THE IMPACT OF CHILDHOOD OBESITY ON ACADEMIC PERFORMANCE

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ABSTRACT

Besides resulting in numerous physical health problems, childhood obesity has also been proven to lead to mental and emotional problems, such as anxiety and depression. In this study, I hypothesize that, through the mechanism of depression, childhood obesity also leads to lower academic performance. Multivariate analysis, using ordinary-least squares regression, suggests that obesity does negatively impact academic performance, with parental obesity and time spent watching television accounting for part of obesity's total effect. However, after controlling for a variety of socioeconomic factors, the negative effect of obesity becomes statistically insignificant. It is worth noting though that this study's bivariate analysis reveals a strong correlation between these factors and obesity. For policy makers, the results of this study should serve warning that if the threat of obesity is not addressed, the labor market could suffer due to the diminished academic performance of America's next generation.

I would like to thank my thesis advisor, Associate Professor Donna Ruane Morrison, for her guidance and assistance in this endeavor. Additionally, I want to thank all of my professors from the Georgetown Public Policy Institute who provided me with the knowledge and skills necessary to complete this type of statistical analysis.

TABLE OF CONTENTS

LIST OF TABLES

Chapter 1. Introduction

On June 28, 2005, Senate Majority Leader Bill Frist (R-TN) and Senator Ron Wyden (D-OR) introduced the "Childhood Obesity Reduction Act." This comprehensive bill would, among other things, create a congressional council to provide over $2 million annually in grants to schools that implement properly managed anti-obesity programs.[1] This proposed legislation is in response to the country's growing obesity crisis. More than 44 million Americans are considered obese – an increase of 74 percent since 1991. From 1976 to 2000, the percentage of adults who were overweight rose from 47 percent to 64.5 percent. Yet, the numbers for this country's next generation are even more drastic; the percentage of overweight children and adolescents more than doubled in that same time period from 12 percent to 27 percent.[2] The health concerns associated with this trend are significant and wide-ranging. Overweight, and especially obese, children can suffer from elevated blood pressure and cholesterol, joint problems, type II diabetes, gallbladder disease, asthma, depression, anxiety, and isolation from peers.[3] Health problems are not the only costs of obesity though. It is reasonable to expect that the physical and emotional consequences of obesity also negatively impact children's performance in school.

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[1] "Frist, Wyden Introduce Childhood Obesity Reduction Act." Press Release: Jun 28, 2005, http://frist.senate.gov/index.cfm?FuseAction=PressReleases.Detail&PressRelease_id=1978

[2] Greenblatt, Alan, 2003. Obesity Epidemic. *The CQ Researcher*: Vol 13, No. 4, on-line.

[3] Satcher, David, 2005. Healthy and Ready to Learn. *Educational Leadership*: Vol 63, p. 26-30.

To begin with, overweight children miss four times as many days of school as normal-weight children, presumably for medical appointments that are related to their weight. This time away from the classroom may result not only in missed instruction, but also missed opportunities for group work with other students, "free study" periods, and other supplemental work. Additionally, the majority of overweight and obese children eat foods that are high in fat and sugar, rather than adhering to a healthy diet. This is significant because only a well-balanced diet consisting of the four food groups can provide the essential vitamins, minerals, fats, and proteins necessary for optimal cognitive function.[4] A third reason to posit a relationship between obesity and having trouble in school is the increased risk of depression among students with weight problems. Because of the stigma that being overweight has in American society, these children and adolescents often have low self-esteem. Results from a small-scale study of 106 obese children, between the ages of 5 and 18, revealed that obese students were often subject to teasing and ostracism, and that they reported having trouble keeping up with their peers, both physically and academically.[5] However, there are surprisingly few nationally representative studies of this issue. An exception is a recent longitudinal study conducted by Robert Crosnoe and Chandra Muller, using a sample of 11,658 students in grades 7 – 12. They hypothesized that adolescents *at risk of*

[4] Ibid.
[5] Browman, Darcia Harris, 2003. Child Obesity Hurts Emotional Health, Study Says. *Education Week*:

obesity would have lower overall academic achievement than other students; their results supported this hypothesis.[6]

The aim of the present study is to expand upon the work of Crosnoe and Muller by examining whether and to what extent actually being clinically obese affects academic performance. I use the National Longitudinal Survey of Youth 1997 (NLSY97), a nationally representative data set to address this problem. I control for individual, family, and school-level variables to assess the effect of the youth's body mass index (BMI) on students' level of academic performance, as measured by their scores on a standardized math exam. This is an improvement over the Crosnoe and Muller study that relied on self-reported grades in four subjects. This eliminates the potential for self-reporting bias, and also resolves the issue of differences in grading scales across different schools. Another key strength of this study lies in the way that weight problems are defined. Crosnoe and Muller devised an indicator of "risk of obesity" using the BMI[7], but their operationalization is conceptually flawed. By including children who only have a BMI at or above the 85th percentile, based on growth charts from the Center for Disease Control, their sample probably includes

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Vol 22, Issue 32, p. 9.

[6] Crosnoe, Robert and Chandra Muller, 2004. Body Mass Index, Academic Achievement, and School Context: Examining the Educational Experiences of Adolescents at Risk of Obesity. *Journal of Health and Social Behavior*: Vol 45, p. 393-407.

[7] Ibid.

some athletes with high muscle mass (since muscle weighs more than fat). In this study, a young person is classified as "obese" if their BMI is at or above the 95th percentile. This distinction is important because it removes the possibility of including muscular children (who are not overweight) in the sample.

If obesity does negatively impact academic performance -- parents, educators, and policy makers alike will have an even greater incentive to curb the threat of obesity in this country. For parents, the results of this study might persuade them to help their children maintain a healthy weight. For educators, the results might help provide insight into why American students fall behind the rest of the industrialized world's students in high school test scores. And for policy makers, the results of this study should serve warning if the threat of obesity is not addressed, the labor market could suffer due to the diminished academic performance of America's next generation.

Explanations for Rise in Obesity

Much, if not all, of the rise in obesity among children can be attributed to our changing society. Over the past few decades, students have been exposed to changes both in the school and at home. To begin with, in today's gender-integrated workforce, families are eating a greater percentage of meals from restaurants and fast food take-out. The nutritional and caloric implications of this are obvious. Additionally, in an

effort to improve America's academic standing (student performance on standardized tests) throughout the world, many school districts have sacrificed recess, extracurricular sports, and physical education to provide more time for core subjects. The lack of exercise continues after the school day ends: children and teenagers are spending more time watching television and playing computer games than the previous generation did. In 1997, the International Life Sciences Institute estimated that less than 25 percent of children in this country were getting at least 30 minutes of any kind of daily physical activity. A decrease in physical activity is not the only significant change though; the quality of nutrition among students has significantly decreased as well. Many schools today, in an effort to raise more money, now have candy and soda vending machines – a problem compounded by the fact that students no longer go home for lunch. According to a 1996 study, conducted by the U.S. Department of Agriculture, only 2 percent of students were consuming the recommended daily servings from each of the major food groups.[8]

Links Between Obesity and Academic Performance

While the links between obesity and risks to physical health are well known, the link between clinically problematic weight levels and measures of academic success may be less obvious. One mechanism for the effect of obesity on schooling

[8] Satcher, David, 2005. Healthy and Ready to Learn. *Educational Leadership*: Vol 63, p. 26-30.

outcomes is the self-concept of students. Students who are classified as obese generally consider themselves to be less academically proficient than their counterparts. Obviously though, students' own actions will also determine their level of success in school. For this reason, this study also controls for variables that have been used in previous studies as well, to include: hours of television watched and school attendance. As mentioned in the introduction, obese students tend to miss significantly more school – which intuitively has an impact on academic performance. Additionally, I control for whether or not the student has a chronic medical condition. While a potential problem of multi-collinearity exists with the variable "attendance," I believe it is still necessary to include this independent variable. A student could have a chronic condition that does not require him or her to miss much school, but makes studying or test-taking difficult, such as Attention Deficit Disorder.

According to the National Association for Sport and Physical Education, students who participate in daily physical education classes display a better attitude toward school and superior academic performance. Two different studies, conducted in 1984 and 1997 both showed that reducing class time to provide more time for daily physical activity can lead to higher test scores, especially in math. In 2001, the California Department of Education examined student physical fitness test scores and SAT scores; the department found a strong, positive correlation between high fitness

scores and high SAT scores in the grades tested: 5, 7, & 9. And the President's Council on Physical Fitness & Sports states that "Youth who spend less time in other subjects to allow for regular physical education have been shown to do equally well or better in academic classes." Yet, as mentioned earlier, schools across the country continue to drop physical education in favor of more class time.[9]

In the previously mentioned study by Renman, the researchers controlled for drug use and hours of daily TV watching. In the obese group, 5.2 individuals reported that they had ever used narcotics – compared to 11 in the non-obese group. These numbers do not suggest a correlation between drug use and obesity. With a larger sample size though, the coefficient estimate might have become statistically significant though. Either way, I suspect that a negative correlation does exist between drug use and academic performance. Similarly, with a p-value of 0.223, hours spent watching TV did not appear to be significant in this study. Again though, I believe this is attributed to the small sample size of 58. In the obese group, 14 students reported watching more than 4 hours daily; only 7 students in the non-obese group reported watching this much. These numbers switch when looking at those who watch less television. 12 students in the obese group watch less than one hour each day, whereas 21 of the non-obese students fall into this category.[10]

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[9] Satcher, David, 2005. Healthy and Ready to Learn. *Educational Leadership*: Vol 63, p. 26-30.
[10] Renman, C, I Engstrom, S-A Silfverdal, and J Aman, 1999. Mental Health and Psychosocial

However, a recent study utilizing over 11,000 kindergartners from the Early Childhood Longitudinal Study suggested that younger children are not affected by obesity in the same manner as adolescents. The study determined that while overweight students had significantly lower test scores than non-overweight students, the differences became insignificant after controlling for various socioeconomic and behavioral variables. The study concluded that race, ethnicity, and mother's education had a much greater impact on test performance than a child's weight.[11] However, it is quite plausible that weight was not significant in this study because of the age of the children involved. The stigmatization, and thus depression, of obesity does not occur until children are older when athletic ability and romantic endeavors play a bigger role in their lives.

This hypothesis has already been tested by researchers in Thailand, who performed a cross-sectional and longitudinal study to determine if an association existed between weight status and academic performance among children and adolescents in that country. Controlling for gender, age, school, grade, and parental factors, they found that in grades 3-6, being overweight (BMI $\geq$ 85th percentile) had no

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Characteristics in Adolescent Obesity: A Population-Based Case-Control Study. *Acta Paediatr*: Vol 88, p. 998-1003.

[11] Datar, Ashlesha, Roland Sturm, and Jennifer Magnabosco, 2004. Overweight Children and Academic Performance – Obesity in Children and Adolescents. *Nutrition Research Newsletter*: Feb.

effect on grade point averages (GPA). Yet, when they conducted the same study for students in grades 7-9, overweight students had a mean GPA that was 0.2 points lower than their counterparts. This study suggests that older children are more adversely affected (in terms of academic performance) by being overweight than younger ones. However, it should also be noted that they had a relatively small sample size of 587 students in grades 7-9.[12]

However, some researchers warn about potential endogeneity when reaching conclusions about weight status and academic performance. Taras and Potts-Datema point out that researchers must acknowledge the possibility that a student's poor performance in school could lead to depression, and cause the child to then gain weight.[13] This correlation between depression and weight gain served as the focus of a study by Lumeng and Gannon. When looking at a sample of 8-11-year old children from the NLSY98 cohort, they concluded that children experiencing behavioral problems were more likely to become overweight (BMI $\geq 95^{th}$ percentile) than their counterparts. However, this study combined 28 different behavioral problems into one independent variable, rather than just focusing on depression (which was one of the 28

[12] Mo-suwan, L, L Lebel, A Puetpaiboon, and C Junjana, 1999. School Performance and Weight Status of Children and Young Adolescents in a Transnational Society in Thailand. *International Journal of Obesity*: Vol 23, p. 272-277.

[13] Taras, Howard and William Potts-Datema, 2005. Obesity and Student Performance at School. *Journal of SchoolHealth*: Vol 75, p. 291-295.

problems).[14] Theoretically though, it is still possible that depression from poor academic performance could lead to weight gain.

To avoid this problem, Crosnoe and Muller, as mentioned earlier, conducted a longitudinal study in which they examined a student's risk of obesity (BMI $\geq 85^{th}$ percentile) at one point in time, and then measured academic performance at a later point in time. The theory guiding their study was the "looking glass self," in which individuals internalize negative social judgments into their own self-esteem. As with other studies, they also controlled for gender, age, race/ethnicity, attendance, level of parental education, and family structure (single or dual parents). Their results were surprising though: the negative correlation between risk of obesity and academic performance was stronger in schools with high levels of romantic activity, but weaker in schools with high rates of athletic participation.[15] However, I believe that the reason they found a weak correlation in schools with strong athletic participation rests in their construct of the independent variable; highly athletic individuals can often have a BMI above the 85^{th} percentile since muscle weighs more than fat.

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[14] Lumeng, Julie, Kate Gannon, Howard Cabral, Deborah Frank, and Barry Zuckerman, Association Between Clinically Meaningful Behavior Problems and Overweight in Children. *Pediatrics*: Vol 112, No 5, p. 1138-1145.

[15] Crosnoe, Robert and Chandra Muller, 2004. Body Mass Index, Academic Achievement, and School Context: Examining the Educational Experiences of Adolescents at Risk of Obesity. *Journal of Health and SocialBehavior*: Vol 45, p. 393-407.

BMI is computed by dividing a person's square of height in meters into their weight in kilograms. The International Task Force on Obesity has stated that BMI and BMI percentiles serve as the best way to define obesity in children, while acknowledging its limitation regarding athletic individuals. For adolescents from ages 13-17, The American Obesity Association uses the Centers for Disease Control and Prevention BMI-for-age growth charts to define "overweight" as BMI greater than 25 or the 85th percentile; "obesity" is defined as BMI greater than 30 or the 95th percentile.[16] The current study uses this construct for its independent variable of "obesity." While muscle mass can bring a person's BMI over the 85th percentile, it is very unlikely that a highly athletic individual will have a BMI over the 95th percentile.

Differential Risk by Socioeconomic Status

The need to control for socioeconomic factors when looking at predictors of academic performance is well recognized – as a student's lifestyle outside of the school has an effect on his or her performance in school. While there are numerous studies that control for these variables, two serve as exemplars. Renman of Sweden and colleagues (1999) used a population-based sample of 58 obese adolescents (BMI $\geq$ 99.6th percentile – based on the Swedish height and weight charts) to examine the

[16] Taras, Howard and William Potts-Datema, 2005. Obesity and Student Performance at School. *Journal of SchoolHealth*: Vol 75, p. 291-295.

correlation of obesity and mental health. Both the control and experimental groups ranged in age from 14-18, with a mean age of 16.9 years. The obese group was 40 kilograms heavier, on average, than the control group. Yet, based on self-reported answers, the researchers concluded that obese adolescents did not differ from their normal-weight peers in terms of mental health issues, including depression. They did find a significant effect of family structure on weight status, however. The obese group was more likely than the non-obese group to live with only one parent (39.2% compared to 15.1%; $p < 0.005$). Additionally, their results also revealed that a greater prevalence of mothers of the obese adolescents worked in lower-paying jobs than mothers of the non-obese ones (45.6% versus 17.5%). They conclude that this implies that the mothers of the obese children had a lower level of education than their counterparts.[17] This study controls for race/ethnicity, gender, parents' education level, and parent's BMI.

The previously mentioned study, conducted by Lumeng et al, relied on NLSY98 interview data for 8-11-year old children to examine the association between obesity and clinically meaningful behavior problems. They also controlled for many of the same variables as previous studies mentioned, to include the always utilized demographic variables of race/ethnicity and gender. While race did not appear to

[17] Renman, C, I Engstrom, S-A Silfverdal, and J Aman, 1999. Mental Health and Psychosocial Characteristics in Adolescent Obesity: A Population-Based Case-Control Study. *Acta*

affect whether or not a child suffered from a behavioral problem, they did find a strong association between race and obesity. Specifically, being Hispanic was highly statistically significant with a p-value of 0.0003. Additionally, this study controlled for the mother's BMI – and like several other studies, concluded that a strong, positive association exists between a mother being overweight and her child being overweight.[18] This could be attributed either to a genetic predisposition or a lack of stigmatization at home about a child's weight gain.

In addition to the socioeconomic variables described above, this study also controls for effects of the school environment on academic performance. Intuitively, school structure must have an impact on academic performance. The three variables that I use are school type, student-to-teacher ratio, and feeling of safety. School type simply compares public and private schools; most studies suggest that academic performance on standardized tests is slightly higher at private schools. Student-to-teacher ratio is also intuitive; and studies show that a smaller ratio tends to facilitate better learning. Finally, while I have not found any research supporting this point, I

Paediatr: Vol 88, p. 998-1003.

[18] Lumeng, Julie, Kate Gannon, Howard Cabral, Deborah Frank, and Barry Zuckerman, Association Between Clinically Meaningful Behavior Problems and Overweight in Children. *Pediatrics*: Vol 112, No 5, p. 1138-1145.

believe that a threatening atmosphere (or even a student's perception of one) at school will have a negative association with test scores.

The Focus of Policy

Parents and children alike, through their current lifestyles, should bear much of the responsibility for this country's growing obesity epidemic. However, the association between obesity and academic performance should concern elected officials as well, and cause them to take action. The problem already concerns educators, parents, and children alike. In a 2002 poll, conducted by the non-profit organization Action for Healthy Kids, 81 percent of the 1,308 students surveyed said that schools should make nutritious meal planning a priority; 72 percent said that physical activity should be more of a priority. In several states, Action for Healthy Kids is working in conjunction with the Departments of Education to create and emplace new health school policies that focus on physical education, food-service operation, and nutritional education. The organization has been successful so far because its members operate as small teams, organized at the local level. The teams incorporate advice and assistance from school administrators, teachers, health professionals, local elected officials, parents, and students.[19] Obviously though, with

[19] Satcher, David, 2005. Healthy and Ready to Learn. *Educational Leadership*: Vol 63, p. 26-30.

obesity on the rise, Action for Healthy Kids and similar NGOs will probably not be able to resolve this problem on their own. The federal government must review its own legislative capabilities in this matter, and decide how to best offer assistance to state and local school boards. And perhaps the government should begin by taking a close look at the effects of socioeconomic conditions on obesity.

Chapter 2. Data and Methods

Data

This study uses the NLSY97 data set, which includes height and weight information on respondents. By using growth charts from the CDC, I use this information to determine individual BMI. This is my measure for obesity, which is the study's independent variable of interest. For the dependent variable of academic performance, I use updated test scores from the Peabody standardized math exam; this test is widely accepted as the most unbiased measure of academic achievement available to researchers. This study contains a sample of 1626 students of the nearly 9000 that were surveyed under NLSY97. The 1626 students are the 13 and 14-year old ones who took the Peabody math exam in 1998. All other variable data comes from the previous year, to include their height and weight. Of these 1626, sufficient enough height / weight data to compute BMI only exists on 1503 of them. Of these, 14.7 % are at or above the 95th percentile for their age and gender (see Table 1). This number matches my expectations, based on recent news reports and literature. I could obtain a much larger percentage of "overweight" students if I used the 85th percentile, but my data would then be skewed because of measurement problems associated with BMI.

While the sample size is relatively small, it is still reasonable to assume that my results will be generalizable to the nation as a whole. The control variables fall into

three categories: school conditions, to include school type, student-to-teacher ratio, and sense of safety; socioeconomic factors, to include parent BMI and parents' education level; and individual characteristics, to include gender, race/ethnicity, attendance rate, hours TV watched, and chronic medical conditions.

Limitations

Despite the advantages of using the NLSY data set for a longitudinal study of the effects of obesity on test scores, limitations exist as well. To begin with, my empirical model would have been better specified had I been able to control for physical activity and nutrition, both strongly correlated with childhood obesity, but not available for my analysis. Both of these factors positively affect student performance by increasing student's energy levels throughout the day. Unfortunately, less than ten percent of the students in my sample of 1503 had been asked about their weekly level of physical activity. I found no relevant (and measurable) questions in the NLSY pertaining to daily nutrition. Finally, I am unable to control for family income in this study – which is significant because of the proven correlation between obesity and socioeconomic level. However, I compensate for this by using the education level of both parents (residential, not necessarily biological) as proxy variables for income.

Variables

The dependent variable for this analysis is the student's revised score on the Mathematics portion of the Peabody Individual Achievement Test, a nationally standardized test of achievement, administered as part of the 1998 interview. Means or percentages for all variables used in this study are presented in Table 1. Approximately, 15 percent of the students in the sample are classified as obese, in keeping with recent news stories reporting a similar figure for young teenagers in the nation at large. Moreover, white students who watch 1-3 hours of television daily make up the majority of the sample. The explanatory variables, along with their coding, are outlined in the table on the following page.

Category	Variables	Measurement
Dependent Variable	Math PIAT-R Score	Math Peabody Individual Achievement Test-revised standard score (1998)
Independent Variable	Obese	BMI at or above the 95th percentile, based on student's height, weight, and age
Gender	Male	1 if male; 0 otherwise
Race / Ethnicity	Black Hispanic Mixed Race	1 if black; 1 if Hispanic; 1 if mixed race; 0 otherwise
Health Status	Chronic Medical Condition	1 if student has now or has ever had a chronic medical condition or life threatening disease; 0 otherwise
Attendance at School	High Absence ($\geq$ 6 days) Very High Absence ($\geq$ 10 days)	Number of days absent during the Fall term
Time Spent Watching TV	Average TV (1-3 hours) High TV (> 3 hours)	Average number of hours of TV watched per weekday
Education Level of Parents	Father High School Degree Father Undergrad Degree Father Graduate Degree Mother High School Degree Mother Undergrad Degree Mother Graduate Degree	Highest grade completed in school by residential father and mother
Weight Status of Parent	Obese Parent	BMI is at or above "30", based on parent's height and weight
Class Size	High Student-to-Teacher Ratio (>17 students per teacher)	Number of students per teacher in current school
School Environment	Feels Safe at School	1 if student feels safe at school; 0 otherwise
School Type	Public School	Student attends a public school, as opposed to a private or parochial one

Methods

I begin with two bivariate analyses that focus on the relationships between math scores, obesity, and my controls for student-, family-, and school-level variables. I then turn to a multivariate analysis, using ordinary-least squares regression. I estimate four models, incrementally accounting for the effects of school conditions, socioeconomic factors, and individual characteristics on the math test scores. This series of models will allow me to first demonstrate the correlation between obesity and academic performance, and then reveal the mechanisms through which the effect of obesity is transmitted to math achievement.

Chapter 3. Results and Conclusion

Results

Table 2 provides mean math scores by individual, family, and school characteristics. The first thing to note is that the mean test score for obese students is 2 points below the overall mean, with non-obese students scoring, on average, 3.16 points higher. Results of a t-test suggest that this differential is statistically significant. Even more marked differences across students in the two groups are evident across the other explanatory variables, with the differential in parental education level appearing particularly large. We see that students whose mothers or fathers have obtained a graduate degree tend to score approximately 9 points higher on the PIAT math test than the average student. Also noteworthy, is that there is a 7.26 point difference in math scores (half of a standard deviation) between students who watch less than one hour daily and those who watch more than three hours daily.

Turning to Table 3, I next examine the relationship between obesity and individual, family, and school characteristics. Here, the first difference worth noting is that while only 12.34 percent of obese students achieved or exceeded the mean score on the math test, 16.88 percent of these students scored below the mean. Perhaps even more noteworthy though is the strong correlation between hours spent watching TV and obesity. While fewer than one in ten (7.56 percent) of those students who watch

less than one hour daily are classified as obese, this is true of 20.27 percent of the students who watch more than three hours daily. This finding is not surprising given that time spent watching television decreases time available for and spent on physical activity. As we saw in Table 2, the differences in obesity levels across both race/ethnicity groups and years of parental education are also highly statistically significant.

Perhaps the most interesting correlation seen in Table 3 though, is that of obesity and parental obesity. Nearly one third (27.89 percent) of students whose parents are obese are classified as obese themselves. In contrast, only about 10 percent of students with normal-weight parents are obese. This can be attributed to three different reasons. First, these children (like their parents) might just have a genetic predisposition to being overweight. However, since the percentage of overweight adults has also been rising significantly over the past 25 years due to cultural changes, I would argue that this correlation exists for the two other reasons. Either these children are not raised to understand and appreciate the advantages of healthy nutrition and physical activity, or they feel that there is simply nothing wrong with being obese since they love and respect their parents. This implies that in order to reverse the trend of childhood obesity, we must first find a way to make adults understand the importance of leading healthy lifestyles.

Having established that there are 2-way correlations between obesity and my explanatory variables, it is important to use multivariate analysis to determine whether the association between obesity and academic performance persists when these additional factors are controlled. Table 4 displays the four models and the resulting coefficients of the regressions. Model 1 is a simple model, used to show the total effect of obesity on academic performance. As expected from the results of the bivariate analysis, we see that obese students score 3.16 points lower than non-obese students on average, a difference that is statistically significant at the 0.01 level. Given its strong correlation with the propensity for students to be overweight, Model 2 incorporates parental obesity. We see that parental obesity does indeed serve as a partial mechanism of the effect of student obesity since the coefficient value and its significance now diminish. Adding the two coefficient values, the results suggest than an obese student (who also has an obese parent) will, on average, score 6.39 points lower on the standardized test. It is important to note though that a parent's (and therefore student's) likelihood of being obese can often be attributed to socioeconomic factors, with a greater percentage of poor blacks and Hispanics tending to be obese than those with a higher socioeconomic status.

Model 3 adds the number of hours spent watching television. Here we see that a student's propensity to watch TV directly affects his or her time spent studying and

motivation to do well in school. Since this time spent in front of the television also affects the time they can spend on physical activity, part of the total effect of obesity apparently works through television watching, as both the magnitude and statistical significance of the coefficient for obesity decline when this variable is taken into account. The results thus far suggest that an obese student, with an obese parent, who watches more than three hours of television per day will score, on average, 11.66 points lower than their non-obese counterparts. In my final model, Model 4, I add controls for all other variables. Under this specification, the effect of obesity on math achievement ceases to be statistically significant. This is not surprising since socioeconomic factors (race/ethnicity and education level) are highly related to a person's propensity to be obese, and also play a key role in predicting academic performance. However, watching television is still slightly significant (at the 0.1 level), suggesting that obesity might still have an indirect impact on test scores, net of socioeconomic factors.

Summary / Conclusion

The multivariate analysis shown here suggests that obesity has a negative impact on the academic performance of young teenagers, and is likely transmitted via a variety of personal, family, and school characteristics. While there is no way of

knowing for certain if this is due to the mechanism of depression as I hypothesize, it certainly seems the most plausible. The social setting of junior high and high school tends to place an emphasis on the popularity of athletic individuals. If students feel like they do not or cannot belong to such a crowd, their self-esteem may suffer. The series of models suggests that socioeconomic factors play a greater role in predicting academic performance than obesity. Yet, it is important to note that the bivariate analysis shows a statistically significant relationship between these factors and obesity.

This study lends support to previous research conducted by Crosnoe and Muller (2004). Like them, using a longitudinal sample, I find that a student's weight status has an effect on their academic performance. However, my study offers three additional contributions to the existing literature on this topic. First, and most importantly, I use a narrower construct for weight status. Although Crosnoe and Muller were able to obtain a larger sample size by including children "at risk of obesity" (85^{th} percentile), their definition of problematic weight was probably too liberal. By using the 95^{th} percentile as my standard (which is essentially equivalent to an adult BMI score of 30), I was able to isolate those individuals who are truly obese. Second, unlike Crosnoe and Muller, I include parental weight status which has a well-established correlation with the propensity to be obese. Third, I rely on a standardized

test (which is regarded as a highly accurate measure of academic proficiency) as my dependent variable, rather than self-reported grades.

Parents, educators, and policy makers alike must continue to address the childhood obesity crisis in this country. Obesity affects not only their health, but also (in many cases) their ability to perform well in school. This could someday pose a grave threat to our workforce and competitive stance in the global market. This study suggests that parents must take action to better care for themselves and curb the amount of television their children watch. The government seems to have the greater challenge though. Policy makers must clearly focus not only on the obesity crisis itself (through such initiatives as school health education programs), but also on improving the quality of life of our poorest citizens. It is most likely due to poor educational experiences, lack of job opportunities, and cultural backlash that a greater percentage of this country's minority populations are obese, when compared to the white majority.

Table 1: Means for Key Variables

	N	Mean
Math PIAT-R Score	1626	93.40
		(14.54)
Obese (BMI > 95th percentile)	1503	0.15
Individual Characteristics		
Male	1626	0.52
Black	1626	0.25
Hispanic	1626	0.22
Mixed Race	1626	0.01
Chronic Medical Condition	1449	0.10
High Absence ($\geq$ 6 days)	1583	0.18
Very High Absence ($\geq$ 10 days)	1583	0.05
Average TV (1 – 3 hours per wkdy)	1545	0.67
High TV (> 3 hours per wkdy)	1545	0.25
Family Characteristics		
Father High School Degree	1073	0.54
Father Undergrad Degree	1073	0.16
Father Graduate Degree	1073	0.09
Mother High School Degree	1483	0.56
Mother Undergrad Degree	1483	0.14
Mother Graduate Degree	1483	0.06
Obese Parent (BMI > 30)	1387	0.24
School Characteristics		
High Student-to-Teacher Ratio (> 17 students per teacher)	1358	0.39
Feels Safe at School	1623	0.87
Public School	1623	0.92

Standard deviation in parenthesis

Table 2: Mean Math Scores by Individual, Family, & School Characteristics

Characteristics	Mean Math Score
Student BMI $\geq$ 95th percentile	91.39
Student BMI < 95th percentile	94.55
Male	94.16
Female	92.57
Non-Black / Non-Hispanic	98.13
Black	86.10
Hispanic	90.37
Mixed Race (Non-Hispanic)	94.67
Chronic Medical Condition = Yes	95.31
Chronic Medical Condition = No	93.54
Low Absence (< 6 days per semester)	94.06
High Absence ($\geq$ 6 days)	90.91
Very High Absence ($\geq$ 10 days)	85.54
Low TV (< 1 hour per weekday)	97.30
Avg TV (1 to 3 hours)	94.42
High TV ($\geq$ 4 hours)	90.04
Father Education $\geq$ High School Degree	94.53
Father Education $\geq$ Undergrad Degree	101.83
Father Education $\geq$ Graduate Degree	103.28
Mother Education $\geq$ High School Degree	94.20
Mother Education $\geq$ Undergrad Degree	100.87
Mother Education $\geq$ Graduate Degree	103.66
Parent BMI < 30	94.81
Parent BMI $\geq$ 30	89.76
Low Student-to-Teacher Ratio ($\leq$ 17 students per teacher)	93.98
High Student-to-Teacher Ratio (> 17 students per teacher)	92.47
Feels Safe at School = Yes	94.13
Feels Safe at School = No	88.33
Public School	93.14
Private and/or Parochial School	96.55

Table 3: Relationship between Obesity and Characteristics

Characteristics	Percent Obese (BMI $\geq$ 95th percentile)
Math PIAT-R Score < Mean Score	16.88%
Math PIAT-R Score $\geq$ Mean Score	12.34%
Male	18.10%
Female	10.83%
Non-Black / Non-Hispanic	10.20%
Black	18.75%
Hispanic	21.71%
Mixed Race (Non-Hispanic)	17.65%
Chronic Medical Condition = Yes	16.03%
Chronic Medical Condition = No	14.73%
Low Absence (< 6 days per semester)	14.26%
High Absence ($\geq$ 6 days)	15.12%
Very High Absence ($\geq$ 10 days)	19.44%
Low TV (< 1 hour per weekday)	07.56%
Avg TV (1 to 3 hours)	13.64%
High TV ($\geq$ 4 hours)	20.27%
Father Education $\geq$ High School Degree	14.39%
Father Education $\geq$ Undergrad Degree	11.88%
Father Education $\geq$ Graduate Degree	03.19%
Mother Education $\geq$ High School Degree	15.73%
Mother Education $\geq$ Undergrad Degree	11.62%
Mother Education $\geq$ Graduate Degree	07.06%
Parent BMI < 30	10.09%
Parent BMI $\geq$ 30	27.89%
Low Student-to-Teacher Ratio ($\leq$ 17 students per teacher)	13.32%
High Student-to-Teacher Ratio (> 17 students per teacher)	17.55%
Feels Safe at School = Yes	14.20%
Feels Safe at School = No	17.28%
Public School	14.96%
Private and/or Parochial School	11.29%

Table 4: OLS Coefficients for Models Predicting Academic Performance

	Model 1	Model 2	Model 3	Model 4
Constant	94.55***	95.36***	98.31***	88.71***
Obese	-3.16**	-2.27*	-1.88†	-0.88
Obese Parent		-4.12***	-3.46***	-0.90
Avg Hours TV Watched			-2.34†	-1.54
High Hours TV Watched			-6.32***	-2.55†
Male				0.78
Black				-8.79***
Hispanic				-3.76***
Mixed Race				-3.15
Chronic Medical Condition				0.66
High Absence				0.19
Very High Absence				-5.52**
Father High School Degree				1.98†
Father Undergrad Degree				5.65***
Father Graduate Degree				5.27**
Mother High School Degree				5.03***
Mother Undergrad Degree				7.65***
Mother Graduate Degree				10.09***
High Student-to-Teacher Ratio				-0.05
Feels Safe at School				2.60**
Public School				0.87
Adj R^2	0.01	0.02	0.03	0.20
N	1503	1503	1503	1503

*** significant at the .001 level
** significant at the .01 level
* significant at the .05 level
† significant at the .1 level

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