Published in final edited form as:

Econ Hum Biol. 2013 March ; 11(2): 178–184. doi:10.1016/j.ehb.2012.06.003.

The association of adolescent socioeconomic position and adult height: variation across racial/ethnic groups

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Abstract

Numerous studies have demonstrated the association of childhood socioeconomic position and adult height. Many have suggested the use of adult height as a marker of overall childhood well-being. However, few studies have examined the relationship between child/adolescent socioeconomic position and adult height in a racially/ethnically diverse cohort. Using the National Longitudinal Study of Adolescent Health, we examined the association of child/adolescent SEP (maternal education and maternal report of household income) and measured adult height in a diverse cohort of US adolescents/young adults. We found a positive gradient effect of maternal education on height in the overall population and in White and Mixed race males and females; no such gradient existed in Hispanic, Asian, or Black males or females. Only in Mixed race females was household income positively associated with height. These findings emphasize the need to recognize differential effects of socioeconomic status on height in different racial/ethnic and gender subpopulations.

Keywords

Height; childhood; socioeconomic position; race/ethnicity

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Conflicts of Interest: The authors have no conflicts of interest to report.

Contributor's Statement

All authors have contributed substantially to the conception and design, acquisition of data, or analysis; have drafted or critically revised the article; and have given approval of the final version to be published.

Financial Disclosures: Tracy Richmond is funded by the NIH Career Development Award (NICHD K01 HD058042).

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1. Introduction

Though adult height is largely predicted by genetics, there is ample evidence that environmental factors play a role. Classic studies dating back to the late 1800s established mid-parental height as highly predictive of the height of offspring, thus providing evidence for the influence of genetics (Galton et al., 1885; Pearson and Lee, 1903). Studies today have successfully begun to map particular genes that influence height (McEvoy and Visscher, 2009). However, the recognition of secular increases in height across diverse cohorts has provided evidence that genes alone cannot fully explain trends in individual measures of height (Komlos et al., 2007). A number of environmental factors influencing height have been identified including maternal health, child's nutrition, history of childhood illness, and childhood socioeconomic position (SEP) (Victora et al., 2008; Bozzoli et al., 2009; Li et al., 2004; Kuh and Wadsworth, 1989).

A growing body of literature has demonstrated the influence of childhood socioeconomic factors on adult height (Peck and Lundberg, 1995; Peck and Vagaro, 1987, Perkins 2011). Studies to date have examined cohorts in developing and developed countries (Meyer and Selmer, 1999; Webb et al., 2008a; Subramanian et al., 2011) and have used a number of different markers of childhood SEP (Tucker-Seeley and Subramanian, 2010). As the evidence linking childhood SEP and height has grown, there has also been increasing interest in height as a potential proxy for early childhood conditions—both social and physiologic. If height were a reliable measure of overall childhood conditions, adult height as a measure could obviate the need for long-term longitudinal studies examining the influence of childhood conditions on adult health outcomes. However, it is unclear if adult height has equal meaning across different racial/ethnic and gender groups in different countries.

Despite the large number of studies examining the association between childhood SEP and adult height, questions remain regarding the relationships in certain US populations. In particular, no studies of which we are aware have examined the association between child/adolescent SEP and adult height in US racial/ethnic groups beyond Whites and Blacks. The National Longitudinal Study of Adolescent Health (Add Health) provides a diverse population of young adults in which to examine the association of child/adolescent SEP and adult height. Add Health is a US-based nationally representative cohort of students in grades 7–12 at baseline (Wave I collected in 1994–95). Participants have been followed prospectively across four waves of data collection to date (Wave II collected in 1995–96, Wave III collected in 2001–2002, Wave IV collected 2007–2008).

The objective of our study was to determine if child/adolescent SEP measured by maternal education and maternal report of household income (at Wave I when participants were aged 12–19 years) has similar associations with adult height (at Wave III when participants were aged 19–26 years) in males and females of different races/ethnicities (i.e. are the associations of SEP and adult height modified by gender and race/ethnicity?)

2. Population and Methods

2.1 Study Population

This study uses data from Waves I (collected in 1994–5 when participants were aged 12–19 years, n=20,745) and III (collected in 2001–2 when participants were aged 19–26 years, n=15,197) of Add Health, a nationally representative longitudinal study of adolescents originally sampled from schools, the primary sampling unit (Harris et al., 2009). Schools were sorted by size, school type, census region, level of urbanization, and the percentage of the student body that is White prior to sampling. Implicit stratification and systematic

sampling methods were used to ensure the sample was representative of all US schools (Harris et al., 2009). All of the students within a chosen school were asked to participate in an In-School survey (the In-School survey was collected only once, at baseline--Wave I) and all were eligible for the In-Home survey (In-Home surveys were performed prospectively at Waves I–IV and are ongoing). Students were stratified by gender and grade and then randomly selected for the Wave I In-Home survey. Students who were seniors in high school (i.e. in their final year of high school) at the time of Wave I were not eligible for the Wave II In-Home Survey but were eligible for subsequent In-Home surveys. Non-seniors at the time of Wave I were eligible for all subsequent In-Home surveys. The final In-Home Sample in Wave I (n=20,745) was derived from 132 schools. This sample was made up of, on average, 200 students per school with the exception of the 16 schools in which the entire student body was sampled. The sample included specific over-samples including an over-sample of Puerto Rican, Chinese, and Cuban adolescents and Black adolescents from high-education families.

Of the 20,745 participants in Wave I, 15,197 were reached and agreed to participate in Wave III. (Please see Chantala et al for further information regarding the reasons for attrition as well as for information about response bias). Of the 15,197 Wave III participants, 14,322 had sample weights. These 14,322 participants with longitudinal weights made up our initial sample population. We then excluded those individuals missing data on key variables or with implausible values. We excluded the 133 participants who were missing data on height at Wave III. Participants with weight less than 50 pounds or greater than or equal to 500 pounds were excluded due to concerns about implausibility as well as the potential for a condition that might affect both height and weight. Additional exclusions were those missing household size (n=670) as it was needed to calculate one of our markers of SEP and race/ethnicity (n=11). There was considerable overlap in those missing values for particular variables (i.e. those missing information on one variable often were missing information on additional variables). The total excluded due to missing data (after having excluded those missing sampling weights) was 814. Due to concern about the heterogeneity in our outcome variable, height, among foreign-born participants, we additionally eliminated foreign-born subjects from our analysis (Rosenbaum, 2005). After excluding all participants with missing values described above, an additional 1,141 foreign born participants remained, and were therefore excluded. After excluding these participants, we were left with a core sample of N=12,367.

The response rate for the parent questionnaire was 85% for the child-specific data. Of those who participated, a number of parent respondents refused to provide information regarding household income or maternal education leaving 23% of our final sample with no information on household income and 13% of our final sample without information on maternal education. To decrease bias due to listwise deletion (King, 1998), we imputed both maternal education and maternal report of household income by Gaussian normal regression imputation method (further details provided below). After our imputation of parental variables and all exclusions our final sample contained 12,367 adolescents and young adults.

2.2 Study Variables

Outcome variable

Adult height: Our primary outcome variable was adult height (in) objectively measured as part of the Wave III In-Home study protocol when participants were aged 19–26.

Independent variables

Child/adolescent SEP: Our primary predictor variables were markers of child/adolescent SEP: maternal report of highest education level achieved and maternal report of household

income converted into a measure relative to the federal poverty level, each measured at Wave I when participants were aged 12–19. As noted above, the response rate for the parental questionnaire overall was 85% and the response rate to the questions regarding SEP was even lower. In an attempt to reduce bias from listwise deletion, we imputed values for both maternal education and household income using best subset regression (Stata Corp. Help for impute.). We used Census variables describing the neighborhood educational and income makeup, individual race/ethnicity, parental responses about need for assistance, and individual health characteristics to impute both income and maternal education. 23% of our final sample had an imputed value for household income while 13% of our final sample had an imputed value for maternal education. We performed sensitivity analyses with an imputed sample and a non-imputed sample to compare findings and found negligible differences (see appendix Table 1A) so present only findings for our imputed sample.

At Wave I the mother or female guardian was asked to report her highest education level with responses ranging from less than 8th grade to professional training beyond college. After the imputation described above, we categorized this variable into 4 categories: less than high school education; high school/vocational/or high school equivalent; some college but not college graduate; completed college or beyond. Additionally, the mother or female guardian was asked, “About how much total income, before taxes, did your family receive in 1994? Include your own income, the income of everyone else in your household, and income from welfare benefits, dividends, and all other sources” and responses were on a continuous scale with a range from \$0–999,000. Due to the large percentage of missing values, we imputed this variable as described above. We created a poverty index ratio variable by comparing the reported household income to the poverty level in 1995 for each household size (US Census Bureau, 1995). Household size was constructed from a series of questions asking about household members. Participants provided information about their relationship with each member of their household but did not provide ages of those living with them. Thus, we were unable to estimate the number of children in the household accurately and chose instead to use the weighted poverty thresholds for each *overall* household size provided by the Census rather than the thresholds relating to the number of children and parental structure (US Census Bureau, 1995).

Additional demographic variables: We also examined the effects of individual race/ethnicity on the association between our primary predictors and our outcome variable. Individual race/ethnicity was constructed to mirror current US Census definitions of race/ethnicity (Humes, 2011). First participants were asked if they were of Hispanic ethnicity. If they answered yes they were considered Hispanic regardless of which race category (ies) they chose. The Hispanic category was made up of a number of subpopulations including Mexican-Americans, Puerto Ricans, Central and South Americans, and Other Hispanics. All participants, regardless of whether they responded that they were of Hispanic ethnicity or not, were next asked to choose among racial categories: White; Black or African-American; American Indian or Native American; Asian or Pacific Islander; and Other. Those who chose more than one racial category were considered Mixed race and were combined with the Other category to form one “Mixed” category. The three most common racial/ethnic combinations in the “mixed” category were White and Black, White and Asian, and White and Native American. These three racial/ethnic combinations made up more than 80% of the Mixed category. We additionally examined the effect of gender on the association of child/adolescent SEP and young adult height and adjusted for age.

2.3 Analyses

We first examined univariate distributions and performed bivariate analyses of our variables of interest. Our bivariate analyses were exploratory examinations of relationships between

our predictor variables of interest and individual race/ethnicity and helped identify potential confounders. We first tested for effect modification of the association of child/adolescent SEP and height by gender and race/ethnicity in models adjusting for age. We ultimately identified the need for gender- and race/ethnicity-stratified multiple linear regression models (models controlling for more than one covariate) to examine the association of Wave I child/adolescent SEP (maternal education and household income as poverty income ratio) and Wave III height, controlling for age. All analyses were conducted in STATA SE 12 (College Station, TX) and were adjusted for the complex survey design using svy commands (STATA Corp. Stata help for svy). We applied sampling weights to account for the unequal likelihood of being sampled in certain populations.

3. Results

Results of univariate analyses

The mean age for females at Wave III was 21.8 and for males 21.9 years. The average measured height for females was 64.3 inches and for males 70.2 inches. The mean maternal reported household income was \$45,100 and the mean poverty income ratio was 371% or 3.71 times the federal poverty level for the participant's household size. In our sample with imputed values for markers of child/adolescent SEP, approximately 14% of the mothers/female guardians reported less than high school education, 36% reported high school education or its equivalent, 30% reported attending some college but not graduating, and 20% reported having a college degree or beyond.

Results of bivariate analyses

Table 1 shows demographic and anthropometric characteristics by gender and race/ethnicity. Because of the small sample size of Native Americans/American Indians (45 males, 49 females), we have not included those values in any of our Tables. Hispanic and Asian males and females were significantly shorter than their White peers as were Native American/American Indian males. A higher percentage of Whites and Asians had mothers or female guardians with a college degree compared to other racial/ethnic groups; they also had higher reported household incomes compared to other racial/ethnic groups.

Figures 1 and 2 show the unadjusted heights for each maternal education category for the overall population as well as broken down into gender-specific racial/ethnic groups. For ease of presentation we opted to show only the three largest racial/ethnic groups. The White males and females follow the pattern of the overall sample with an incremental increase in height with greater maternal education. Neither the Blacks nor the Hispanics demonstrate similar patterns. Hispanic females appear to have a threshold effect of education on height with those having a mother or female guardian with at least a college degree appearing to be on average approximately 1 inch taller than those with less than a high school education.

Results of multivariate analyses

We began our multivariate analyses by examining the improvement in fit or lack thereof with the addition of different interaction terms to our models. We began with the overall sample—males and females together—to determine whether there was justification for gender stratification. In our models including males and females together, we found differences in the association of child/adolescent SEP and height in males versus females justifying our subsequent gender stratification. We then examined the fit of the model with and without the interaction terms of race/ethnicity and household income and found improvement of fit ($p=0.025$), providing evidence of effect modification of the association of household income and height by race/ethnicity and justifying our stratification by race/ethnicity. Thus, having found the most parsimonious models, we ultimately used gender-

and race/ethnicity-stratified models to examine the associations of the different markers of SEP across gender specific racial/ethnic groups.

Table 2 presents the results of our final models--gender and race/ethnicity stratified models examining the association of child/adolescent household income and maternal education with height measured in inches as our continuous outcome controlling for age. The association between maternal education and adult height varied across gender and racial/ethnic groups. Among White males and females, having a mother or female guardian with some college experience or a college education or beyond was associated with on average more than ½ an inch greater height when compared to those whose mother or female guardian had less than a high school education though this association was not significant in males whose mothers had only some college. The effect sizes appeared even larger in the Mixed race participants. Mixed race females with a mother or female guardian who had completed college or more had an adult height on average 1.7 inches greater than their peers with mothers or female guardians who did not complete high school ($p<0.05$). In the Mixed race males, the height differential was larger. Those Mixed race males with mothers or female guardians with more than a college degree had heights on average nearly 2 ½ inches greater than those with mothers or female guardians reporting less than a high school diploma ($p<0.05$). Native American/American Indian males also had a significant height differential associated with maternal education though Native American/American Indian females had no significant association between maternal education and adult height. Among Hispanics, only in females, was there a significant association noted and it was only in those whose mothers or female guardians had completed college when compared to those whose mothers had less than a high school education.

The association between child/adolescent household income as the poverty income ratio and adult height was less consistent with statistically significant associations only in Mixed race females. There was no age effect in any of the racial/ethnic or gender subgroups.

4. Discussion

In this nationally representative US study of an ethnically diverse cohort of young adults we found variability in the relationship of child/adolescent SEP and adult height in different gender and racial/ethnic subpopulations. We found no association of maternal education and adult height in Hispanic males, Native American/American Indian females, or Black, or Asian participants and only in Mixed race females was there a significant positive association between adolescent household income and adult height. These findings differ from many previous studies that demonstrated a positive association between child/adolescent SEP and adult height (Singh-Manoux et al., 2010, Komlos and Baur, 2004). However, our study includes a more racially/ethnically diverse population and is the first to our knowledge to examine associations in a Hispanic population that includes sub-groups beyond Mexicans, as well as Asian, Native American/American Indian, and Mixed race populations.

Our findings reflect other studies that have demonstrated a diminishing socioeconomic gradient effect on height in developed countries (Rona et al., 2000; Gulliford et al., 1991). There has been speculation that countries with increasing standards of health have non-significant differences in height between different socioeconomic groups. However, in our sample, we find the greatest gradient effect of maternal education on adult height in the traditionally healthiest and most advantaged group, White males and females as well as in those who are Mixed race (a large portion of whom self-identify as biracial White plus another race/ethnicity). Our findings add to a body of literature that has found inconsistent relationships between markers of socioeconomic position and health in different racial/

ethnic groups and across different health domains. In their study examining a number of different child and adult outcomes, Braveman et al. found striking socioeconomic gradients in Blacks and Whites for most outcomes (Braveman et al., 2010). However, there was less evidence of a socioeconomic gradient effect on health in Hispanics. Other studies have demonstrated heterogeneity in the association between socioeconomic markers and weight status in different racial and ethnic populations (Sanchez-Vaznaugh et al., 2009; Wang and Beydoun, 2007). It is unclear why there are differential effects of SEP on health in different racial/ethnic groups and this differential effect warrants further attention.

This study has limitations which should be noted. First, parental height was not available and thus is a major influence for which we could not adjust. Second, our primary predictor variables relied on maternal self-report at the time that the participants were already at least in 7th grade. We could anticipate significant change in the household income from the time the participant was a young child to the time of maternal report. This could explain our largely null findings relative to the association of maternal report of childhood household income and adult height. However, we would expect very little change in maternal education between the participant's birth and the time of maternal report. There was also a large percentage of missing data in the maternal reported income and education variables due to non-participation by a number of parents as well as parental refusal to provide information. However, we attempted to remedy the issue of missing data by using imputation techniques. A final limitation is our inability to establish a causal relationship between child/adolescent SEP and adult height with the data available. Our findings should be viewed as an initial exploration of associations.

Given the increasing desire to treat adult height as a proxy for childhood experiences including psychological, medical, and socioeconomic well being, it is important to understand how childhood circumstances may impact height in different racial/ethnic subpopulations. Our findings emphasize the need to exercise caution when using adult height as a proxy for childhood circumstances in a diverse cohort.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This research uses data from Add Health, a program project directed by Kathleen Mullan Harris and designed by J. Richard Udry, Peter S. Bearman, and Kathleen Mullan Harris at the University of North Carolina at Chapel Hill, and funded by grant P01-HD31921 from the Eunice Kennedy Shriver National Institute of Child Health and Human Development, with cooperative funding from 23 other federal agencies and foundations. Special acknowledgment is due Ronald R. Rindfuss and Barbara Entwisle for assistance in the original design. Information on how to obtain the Add Health data files is available on the Add Health website (<http://www.cpc.unc.edu/addhealth>). No direct support was received from grant P01-HD31921 for this analysis.

Tracy Richmond is supported by the National Institutes of Health Career Development Award (NICHD K01 HD058042).

Abbreviations

Add Health	National Longitudinal Study of Adolescent Health
SEP	socioeconomic position

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Highlights

Childhood socioeconomic position appears to have a gradient effect on adult height.
However, this effect is not consistent when examining racial/ethnic subpopulations.
Childhood SEP has no effect on adult height in Asians, Blacks, and Hispanics.

Figure 1.
Average height (inches) in males of different races/ethnicities by categories of maternal education

Figure 2.
Average height (inches) in females of different races/ethnicities by categories of maternal education

Table 1
Demographic and anthropometric characteristics of participants by race/ethnicity: results of bivariate analyses

	Whites (N=3282)	Blacks (N=1172)	Hispanics (N=846)	Asians (N=272)	Multi-racial (N=214)
MALES					
Wave III height	70.4±0.1	70.3±0.1	68.9±0.2 *	68.2±0.4 *	70.2±0.3
Maternal Edu					
Less than HS	9%	15%	36%	8%	9%
HS equivalent	37%	41%	33%	24%	38%
Some college	32%	29%	23%	33%	39%
College plus [^]	22%	15%	8%	35%	14%
Household inc ⁺	49.4±1.7	29.2±1.6 *	37.6±3.3 *	55.6±4.1	43.5±2.7 *
Poverty inc ratio	4.1±0.2	2.39±0.1 *	2.9±0.2 *	4.0±0.4	3.4±0.3 *
% below poverty	8%	26% *	21% *	2% *	8%
Age	21.9±0.1	22.1±0.2	21.9±0.2	21.6±0.3	21.7±0.3
% Male	51%	50%	52%	58%	53%
FEMALES					
Wave III height	64.5±0.1	64.3±0.1	63.2±0.2 *	62.5±0.4 *	64.5±0.2
Maternal Edu					
Less than HS	10%	18%	35%	15%	15%
HS equivalent	39%	44%	39%	24%	34%
Some college	31%	25%	18%	31%	34%
College plus [^]	21%	12%	8%	30%	17%
Household inc ⁺	50.7±2.0	28.3±1.4 *	36.6±2.4 *	66.3±8.3	39.2±2.2 *
Poverty inc ratio	4.2±0.2	2.3±0.1 *	2.7±0.2 *	4.9±0.7	3.30±0.2 *
% below poverty	9%	29% *	19% *	9%	15%
Age	21.7±0.1	22.0±0.2	21.7±0.22	21.8±0.31	21.7±0.19
% Female	49%	50%	48%	43%	47%

* For continuous variables, $p < 0.05$ indicates significantly different from Whites

^Δ Indicates those who completed college or beyond

[‡] Household income is presented in thousands of dollars

Table 2

The association of child/adolescent SEP (maternal education and household income) and adult height across racial/ethnic and gender groups.[#]

	Whites (β coeff)	Blacks (β coeff)	Hispanic (β coeff)	Asian (β coeff)	Mixed (β coeff)
FEMALES					
Maternal Edu^d					
High school	0.3 (-0.2, 0.8)	-0.4 (-0.9, 0.1)	0.2 (-0.5, 0.9)	0.4 (-1.8, 2.5)	1.6 ^b (0.5, 2.7)
Some college	0.6 ^a (0.1, 1.1)	-0.3 (-1.0, 0.2)	0.1 (-1.0, 1.0)	0.2 (-1.5, 2.0)	1.3 ^a (0.2, 2.4)
College grad	0.7 ^a (0.2, 1.2)	-0.2 (-1.0, 0.6)	1.3 ^a (0.3, 2.3)	1.2 (-0.8, 3.1)	1.7 ^a (0.1, 3.2)
Household inc^a	0.0 (0.0, 0.0)	0.0 (-0.1, 0.1)	-0.0 (-0.1, 0.1)	0.0 (-0.1, 0.2)	0.1 ^a (0.00, 0.3)
MALES					
Maternal Edu^d					
High school	0.1 (-0.3, 0.6)	-0.3 (-1.3, 0.8)	0.1 (-0.7, 0.8)	-1.0 (-3.8, 1.9)	1.2 (-0.9, 3.4)
Some college	0.5 (0.0, 1.0)	-0.6 (-1.6, 0.5)	-0.7 (-1.6, 0.2)	-0.1 (-2.8, 2.7)	2.1 ^a (0.3, 3.9)
College grad	0.6 ^a (0.1, 1.2)	-0.4 (-1.5, 0.8)	-0.1 (-1.4, 1.2)	-0.5 (-3.4, 2.4)	2.4 ^a (0.1, 4.8)
Household inc^a	0.0 (-0.0, 0.1)	0.1 (-0.0, 0.2)	0.1 (-0.0, 0.2)	0.06 (-0.2, 0.3)	0.0 (-0.1, 0.2)

^{a, b, c} denote significance at $P < 0.05$, $P < 0.01$, and $P < 0.001$, respectively.

^d denotes less than high school education is reference category. Additional education categories are high school, some college, college graduate or beyond

^a Household income is measured as the poverty income ratio

[#]This table presents results of our gender- and race/ethnicity-stratified multiple regression models without imputed values and adjusting for age