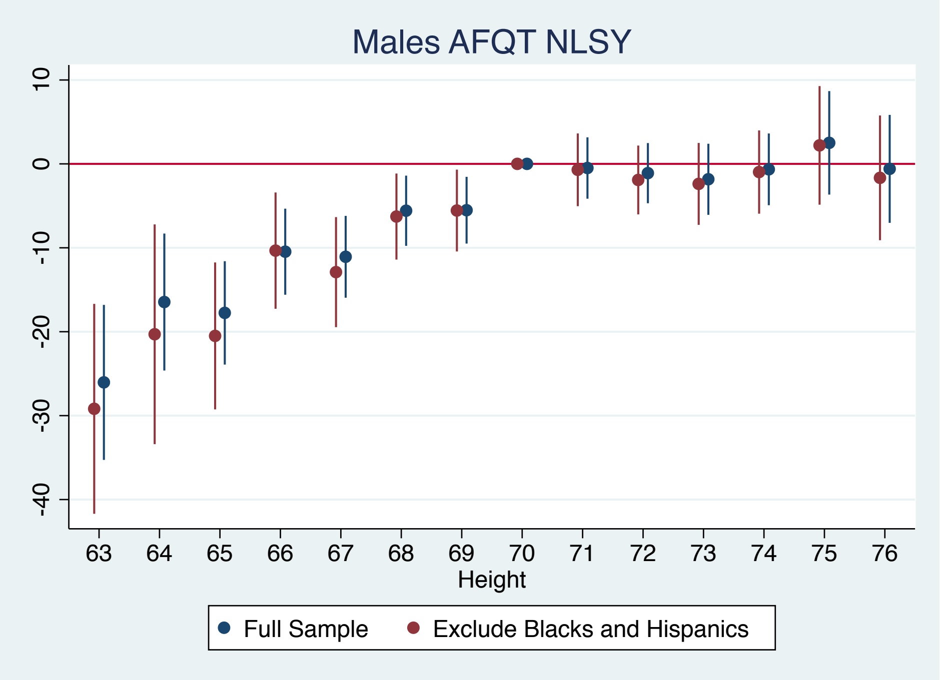
Figure 5: Males' and Females' Self Reported Health by Height, NHIS

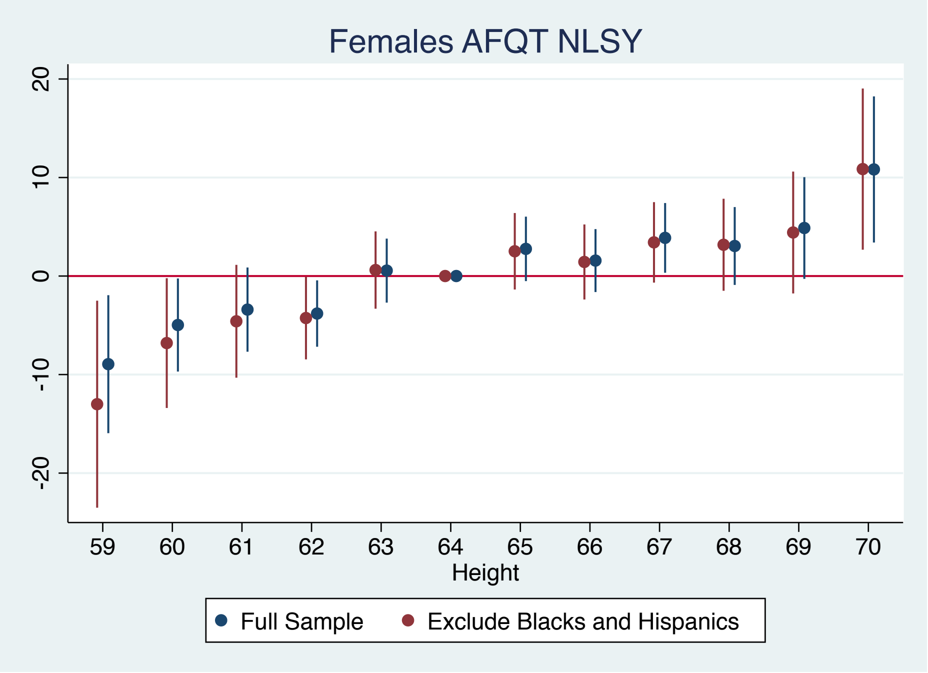




Notes: Authors calculations from 1990-94 NHIS. The reported parameters are estimates of single inch height dummy variables from a regression of the indicated outcome on height, age (single year), region, race/ethnicity (as applicable), foreign birth and indicators for survey year. Mean height (70' males, 64" females) is the omitted category. Robust 95 percent confidence intervals.

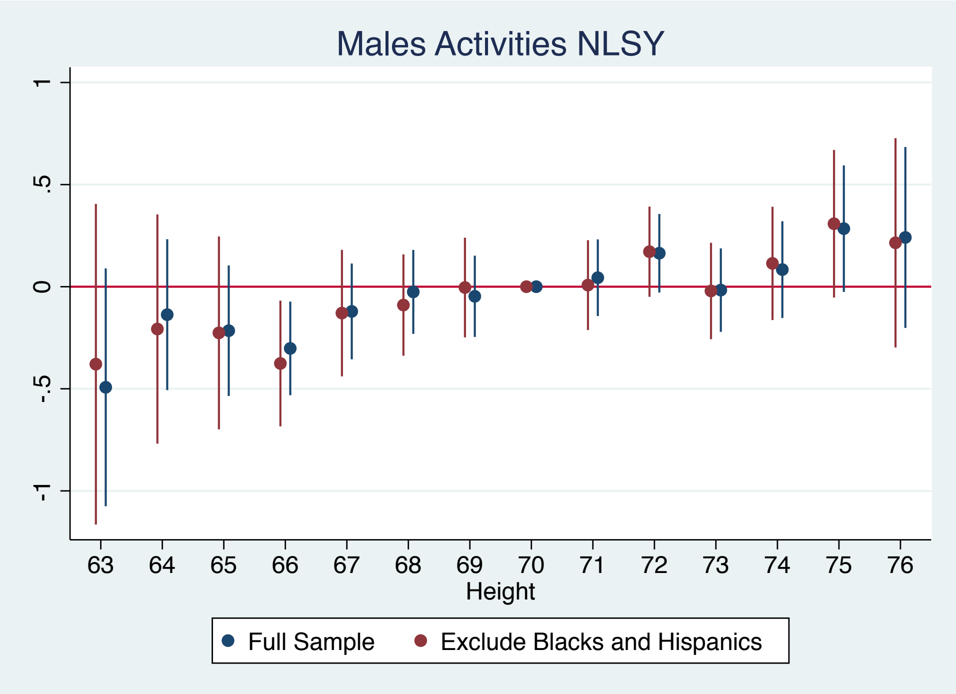
Figure 6: Males' and Females' AFQT scores by Height, NLSY79

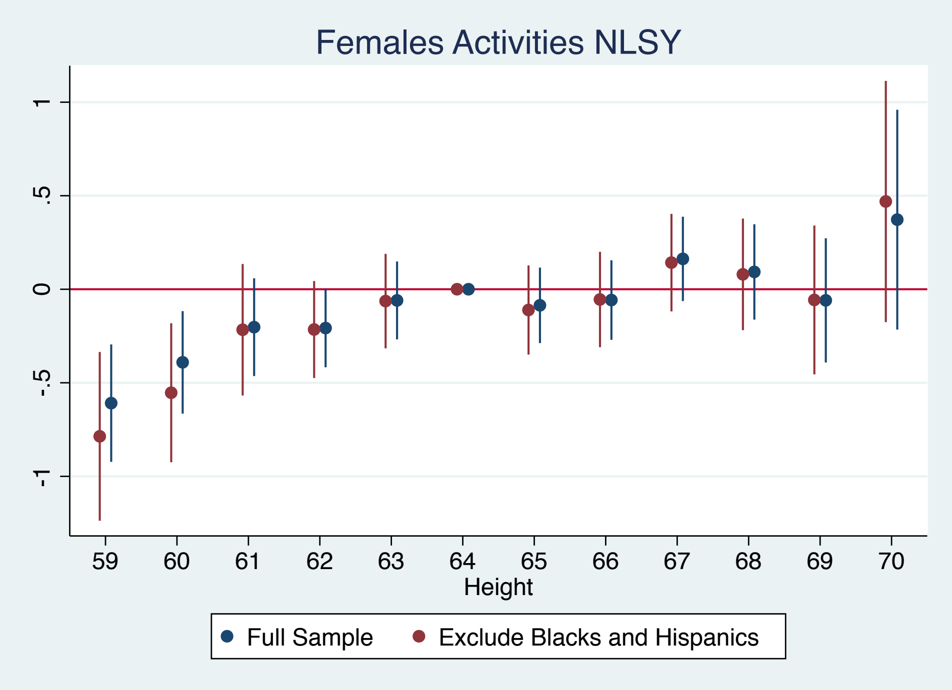




Notes: Authors calculations from the NLSY79. The reported parameters are estimates of single inch height dummy variables from a regression of the indicated outcome on height age (single year), age (single year), region, and race/ethnicity (as applicable). Mean height (70' males, 64" females) is the omitted category. Robust 95 percent confidence intervals.

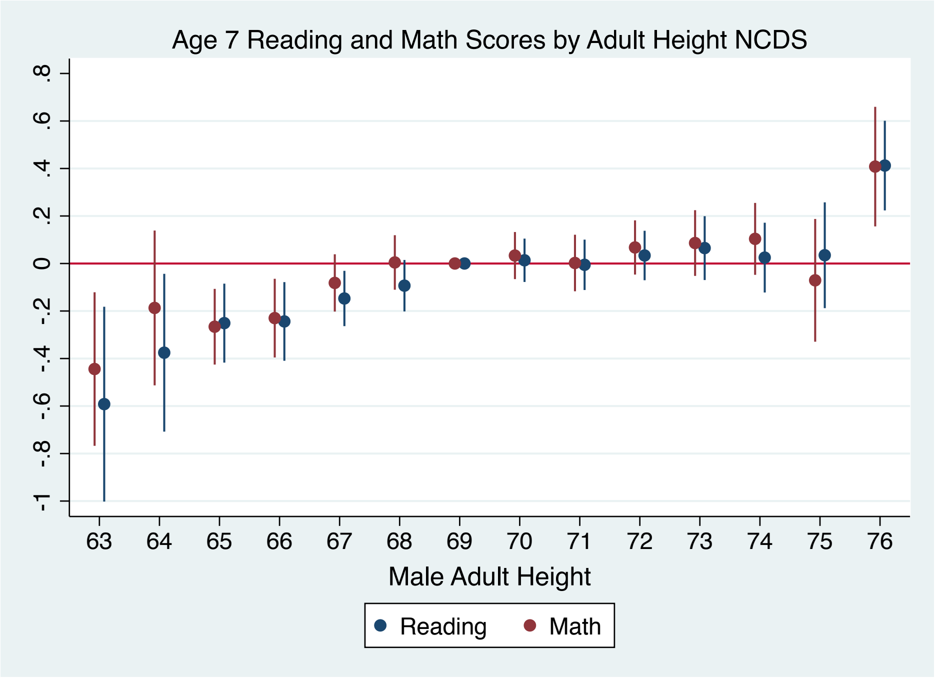
Figure 7: Males' and Females' High School Activities by Height, NLSY79

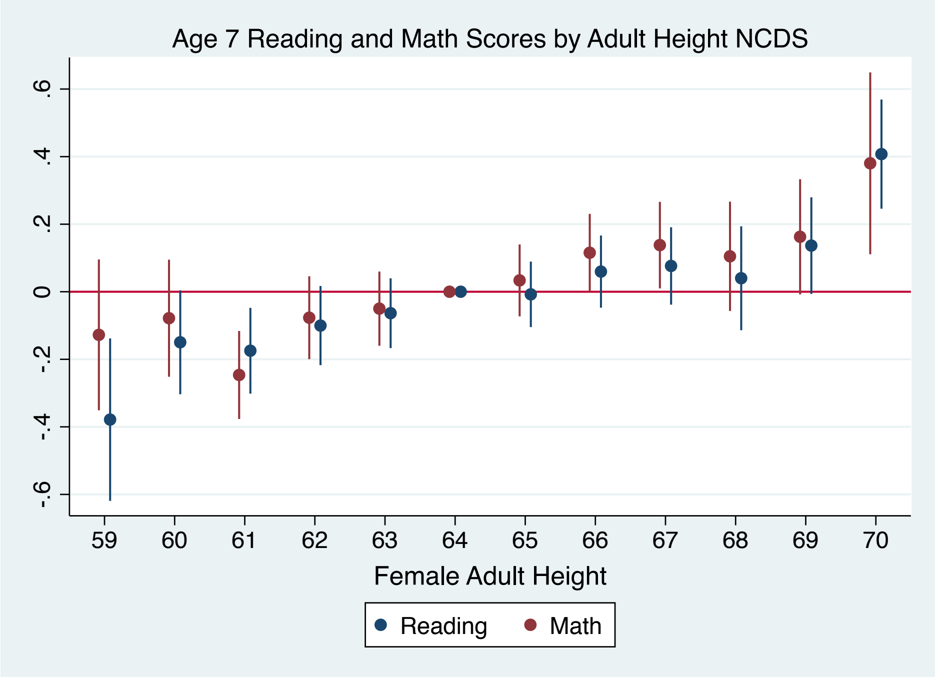




Notes: Authors calculations from the NLSY79. The reported parameters are estimates of single inch height dummy variables from a regression of the indicated outcome on height age (single year), age (single year), region, and race/ethnicity (as applicable). Mean height (70' males, 64" females) is the omitted category. Robust 95 percent confidence intervals.

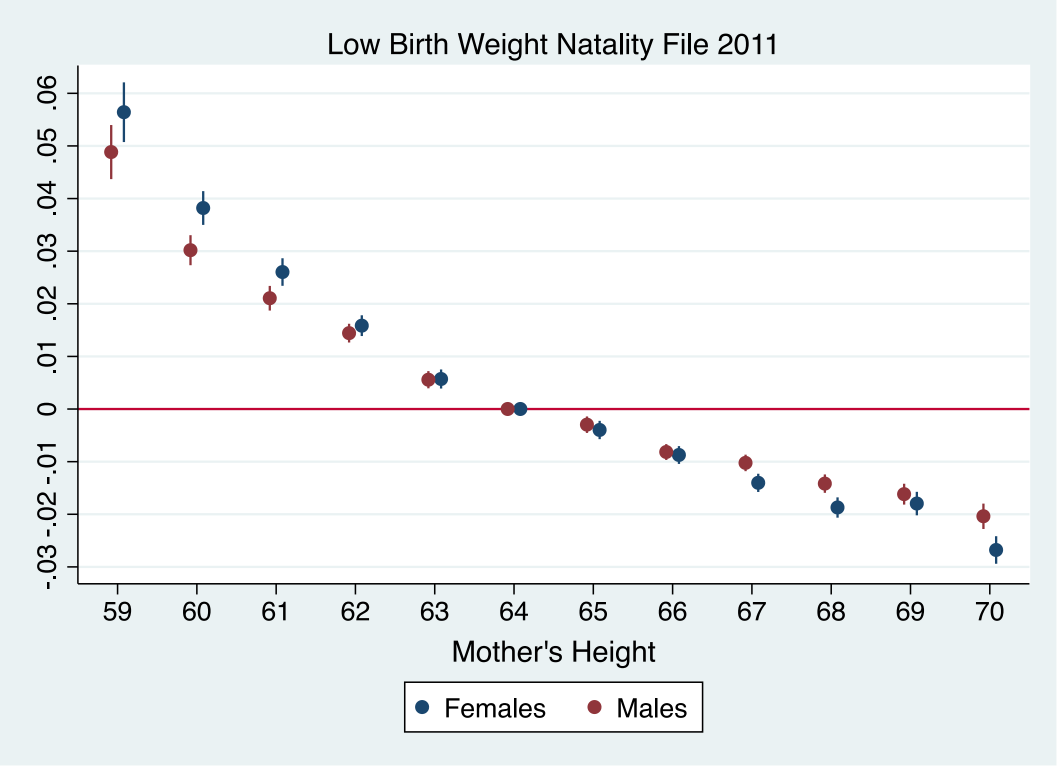
Figure 8: Males' and Females' Age 7 Cognitive Scores by (Adult) Height, NCDS





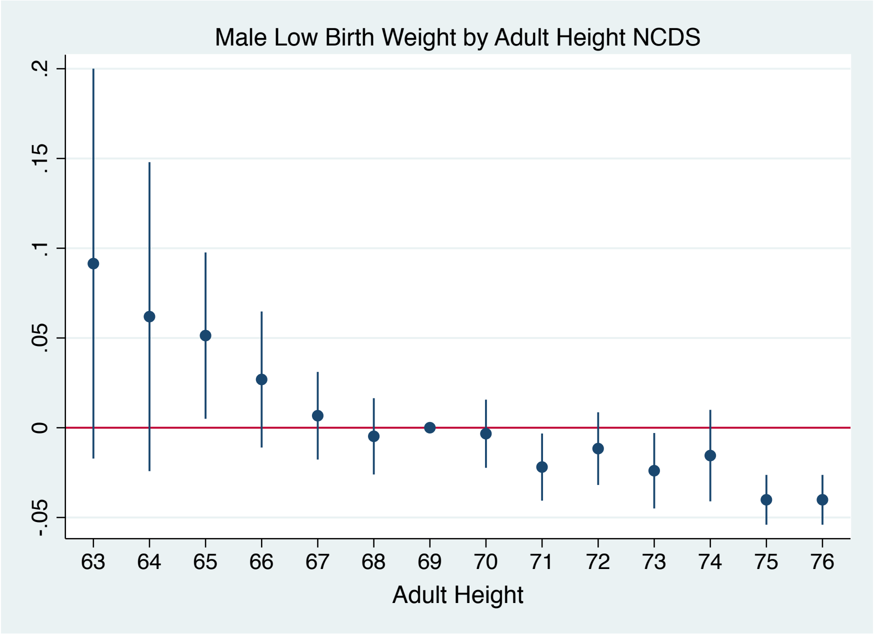
Notes: Authors calculations from the NCDS. The reported parameters are estimates of single inch height dummy variables from a regression of the indicated outcome on height, age at which the indicated test was taken (months), region. Mean height (70' males, 64" females) is the omitted category. Robust 95 percent confidence intervals.

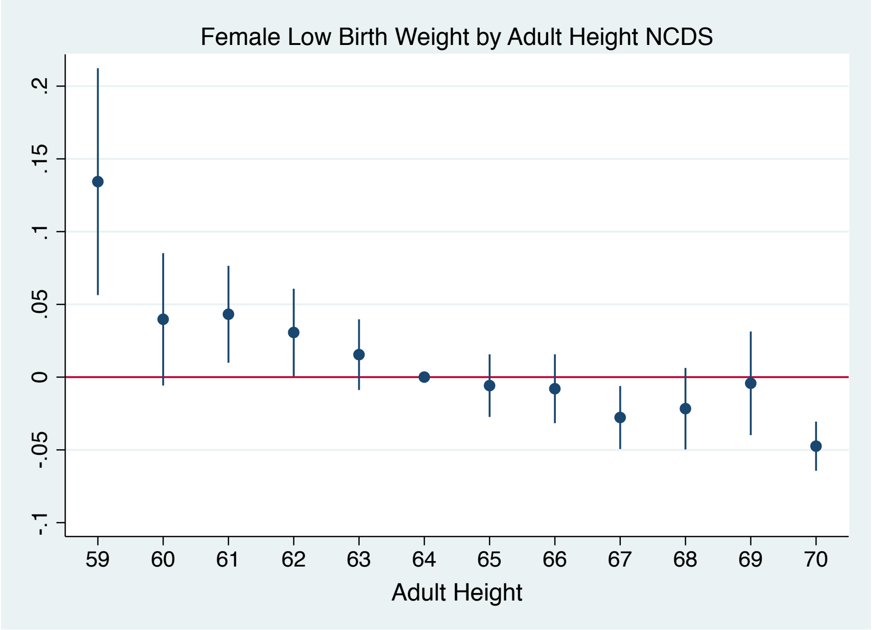
Figure 9: Incidence of a Low Birthweight Singleton Births by Mother's Height for Non Hispanic Whites, 2011 Natality File



Notes: Authors calculations from the 2011 Natality File. The reported parameters are estimates of single inch height dummy variables from a regression of the indicated outcome on height. Mean height (64") is the omitted category. Robust 95 percent confidence intervals.

Figure 10: Males and Females Low Birth Weight by (Adult) Height, NCDS





Notes: Authors calculations from the NCDS. The reported parameters are estimates of single inch height dummy variables from a regression of the indicated outcome on height. Mean height (70' males, 64" females) is the omitted category. Robust 95 percent confidence intervals.

Table 1: Summaries of Heights in the NHIS and NLSY79 Samples

	Females		Males	
NHIS	1990-94	2010-13	1990-94	2010-13
Mean	64.50”	64.40	70.09”	69.97
Std. Deviation	2.78	2.55	3.06	2.82
Interquartile Range	63”-66”	63”-66”	68”-72”	68”-72”
90/10 range	61”-68”	61”-68”	66”-74”	66”-74”
N	138,221	39,631	124,552	33,333

NLSY79	Females	Males
Mean	64.49”	70.40”
Std. Deviation	2.69	2.90
Interquartile Range	63”-66”	68”-72”
90/10 range	61”-68”	67”-74”
N	5,181	4,941

Notes: Authors calculations from the 1990-94 and 2010-13 NHIS and the NLSY79.

Table 2: Socio-economic Outcomes by Height, and for African Americans and Hispanics, NHIS

	% of POP	No High School		College		Employment		Health	
Males		1990-94	2010-13	1990-94	2010-13	1990-94	2010-13	1990-94	2010-13
Height≤66”	12	0.153	0.103	-0.134	-0.138	-0.046	-0.041	-0.107	-0.105
		(0.004)	(0.007)	(0.004)	(0.008)	(0.003)	(0.008)	(0.004)	(0.009)
66”<Height ≤68”	17-18	0.055	0.035	-0.069	-0.067	-0.017	-0.038	-0.051	-0.052
		(0.003)	(0.005)	(0.003)	(0.008)	(0.002)	(0.007)	(0.003)	(0.008)
African Americans	11-12	0.079	0.030	-0.133	-0.122	-0.105	-0.123	-0.133	-0.103
		(0.004)	(0.006)	(0.004)	(0.008)	(0.003)	(0.008)	(0.004)	(0.008)
Hispanics	10-15	0.238	0.200	-0.182	-0.241	-0.028	-0.017	-0.086	-0.092
		(0.005)	(0.007)	(0.004)	(0.009)	(0.003)	(0.008)	(0.005)	(0.009)
Females									
Height≤61”	13	0.080	0.061	-0.076	-0.098	-0.046	-0.029	-0.068	-0.069
		(0.003)	(0.006)	(0.003)	(0.008)	(0.004)	(0.008)	(0.004)	(0.008)
61”<Height ≤63”	23-24	0.039	0.020	-0.042	-0.052	-0.030	-0.021	-0.031	-0.047
		(0.002)	(0.004)	(0.003)	(0.007)	(0.003)	(0.006)	(0.003)	(0.007)
African Americans	13-14	0.091	0.065	-0.095	-0.156	-0.041	-0.051	-0.178	-0.146
		(0.003)	(0.005)	(0.003)	(0.007)	(0.004)	(0.007)	(0.004)	(0.007)
Hispanics	10-14	0.264	0.181	-0.134	-0.230	-0.119	-0.058	-0.140	-0.121
		(0.005)	(0.006)	(0.004)	(0.008)	(0.005)	(0.008)	(0.005)	(0.008)

Notes: Authors calculations from the 1990-94 and 2010-13 NHIS. This table shows the estimates of dummy variables for the indicated height and ethnic/race groups from a regression of the indicated dependent variable on these dummy variables, height, age (single year), region, foreign birth and indicators for survey year. The regressions for males also include an additional dummy variable for height equal to 69”. Regressions are weighted using sampling weights. Robust standard errors in parentheses. All estimates statistically significant at the 1% level.

Table 3: The Relationship between Height and Education or Log Wages, NLSY79

	Full Sample		Non Hispanic Whites	
	Years Completed Education	Log wages	Years Completed Education	Log wages
Males				
Height	0.036	0.018	0.044	0.020
	(0.031)	(0.012)	(0.036)	(0.014)
Height x *SH*	0.145***	0.042**	0.169**	0.037
	(0.050)	(0.019)	(0.067)	(0.024)
SH	0.029	0.032	0.136	0.043
	(0.154)	(0.057)	(0.198)	(0.068)
N	4,841	4,506	2,760	2,599
Females				
Height	0.052**	0.034**	0.068**	0.043**
	(0.027)	(0.016)	(0.032)	(0.019)
Height x *SH*	0.145***	-0.018	0.172**	-0.047
	(0.051)	(0.027)	(0.067)	(0.036)
SH	0.164	-0.099	0.238	-0.137
	(0.147)	(0.088)	(0.183)	(0.111)
N	5,069	4,279	2,957	2,535

Notes: Authors calculations from the NLSY79. This table shows the results from regressions of the indicated variables on height, a dummy variable (SH) for height less than the average (70" for males and 64" for females) and an interaction term between this dummy variable and height, along with controls for age (single year), region, and race/ethnicity (as applicable). Regressions are weighted using sampling weights. Robust standard errors in parentheses. ***, ** and * indicate statistical significance at the 10, 5, and 1 percent levels respectively.

Table 4: The Relationship between Height and Cognitive skills or Non-cognitive Skills, NLSY79

	AFQT	Activities	Self-Esteem
Males			
Height	-0.139	0.035*	0.018
	(0.344)	(0.020)	(0.051)
Height x *SH*	2.628***	0.018	0.211**
	(0.565)	(0.029)	(0.083)
SH	-1.836	0.021	0.195
	(1.781)	(0.090)	(0.262)
N	4,641	4,641	4,513
Females			
Height	0.898***	0.038**	0.096**
	(0.297)	(0.020)	(0.050)
Height x *SH*	0.705	0.056*	0.092
	(0.511)	(0.030)	(0.084)
SH	0.526	0.094	0.185
	(1.515)	(0.094)	(0.253)
N	4,952	4,952	4,833
Males, non Hispanic whites			
Height	-0.276	0.040*	0.032
	(0.403)	(0.023)	(0.059)
Height x *SH*	3.210***	0.022	0.262**
	(0.781)	(0.039)	(0.110)
SH	-1.329	0.039	0.423
	(2.329)	(0.116)	(0.333)
N	2,646	2,646	2,578
Females, non Hispanic whites			
Height	0.965***	0.048**	0.110*
	(0.354)	(0.024)	(0.059)
Height x *SH*	1.210*	0.078**	0.101
	(0.687)	(0.040)	(0.111)
SH	1.482	0.159	0.382
	(1.919)	(0.119)	(0.319)
N	2,874	2,874	2,812

Notes: Authors calculations from the NLSY79. This table shows the results from regressions of the indicated variables on height, a dummy variable (SH) for height less than the average (70" for males and 64" for females) and an interaction term between this dummy variable and height, along with controls for age (single year), region, and race/ethnicity (as applicable). Regressions are weighted using sampling weights. Robust standard errors in parentheses. ***, ** and * indicate statistical significance at the 10, 5, and 1 percent levels respectively.

Table 5: The relationship between Height and Log Wages with and without Controls for Cognitive and/or Non-cognitive Skills, NLSY79

Males				
Full Sample (N=4,207)				
Height	0.031***	0.020***	0.024***	0.019***
	(0.006)	(0.006)	(0.006)	(0.006)
Full Sample (N=4,207)				
Height	0.017	0.019	0.013	0.017
	(0.012)	(0.012)	(0.012)	(0.012)
Height x *SH*	0.044**	0.019	0.034*	0.019
	(0.021)	(0.020)	(0.020)	(0.020)
SH	0.051	0.064	0.040	0.054
	(0.060)	(0.059)	(0.058)	(.0.058)
Non Hispanic Whites (N=2,431)				
Height	0.015	0.018	0.011	0.016
	(0.014)	(0.014)	(0.014)	(0.014)
Height x *SH*	0.044*	0.016	0.033	0.015
	(0.026)	(0.025)	(0.025)	(0.025)
SH	0.053	0.057	0.034	0.044
	(0.072)	(0.070)	(0.070)	(0.070)
Females				
Full Sample (N=4,106)				
Height	0.039***	0.024***	0.030***	0.022***
	(0.008)	(0.008)	(0.008)	(0.008)
Full Sample (N=4,106)				
Height	0.031*	0.019	0.022	0.017
	(0.017)	(0.017)	(0.017)	(0.017)
Height x *SH*	-0.010	-0.016	-0.020	-0.019
	(0.027)	(0.026)	(0.027)	(0.026)
SH	-0.094	-0.092	-0.118	-0.104
	(0.089)	(0.085)	(0.087)	(0.085)
Non Hispanic Whites (N=2,414)				
Height	0.040**	0.029	0.031	0.026
	(0.019)	(0.019)	(0.020)	(0.019)
Height x *SH*	-0.035	-0.047	-0.048	-0.050
	(0.036)	(0.034)	(0.035)	(0.034)
SH	-0.121	-0.130	-0.155	-0.145
	(0.111)	(0.106)	(0.109)	(0.106)
Cognitive Skills		X		X
Non-cognitive Skills			X	X

Notes: Authors calculations from the NLSY79. This table shows the results from regressions of the indicated variables on height, a dummy variable (SH) for height less than the average (70” for males and 64” for females) and an interaction term between this dummy variable and height, along with controls for age (single year), region, and race/ethnicity (as applicable). Cognitive skills are AFQT percental scores. Non-cognitive skills are high school social activities and the Rosenberg self esteem index. Regressions are weighted using sampling weights. Robust standard errors in parentheses. ***, ** and * indicate statistical significance at the 10, 5, and 1 percent levels respectively.

Table 6: The Relationship between Height and Log Wages with and without Controls for Cognitive and/or Non-cognitive Skills, NCDS

Males				
Age 7 Cognitive, Age 7 Non Cognitive (N=2,905)				
Height	0.022***	0.015***	0.021***	0.015***
	(0.004)	(0.004)	(0.004)	(0.004)
Age 7 Cognitive, Age 7 Non Cognitive (N=2,905)				
Height	0.009	0.005	0.009	0.005
	(0.006)	(0.006)	(0.006)	(0.006)
Height x SH	0.031*	0.020	0.029*	0.020
	(0.017)	(0.016)	(0.017)	(0.016)
SH	-0.083**	-0.065*	-0.078**	-0.064*
	(0.035)	(0.033)	(0.034)	(0.033)
Age 7 Cognitive, Age 16 Non Cognitive (N=2,312)				
Height	0.017**	0.013*	0.017**	0.014**
	(0.007)	(0.007)	(0.007)	(0.007)
Height x SH	0.029	0.015	0.029	0.021
	(0.019)	(0.018)	(0.018)	(0.018)
SH	-0.050	-0.035	-0.036	-0.032
	(0.037)	(0.036)	(0.037)	(0.036)
Females				
Age 7 Cognitive, Age 7 Non Cognitive (N=1,345)				
Height	0.018***	0.010*	0.017***	0.010*
	(0.006)	(0.006)	(0.006)	(0.006)
Age 7 Cognitive, Age 7 Non Cognitive (N=1,345)				
Height	0.020*	0.016	0.020*	0.016
	(0.011)	(0.011)	(0.011)	(0.011)
Height x SH	0.000	-0.002	0.001	-0.001
	(0.023)	(0.022)	(0.022)	(0.022)
SH	0.016	0.029	0.027	0.033
	(0.106)	(0.104)	(0.104)	(0.103)
Age 7 Cognitive, Age 16 Non Cognitive (N=1,068)				
Height	0.024**	0.019	0.020	0.016
	(0.013)	(0.013)	(0.013)	(0.013)
Height x SH	-0.004	-0.004	0.004	0.006
	(0.026)	(0.026)	(0.025)	(0.025)
SH	0.015	0.029	0.021	0.035
	(0.120)	(0.117)	(0.114)	(0.114)
Cognitive Skills		X		X
Non-cognitive Skills			X	X

Notes: Authors calculations from the NCDS. This table shows the results from regressions of the indicated variables on height, a dummy variable (SH) for height less than the average (69" for males and 64" for females) and an interaction term between this dummy variable and height, along with controls for age (single month) and region. Cognitive skills are Age 7 standardized math and reading scores. Non-cognitive skills are (age 7) a teacher reported index following the Bristol Social Adjustment Guide, or (age 16) teacher reports (5 point scale) of child's impulsiveness, temper, aggression, rigidity, withdrawal and industriousness. Robust standard errors in parentheses. ***, ** and * indicate statistical significance at the 10, 5, and 1 percent levels respectively.

Table 7: The Relationship between Adult Height and Age 7 Math and Reading Scores, NCDS

	Males		*Females*	
	Math	Reading	Math	Reading
Height	0.021**	0.017*	0.041***	0.032***
	(0.010)	(0.009)	(0.012)	(0.010)
Height x *SH*	0.058**	0.056**	-0.011	0.020
	(0.023)	(0.024)	(0.022)	(0.021)
SH	-0.049	-0.122**	-0.072	0.068
	(0.052)	(0.048)	(0.099)	(0.096)
N	4,136	4,153	4,320	4,331

Notes: Authors calculations from the NCDS. This table shows the results from regressions of the indicated variables on height, a dummy variable (SH) for height less than the average (69" for males and 64" for females) and an interaction term between this dummy variable and height, along with controls for age (single month) and region. Robust standard errors in parentheses. ***, ** and * indicate statistical significance at the 10, 5, and 1 percent levels respectively.

Table 8: Incidence of Birth Outcomes by Mother's Height, for Non Hispanic White Singleton Births, 2011 Natality Files

	LBW	VLBW	Low APGAR	Premature
Males				
Height	-0.003***	-0.0003***	-0.0006***	-0.002***
	(0.000)	(0.0001)	(0.0001)	(0.000)
Height x *SH*	-0.005***	-0.0006***	-0.0004**	-0.003***
	(0.000)	(0.0001)	(0.0002)	(0.000)
SH	-0.003***	-0.000	-0.0004	-0.002*
	(0.001)	(0.000)	(0.0006)	(0.001)
N	1,013,472	1,013,472	1,009,842	1,013,442
Females				
Height	-0.004***	-0.0004***	-0.0005***	-0.002***
	(0.000)	(0.0001)	(0.0001)	(0.000)
Height x *SH*	-0.006***	-0.0007***	-0.0006***	-0.003***
	(0.000)	(0.0001)	(0.0002)	(0.000)
SH	-0.004***	-0.0011***	-0.0018***	-0.004***
	(0.001)	(0.0004)	(0.0004)	(0.001)
N	959,117	959,117	955,502	959,038

Notes: Authors' calculations from the 2011 Natality Public Use file. This table shows the results from regressions of the indicated variables on mothers' height, a dummy variable (SH) for height less than the average (64") and an interaction term between this dummy variable and height. Low birth weight (LBW) is defined as < 2500 grams. Very low birth weight (VLBW) is defined as < 1500 grams. Low AGPAR is defined as < 7. Prematurity is defined as gestational age < 37 weeks. All estimates statistically significant at the 1% level except where indicated with a ^ (significant at the 5% level).

Table 9: The Relationship between Adult Height and Age 7 Cognitive Scores with and without controls for Birthweight and Parent's Education, NCDS

Males				
Age 7 Reading (N=2,987)				
Height	0.034***	0.026***	0.027***	0.018***
	(0.007)	(0.006)	(0.007)	(0.007)
Age 7 Reading (N=2,987)				
Height	0.011	0.002	0.006	-0.003
	(0.010)	(0.010)	(0.010)	(0.010)
Height x *SH*	0.050*	0.044	0.046	0.040
	(0.028)	(0.028)	(0.029)	(0.028)
SH	-0.145**	-0.154***	-0.132**	-0.142***
	(0.056)	(0.054)	(0.056)	(0.054)
Age 7 Math (N=2,972)				
Height	0.032***	0.023***	0.023***	0.014**
	(0.007)	(0.007)	(0.007)	(0.007)
Age 7 Math (N=2,972)				
Height	0.017	0.007	0.009	-0.001
	(0.011)	(0.011)	(0.011)	(0.0011)
Height x *SH*	0.052*	0.049*	0.050*	0.047*
	(0.027)	(0.027)	(0.027)	(0.027)
SH	-0.084	-0.095	-0.075	-0.086
	(0.060)	(0.059)	(0.060)	(0.059)
Females				
Age 7 Reading (N=3,141)				
Height	0.040***	0.032***	0.032***	0.024***
	(0.007)	(0.006)	(0.006)	(0.006)
Age 7 Reading (N=3,141)				
Height	0.034***	0.025**	0.028**	0.019*
	(0.012)	(0.011)	(0.011)	(0.011)
Height x *SH*	0.023	0.027	0.019	0.023
	(0.024)	(0.024)	(0.024)	(0.024)
SH	0.097	0.113	0.086	0.103
	(0.114)	(0.112)	(0.113)	(0.111)
Age 7 Math (N=3,132)				
Height	0.032***	0.025***	0.023***	0.016**
	(0.007)	(0.007)	(0.007)	(0.007)
Age 7 Math (N=3,132)				
Height	0.032**	0.025*	0.024*	0.017
	(0.014)	(0.013)	(0.014)	(0.014)
Height x *SH*	-0.000	0.003	-0.003	0.000
	(0.026)	(0.026)	(0.026)	(0.026)
SH	-0.002	0.016	-0.009	0.010
	(0.117)	(0.115)	(0.117)	(0.115)
Parents' Education		X		X
Birthweight			X	X

Notes: Authors calculations from the NCDS. This table shows the results from regressions of the indicated variables on height, a dummy variable (SH) for height less than the average (69" for males and 64" for females) and an interaction term between this dummy variable and height, along with controls for age (single month) and region. Parental Education is single year dummy variables for the age at which the mother or father left school. Birthweight is a quadratic in reported birthweight. Robust standard errors in parentheses. ***, ** and * indicate statistical significance at the 10, 5, and 1 percent levels respectively.

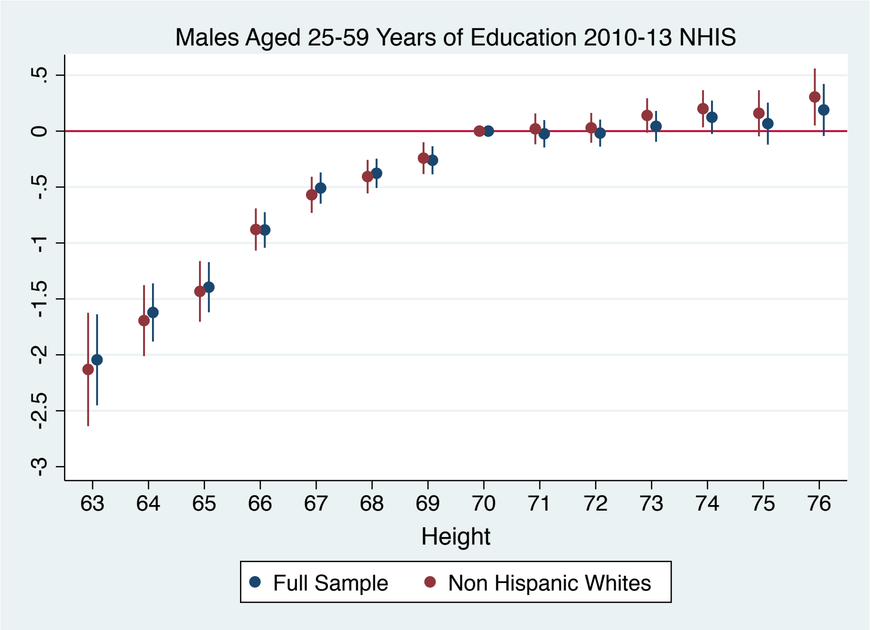
Table 10: The Relationship between Adult Height and Age 7 Cognitive Scores with and without controls for Birthweight, Parent's Height and Parent's Education, NCDS

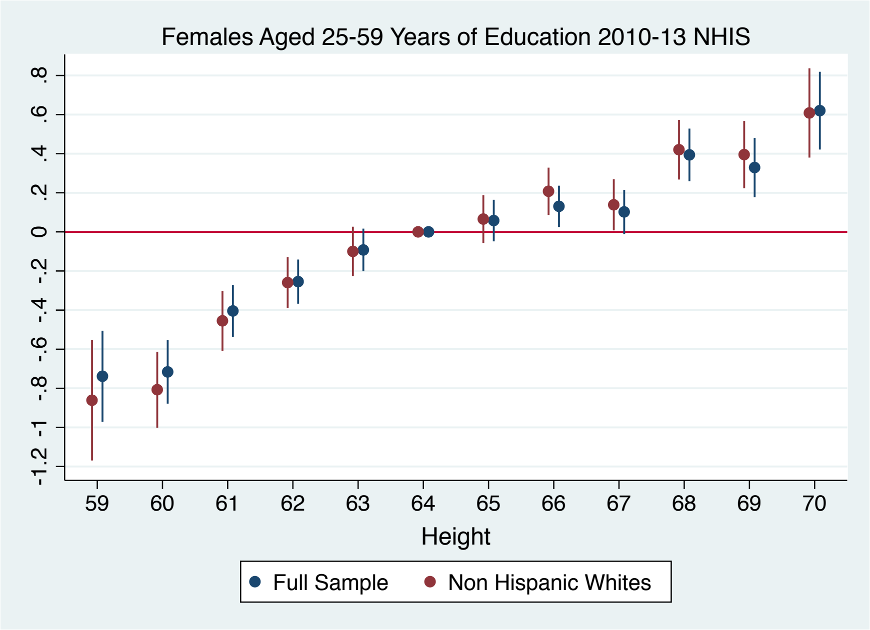
Males								
Age 7 Reading (N=2,602)								
Height	0.033***	0.025***	0.018**	0.026***	0.017	0.018**	0.011	0.011
	(0.007)	(0.007)	(0.009)	(0.007)	(0.009)	(0.007)	(0.009)	(0.009)
Age 7 Reading (N=2,602)								
Height	0.010	-0.001	-0.002	0.005	-0.006	-0.006	-0.007	-0.011
	(0.011)	(0.010)	(0.012)	(0.011)	(0.012)	(0.011)	(0.012)	(0.012)
Height x *SH*	0.040	0.036	0.031	0.038	0.029	0.034	0.028	0.027
	(0.030)	(0.030)	(0.031)	(0.030)	(0.031)	(0.030)	(0.031)	(0.031)
SH	-0.150**	-0.172***	-0.133**	-0.141**	-0.160***	-0.164***	-0.124**	-0.150**
	(0.060)	(0.060)	(0.061)	(0.060)	(0.060)	(0.059)	(0.061)	(0.060)
Age 7 Math (N=2,589)								
Height	0.032***	0.023***	0.019**	0.024**	0.017**	0.015**	0.011	0.009
	(0.007)	(0.007)	(0.009)	(0.007)	(0.009)	(0.007)	(0.009)	(0.009)
Age 7 Math (N=2,589)								
Height	0.019	0.005	0.006	0.011	0.000	-0.001	-0.001	-0.006
	(0.012)	(0.010)	(0.013)	(0.012)	(0.013)	(0.012)	(0.013)	(0.013)
Height x *SH*	0.040	0.039	0.037	0.039	0.037	0.038	0.036	0.036
	(0.029)	(0.028)	(0.029)	(0.029)	(0.029)	(0.028)	(0.030)	(0.029)
SH	-0.081	-0.105*	-0.076	-0.073	0.102	-0.096	-0.067	-0.092
	(0.064)	(0.063)	(0.065)	(0.064)	(0.064)	(0.063)	(0.065)	(0.063)
Females								
Age 7 Reading (N=2,725)								
Height	0.038***	0.030***	0.029***	0.032***	0.029***	0.024***	0.023***	0.023***
	(0.007)	(0.007)	(0.008)	(0.007)	(0.008)	(0.007)	(0.008)	(0.008)
Age 7 Math (N=2,718)								
Height	0.029***	0.023***	0.015*	0.020**	0.016*	0.014*	0.008	0.008
	(0.007)	(0.007)	(0.009)	(0.008)	(0.009)	(0.008)	(0.009)	(0.009)
Parents' Education		X			X	X		X
Parents' Heights			X		X		X	X
Birthweight				X		X	X	X

Notes: Authors calculations from the NCDS. This table shows the results from regressions of the indicated variables on height, a dummy variable (SH) for height less than the average (69" for males and 64" for females) and an interaction term between this dummy variable and height, along with controls for age (single month) and region. Parental Education is single year dummy variables for the age at which the mother or father left school. Birthweight is a quadratic in reported birthweight. Parents' heights are quadratics in mother's and in father's heights, respectively. Robust standard errors in parentheses. ***, ** and * indicate statistical significance at the 10, 5, and 1 percent levels respectively.

Appendix A: Results from the 2010-13 NHIS

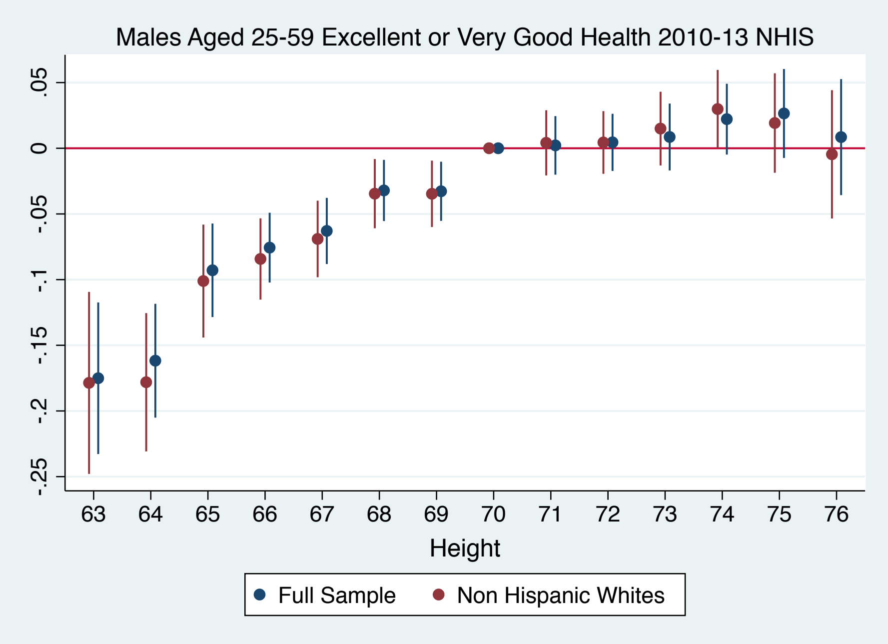
Figure A1: Males' and Females' Years of Educational Attainment by Height, NHIS

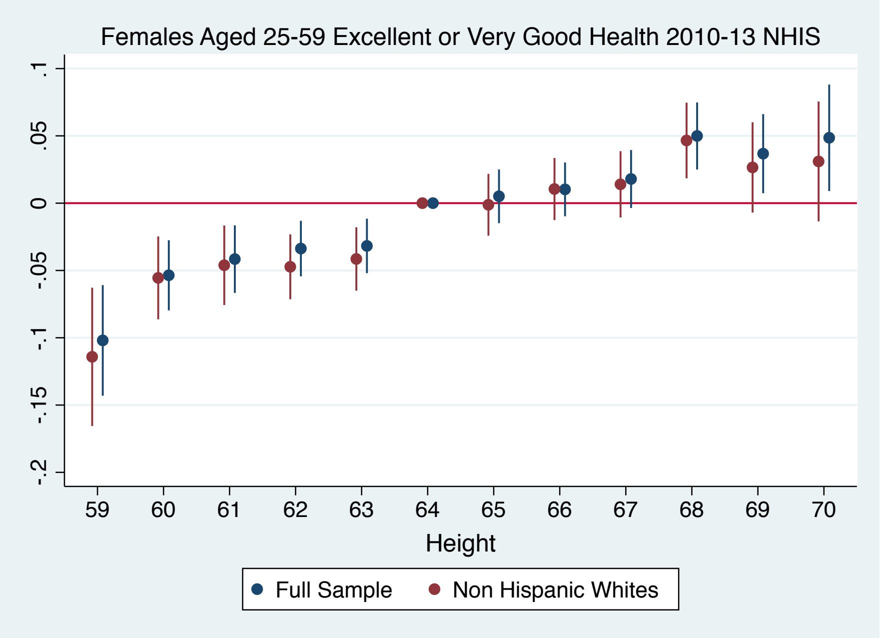




Notes: Authors calculations from 2010-13 NHIS. The reported parameters are estimates of single inch height dummy variables from a regression of the indicated outcome on height, age (single year), region, race/ethnicity (as applicable) foreign birth and indicators for survey year. Mean height (70' males, 64" females) is the omitted category. Robust 95 percent confidence intervals.

Figure A2: Males and Females Self Reported Health by Height, NHIS





Notes: Authors calculations from 2010-13 NHIS. The reported parameters are estimates of single inch height dummy variables from a regression of the indicated outcome on height, age (single year), region, race/ethnicity (as applicable) foreign birth and indicators for survey year. Mean height (70’ males, 64” females) is the omitted category. Robust 95 percent confidence intervals.

Appendix B: A Comparison of Self Reported and Exam Recorded Health in the NHANES

We use data from the 1999/2000 through 2013/2014 waves of the NHANES to investigate the potential implication of using self reported height in our NHIS analysis. We draw data from the "Demographic", "Body Measures" and "Weight History" files in each wave, and again select the sample of respondents between the ages of 25 and 59. NHANES is a much smaller survey of health outcomes, which includes both examination and survey components. Because height is captured in both components, the NHANES offers evidence of the error in self reported height, and has been used for this purpose in the past (e.g., Sahyoun et al. 2008, Merrill and Richardson 2009). That said, the NHANES has a complex sampling design and therefore depends significantly on weights to generate population levels estimates[44], and has a lower response rate than other health surveys (Czajka and Beyler 2016). Also, differences in the survey response reports of medical conditions in the NHANES have been shown to differ from those in other health surveys (Czajka and Beyler 2016).

Our primary concern is that the non linear height profiles we have uncovered are a result of errors in self reported height. In figure B1 we report height profiles, for males and females, of the proportion of respondents reporting less than a high school education, using alternatively examination recorded and self reported heights. As a point of comparison in figure B2 we report the corresponding profiles form the 1990-94 NHIS. Note that the comparison of the NHIS and NHANES figures is complicated by the wide span of survey cohorts we need to include from the NHANES data to generate sufficient sample sizes.

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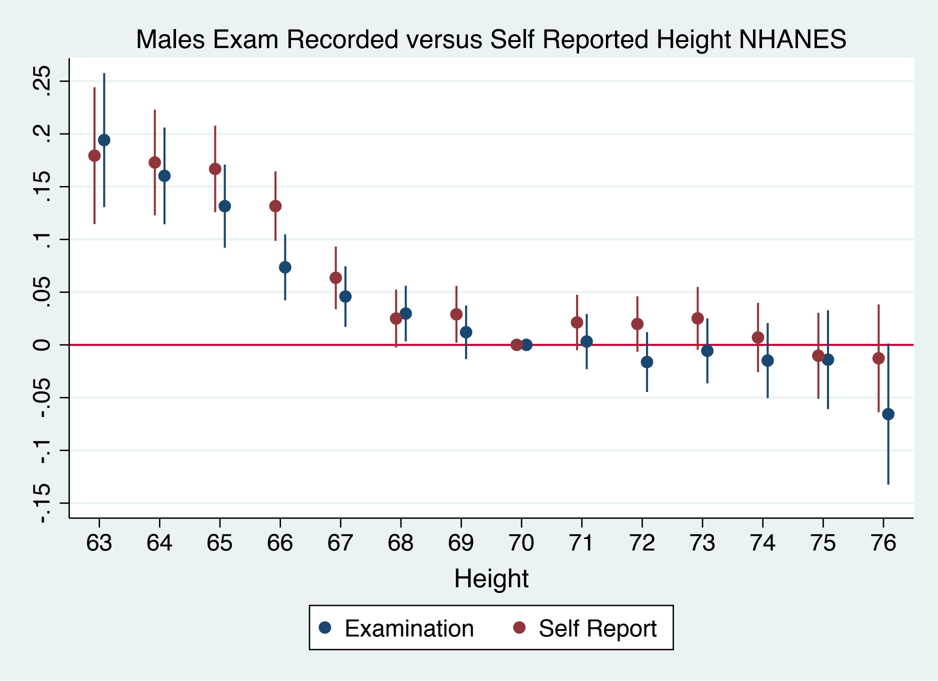
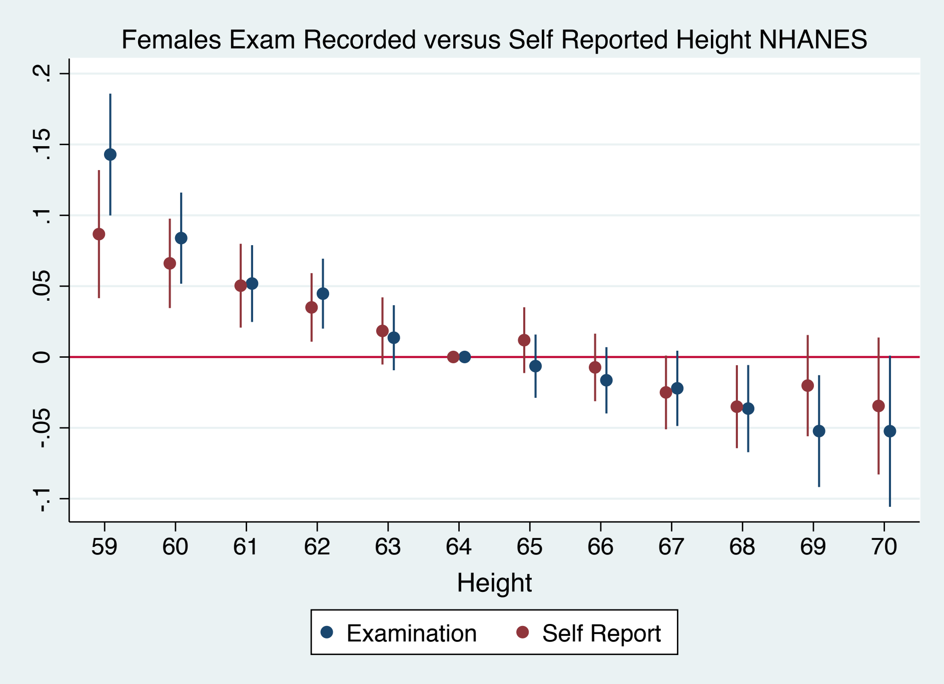
[44] For example, Hispanics and African American make up roughly one quarter each of the unweighted sample aged 25-59.

The NHANES source figure for males displays a similar non linear profile as in the NHIS data, regardless of the measure of height used. In terms of levels, the profile using self reported height lies above the exam recorded height profile, more often than not, especially at some of the shorter heights and the heights just above mean height.

For females the profile using either measure of height is more linear than for males, as it is the NHIS. If anything the profile using examination height displays more non linearity at shorter heights, but more generally both profiles tell a similar story

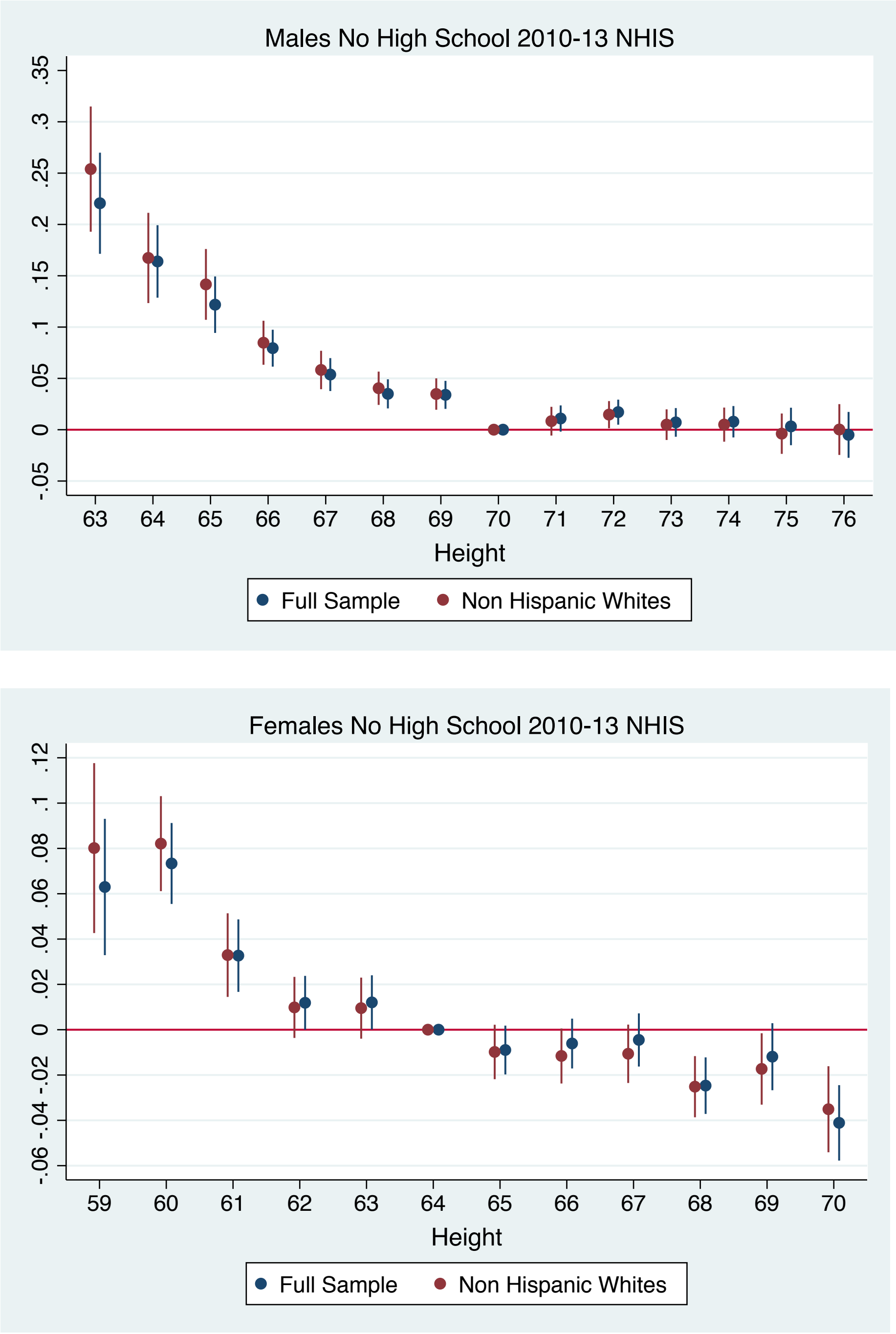
Figure B1: Males and Females Proportion with No High School by Height, NHANES





Notes: Authors calculations from the 1999/00 through 2013/14 NHANES. The reported parameters are estimates of height dummy variables from a regression of the indicated outcome on height, age (single year), race/ethnicity and indicators for survey year. Mean height (70' males, 64" females) is the omitted category. Robust 95 percent confidence intervals.

Figure B2: Males and Females Proportion with No High School by Height, NHIS



Notes: Authors calculations from 2010-13 NHIS. The reported parameters are estimates of single inch height dummy variables from a regression of the indicated outcome on height, age (single year), region, race/ethnicity (as applicable) foreign birth and indicators for survey year. Mean height (70' males, 64" females) is the omitted category. Robust 95 percent confidence intervals.

Appendix C: Does Parental Income or School Quality Mediate the AFQT/Height Relationship in the NLSY79?

To investigate the impact of family environmental factors on the adult height/AFQT profile we estimate (2) with AFQT as the dependent variable, with and without controls for 1979 family income, using the NLSY79 data. To help ensure that family income is capturing childhood inputs, we restrict the sample to respondents who were living in their parents' homes in 1979. The baseline estimates for this sample, with no control for parental income, are presented in columns (1) and (3) of table C1. The non-linear relationship between height and AFQT for males holds in this sample although the standard errors are larger due to the reduction in sample size. For females there is a switch in sign in the interaction effect indicating a flatter relationship between AFQT and height below the mean. In columns (2) and (4) are the estimates controlling for parental income. The estimates change very little for either sex. This evidence suggests that parental income plays a limited role in the relationship between height and AFQT scores in this sample.

Next we test whether school quality mediates the height/AFQT profile. In table C2 we present a corresponding set of regression estimates, this time conditioning on measures of the fraction of students who are disadvantaged; the fraction of students in different racial groups; dropout and attendance rates; enrollment; the number of teachers and counsellors; the number of books in the library; the fraction of teachers with graduate degrees; the fraction of teachers who left the school in the previous year; and starting teacher salaries.[45] Columns (1) and (3) show the baseline results for the sample with non-missing values for the school quality variables, while columns (2) and (4) show the results with the addition of controls. For males, adding school

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[45] The school quality measures are from the "background" section of the NLSY79 school transcript survey.

quality controls leads to a modest decline in the estimate of the interaction effect. For females, the estimate of the main linear effect of height well matches the estimate from the main sample and is unaffected by the additional controls. The estimate of the interaction effect, however, is smaller and switches sign adding the controls for school quality.

Table C1: The relationship between Adult Height and AFQT with and without controls for parents' income, NLSY79

	Males		*Females*	
Height	-0.337	-0.585	1.409**	1.310**
	(0.727)	(0.742)	(0.631)	(0.630)
Height x *SH*	2.075*	2.136**	-1.107	-1.200
	(1.073)	(1.048)	(1.048)	(1.048)
SH	-5.010	-4.659	-2.178	-2.791
	(3.635)	(3.517)	(3.075)	(3.176)
Parents' income		0.001***		0.000**
		(0.000)		(0.000)
N	1,139	1,139	1,085	1,085

Notes: Authors calculations from the NLSY79. This table shows the results from regressions of the indicated variables on height, a dummy variable (SH) for height less than the average (70" for males and 64" for females) and an interaction term between this dummy variable and height, along with controls for age (single year), region, and race/ethnicity. Regressions are weighted using sampling weights. In columns (2) and (4), we also add a control for family income in 1979. The sample is restricted to individuals who were living in their parents' home in 1979. Regressions are weighted using sampling weights. Robust standard errors in parentheses. ***, ** and * indicate statistical significance at the 10, 5, and 1 percent levels respectively.

Table C2: The relationship between Adult Height and AFQT with and without controls for school characteristics, NLSY79

	Males		*Females*	
Height	0.218	0.088	0.903*	0.921*
	(0.518)	(0.508)	(0.479)	(0.470)
Height x *SH*	2.373***	2.024**	0.097	-0.229
	(0.868)	(0.842)	(0.839)	(0.846)
SH	-0.698	-2.325	-0.412	-0.608
	(2.684)	(2.595)	(2.287)	(2.271)
School characteristics		X		X
N	2,049	2,049	2,165	2,165

Notes: Authors calculations from the NLSY79. This table shows the results from a regression of AFQT scores "height", "short" and a "height by short" interaction, along with controls for age (single year), region, and race (black and Hispanic indicators.). In columns (2) and (4), we also add controls for school characteristics. Regressions are weighted using sampling weights. Robust standard errors in parentheses. ***, ** and * indicate statistical significance at the 10, 5, and 1 percent levels respectively.