

Race and Gender Differences in Cognitive Effects of Childhood Overweight

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Abstract: The increase in the prevalence of overweight children (ages 6-13) in the United States over the past two decades is likely to result in adverse public health consequences. We use data from the children of the NLSY79 to investigate an additional consequence of childhood overweight – its effect on relative cognitive development. To control for unobserved heterogeneity, we estimate individual (child) fixed effects models and instrumental variables models. Although recent research suggests that there is a negligible effect of childhood overweight on cognitive ability, our results demonstrate that the effects are uncovered when examining the relationship separately by race. In particular, we find that overweight white boys have math and reading scores approximately a standard deviation lower than the mean. Overweight white girls have lower math scores while overweight black boys and girls have lower reading scores. Our results suggest that in addition to well-documented health consequences, overweight children may also be at risk in terms of experiencing adverse education outcomes which could lead to lower future wages.

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I. INTRODUCTION

In the United States the prevalence of overweight children has increased dramatically over the past two decades creating public health problems (Hedley et al. 2004; Dietz 1998; Schwimmer et al. 2003). Recent research has concluded that overweight has little to no effect on cognitive development (Kaestner and Grossman, forthcoming). We use data from the children of the National Longitudinal Survey of Youth 1979 cohort (NLSY79) to demonstrate that there is an effect which varies by the race and gender of the child.

II. DATA

We use data from the NLSY79 (<http://www.bls.gov/nls/nlsy79.htm>), a panel study of approximately 12,000 individuals who were first interviewed in 1979 when they were between the ages of 14 and 22 and were re-interviewed annually from 1979-92 and bi-annually since 1994. Our analysis focuses on the children (ages 6-13) of the original NLSY79 female respondents and includes data through the 2002 survey year when the mothers were between the ages of 37 and 45 and the children ranged in age from 3 to 15. Anthropometric measures of height and weight were recorded bi-annually for each child beginning in 1986. We exclude from the analysis the approximately 20% of the cases in which these were not measured, but were reported by the child's mother. We measure overweight with the Body Mass Index (BMI), a standard metric in the literature. In order to compare BMI across age and gender cohorts, normalized BMI z-scores (hereafter BMIZ) are calculated using the Nutstat module of the CDC's Epi-Info software. An overweight child has a BMIZ score in excess of 1.65.

Our measures of cognitive development are the math and reading recognition scores from the Peabody Individual Achievement Tests (PIAT) (Dunn and Barkwardt Jr. 1970) administered

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to children ages 5 and over. The PIAT are among the most widely used brief assessments of academic achievement and are individually administered measures of academic achievement. Given that we use standardized scores for both of these tests (i.e. the age-specific mean is 100 and the standard deviation of 15), the appropriate way to interpret them is as a measure of performance relative to normal development.

III. CHILDHOOD OVERWEIGHT AND COGNITIVE DEVELOPMENT

There are various avenues through which childhood overweight may affect relative cognitive development. Overweight children may suffer from deficiencies of nutrients that are understood to be important for the physical development of the brain (Taras, 2005 and Nead et al. 2004). Sleep apnea and asthma are also more common among overweight children and may interfere with cognitive performance (Luder et al., 1998). Low self-esteem that may follow from being overweight can lead to lower academic performance or to a perceived inability to perform well in school (Datar et al. 2004, Swartz and Puhl, 2003, Davison and Burch 2001). In addition, overweight children are more likely to be more socially isolated compared to adolescents who are not overweight (Strauss and Pollack 2003), more likely to have behavior problems (Datar and Sturm 2004), and more likely to act as bullies, and to be bullied (Janssen et al. 2004). Finally, the social functioning of overweight children is likely to be reduced so much that Schwimmer et al. (2003) compare their quality of life to those of children with cancer.

IV. THEORY AND ESTIMATION STRATEGY

The theoretical foundations for modeling cognitive ability are based on integrating health and cognitive ability production functions into a common-preference model of household decision-making in the tradition of Becker (1981). The full model is presented in Averett and Stifel (2007). Our estimation strategy can be summarized by the following equation:

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$$c_{it} = \alpha + \mathbf{X}_{it}'\boldsymbol{\beta} + \mathbf{w}_{it}'\boldsymbol{\gamma} + \varepsilon_{it} \quad (1)$$

where c_{it} is a measure of the relative cognitive ability for child i at time t , \mathbf{X}_{it} is a vector of individual-level, family-level and community-level observables, and \mathbf{w}_{it} is a vector of measures of BMI for child i at time t . The vector of parameters of interest is $\boldsymbol{\gamma}$. We estimate (1) by Ordinary Least Squares (OLS) where BMIZ enters as a dummy variable indicating if the child is overweight (i.e. BMIZ > 95th percentile).

However, OLS estimates of model (1) provide unbiased estimates of $\boldsymbol{\gamma}$ only if the child's BMIZ is exogenous, that is it is uncorrelated with the error term (i.e. $E(\varepsilon|\mathbf{w}) = 0$), and the direction of causality goes from BMIZ to cognitive development. If these conditions do not hold, then the OLS estimator will be biased. There are two general reasons why we might expect such a bias.

First, there may be omitted variables such as those unobserved characteristics that simultaneously determine cognitive ability and BMIZ. In such a situation, changes in these unobservable characteristics lead to coincidental changes in BMIZ and cognitive development, leading us to find a spurious relationship between BMIZ and test scores. An example of one such unobservable is parental behavior. Datar et al. (2004) found that overweight kindergartners were more likely to come from poor families in which the parents did not read to their children or encourage good academic performance. This makes it difficult to determine if being overweight is truly the cause of the poor academic performance, or if poor parenting or some other factor is the cause of both the overweight and the poor academic performance. Unobserved school characteristics may also lead to biased estimates as they may be an important determinant of both academic achievement and BMIZ (Crosnoe and Mueller, 2004). To deal with this

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unobserved heterogeneity, we estimate individual fixed-effects (FE) models. In an individual-fixed effects model, equation (1) becomes

$$C_{it} = \alpha + \mu_i + X_{it}'\beta + w_{it}'\gamma + \varepsilon_{it} \quad (2)$$

where μ_i is a child-specific dummy variable, and X_{it} now includes only those explanatory variables that are not fixed over time. The effectiveness of the fixed effects estimator in reducing the bias in γ depends on the unobservable characteristics that affect both nutritional outcomes and cognitive development being fixed over time and consequently differenced out.¹

Second, the direction of causality may go both ways. For example, while being overweight may cause low self-esteem, depression or other adverse health outcomes and consequently low cognitive development, depression (which may stem from low cognitive ability) may be a cause of overweight (Goodman and Whitaker 2002). Another method of establishing causality is instrumental variables (IV) estimation. This method involves estimating a (set of) first stage equation(s),

$$w_{it} = \theta + X_{it}'\phi + Z_{it}'\lambda + v_{it} \quad (3)$$

where w is the child's BMIZ score and Z is a set of instrumental variables that are excluded from equation (1). Values for BMIZ predicted using the parameter estimates from the first stage estimation (3), \hat{w}_{it} , are then used as an explanatory variable in model (1) instead of observed BMIZ, w_{it} ,

$$C_{it} = \alpha + X_{it}'\beta + \hat{w}_{it}'\gamma_{iv} + \varepsilon_{it} \quad (4)$$

This approach not only addresses the concern of reverse causality, but also, because the instruments are uncorrelated with the error term, it removes biases in the estimator due to unobserved heterogeneity. The difficulty, of course, is finding suitable instruments that explain nutritional outcomes, but not academic achievement.

The strong genetic component of child weight (Cawley 2004; Stunkard et al. 1986; Volger et al. 1995) indicates that a potential instrument is the mother's BMI. To minimize the

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possibility that mother's BMI is correlated with the error term in the second stage, we use an historical measure of mother's BMI from 1981.² For nearly all of the cases in our sample, this BMI measurement was taken before the birth of the mother's first child, and as such is more likely to measure the genetic component of child weight than does the contemporaneous measure of mother's BMI. A simple regression of mother's contemporaneous BMI on her 1981 BMI reveals that only 42 percent of the variation in current BMI is explained by historical levels. Nonetheless, we also include as control variables proxies for unobserved household environment and mother's unobserved abilities and attitudes that may be more/less favorable to cultivating higher academic achievement. These proxies include a dummy variable indicating if the child was breastfed, average household income since the child was born, and the mother's AFQT score and education level. Parental weight status is also used by an instrument for child's BMI by Sabia (2007) in his examination of the effect of adolescent obesity on GPA.

VI. RESULTS

Our estimating sample consists of 20,856 child years. Table 1 presents the results from estimates from the naïve OLS estimates which ignore the potential endogeneity of BMI, individual FE estimates which net out time-invariant heterogeneity and IV models which also control for reverse causality.

The OLS results indicate that overweight black and white children have lower math scores and that overweight black children also have lower reading scores. In the FE models, the coefficients are smaller and insignificant with the sole exception of black girls who score significantly lower on reading tests if they are overweight. The IV models indicate that overweight white girls and boys have lower math scores. For white boys, the coefficient is quite large at -18.74, but for white girls, it is -5.96. Overweight white boys also have standardized

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reading scores 11.44 points lower than white boys who are not overweight. But overweight white girls do not have reading scores that are statistically different from white girls who are not overweight. Overweight black girls and boys do not have significantly lower math scores, and the coefficients are much smaller than those for whites. But their reading scores are about 12 points lower on average than their non-overweight counterparts.

The validity of our IV results depends on how well our instruments perform. In the first stage of the IV estimation (results available upon request), mother's BMI and BMI squared (measured in 1981) are significant predictors of a child's BMIZ score both individually and jointly. The p-values on the F-statistics testing their joint significance are all less than 1 percent. Further, the other coefficient estimates in the first stage for the IV model are of the expected signs and magnitudes. The large Cragg-Donald statistics and Anderson-Rubin *F*-statistics suggest that IV estimation is predictable enough to provide consistent parameter estimates (Murray 2006; Stock and Yogo 2005). Because we use an early measure of the mother's BMI, it is not surprising that it passes the overidentifying restrictions tests. And, we note that mother's BMI has successfully been used as an instrument for child's BMI by Sabia (2007) in an examination of the effect of adolescent obesity on adolescent GPA. Although the coefficients in the IV models for whites are larger than the fixed-effects and OLS coefficients, they are not unreasonably large. Given that we use the standardized scores, they are telling us that scores are roughly one standard deviation lower for overweight children. Our first stage F-statistics are large enough that the finite-sample bias of instrumental variables—which biases the IV estimate toward the OLS estimate—is unlikely to be a serious problem in our IV regressions.

The parameter estimates for the other explanatory variables are as we might expect and are available upon request.

VII. CONCLUDING REMARKS

We used data from children born to the women in the NLSY79 to address whether being overweight *causes* lower cognitive ability. Our IV estimates suggest that obese white boys have math and

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reading test scores that are on average about one standard deviation below those of their peers. Overweight white girls also have lower math scores but the magnitude of the effect is about 1/3 that of overweight white boys. Overweight black boys and girls have significantly lower reading scores but not lower math scores. These findings underscore the importance of disaggregating by race and gender when examining the effect of childhood overweight on cognitive ability. A fruitful path for future research would be to determine the mechanism behind the path from overweight to lower test scores. Is it depression or discrimination from teachers? Is it a lack of essential nutrients brought on by eating a diet too high in fat and calories but nutritionally empty? These are important questions for future research.

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Table 1: OLS, Fixed-Effects and IV Estimates of the Effect of Being Overweight on Math and Reading Scores by Race and Gender (Ages 6-13)

	White Girls						White Boys					
	OLS		Fixed Effects		IV		OLS		Fixed Effects		IV	
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
PIAT Math												
Overweight dummy (bmiz > 1.6449)	-1.85	-2.09 **	-0.76	-1.22	-5.96	-1.96 **	-1.93	-2.04 **	-1.18	-1.85 *	-18.74	-4.03 ***
R-squared	0.17		0.01		0.14		0.14		0.03		0.03	
Partial r-squared					0.04						0.02	
F-test of excluded instruments (p-value)					0.000						0.000	
Weak identification statistics					85.73						42.35	
Cragg-Donald statistic					19.93						19.93	
- Stock & Yogo critical value					0.00						0.01	
Anderson-Rubin F-test (p-value)												
PIAT Reading Recognition												
Overweight dummy (bmiz > 1.6449)	-0.56	-0.78	0.04	0.07	-5.14	-1.60	-1.22	-1.50	-0.57	-0.98	-11.44	-4.18 ***
R-squared	0.15		0.01		0.14		0.16		0.01		0.03	
Partial r-squared					0.04						0.02	
F-test of excluded instruments (p-value)					0.000						0.000	
Weak identification statistics					83.9						40.9	
Cragg-Donald statistic					19.93						19.93	
- Stock & Yogo critical value					0.000						0.000	
Anderson-Rubin F-test (p-value)												
Number of observations	4,351		4,351		4,351		4,563		4,563		4,563	

Note: Mother's BMI and BMI-squared in 1981 used as instruments

	Black Girls						Black Boys					
	OLS		Fixed Effects		IV		OLS		Fixed Effects		IV	
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
PIAT Math												
Overweight dummy (bmiz > 1.6449)	-2.10	-3.14 ***	-0.98	-1.33	-2.44	-1.00	-1.48	-1.99 **	-0.73	-1.00	-0.54	-0.79
R-squared	0.17		0.02		0.17		0.17		0.01		0.17	
Partial r-squared					0.05						0.06	
F-test of excluded instruments (p-value)					0.000						0.000	
Weak identification statistics					73.7						101.5	
Cragg-Donald statistic					19.93						19.93	
- Stock & Yogo critical value					0.08						0.08	
Anderson-Rubin F-test (p-value)												
PIAT Reading Recognition												
Overweight dummy (bmiz > 1.6449)	-1.67	-1.77 *	-1.10	-1.68 *	-12.23	-4.48 ***	-0.68	-0.94	-0.12	-0.19	-11.79	-3.06 ***
R-squared	0.19		0.05		0.08		0.18		0.09		0.12	
Partial r-squared					0.05						0.04	
F-test of excluded instruments (p-value)					0.000						0.000	
Weak identification statistics					75.1						57.5	
Cragg-Donald statistic					19.93						19.93	
- Stock & Yogo critical value					0.000						0.000	
Anderson-Rubin F-test (p-value)												
Number of observations	3,095		3,095		3,095		2,966		2,966		2,966	

Note: Mother's BMI and BMI-squared in 1981 used as instruments

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¹ We also estimated sibling fixed effects models, the results of which were qualitatively similar to the individual fixed effects models presented here. The motivation for this approach is that differences between siblings remove variance in weight attributable to a shared family environment. However, Cawley (2004) argues that this is not an appropriate way to remove unobserved heterogeneity citing evidence that shared family environments explain a negligible proportion of the variance in weight across siblings. However, others have noted that an obesigenic family environment is an important predictor of children's changes in BMI (Davison et al. 2005). These estimates are available upon request.

² Following the suggestion by Klepinger et al. (1995), we began with a set of potential instruments that included the district density of fast-food outlets, district mean fast food prices, and mother's historical BMI and sibling BMI. However, Sargan tests repeatedly rejected the overidentification restrictions. As such, we limited the instruments to mother's historical BMI as this is the strongest of the excluded variables as measured by significance in the first-stage equations.