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The Moderating Effect of Self-Efficacy on Normal-Weight, Overweight, and Obese Children's Math Achievement: A longitudinal Analysis

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THE MODERATING EFFECT OF SELF-EFFICACY ON NORMAL-WEIGHT, OVERWEIGHT, AND OBESE CHILDREN'S MATH ACHIEVEMENT: A LONGITUDINAL ANALYSIS

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ABSTRACT

Increased body weight is associated with decreased cognitive function in school-aged children. The role of self-efficacy in shaping the connection between children’s educational achievement and obesity-related comorbidities has not been examined to date. Evidence of the predictive ability of self-efficacy in children is demonstrated in cognitive tasks, including math achievement scores. This study examined the relationship between self-efficacy and math achievement in normal weight, overweight, and obese children. I hypothesized that overweight and obese children with higher self-efficacy will be less affected in math achievement than otherwise comparable children with lower self-efficacy. I tested this prediction with multilevel growth modeling techniques using the ECLS-K 1998-1999 survey data, a nationally representative sample of children. Increased self-efficacy moderates the link between body weight and children’s math achievement by buffering the risks that increased weight status poses to children’s cognitive function. My findings indicate that self-efficacy moderates math outcomes in overweight, but not obese, children.

THE MODERATING EFFECT OF SELF-EFFICACY ON NORMAL-WEIGHT, OVERWEIGHT, AND OBESE CHILDREN'S MATH ACHIEVEMENT: A LONGITUDINAL ANALYSIS

The number of American children classified as obese has sharply risen in recent years (Ogden *et al.* 2014; Wang and Beydoun 2007). Approximately 17% of children aged 2 to 19 years-old are classified as obese [i.e., have a body mass index (BMI) above 30 kg m^{-2}; (Ogden *et al.* 2014)]. There are, however, large disparities in childhood obesity prevalence between racial and ethnic minority groups, and by geographic location, with the highest incidence among Hispanic children (Ogden *et al.* 2014) and in children residing in the southeast region of the United States (Gopal *et al.* 2010). One population at risk is low-income elementary-aged children (Kopelman 2007), an already vulnerable group whose rates of obesity have steadily increased across all races except Asians/Pacific Islanders, irrespective of gender (Kopelman 2013). Socioeconomic inequality is associated with geographically concentrated childhood obesity among low-income groups that may lead to an accumulation of disadvantage for children throughout their life course (Giskes *et al.* 2008; Power, Manor, and Matthews 2003; Woolf and Aron 2013, p. 233).

The consequences of poor physiological and psychological health extend to the academic domain. An overweight or obese child may succumb to anxiety and depression as a result of social marginalization and/ or peer discrimination due to the stigma associated with being overweight, and, consequently, her math performance may suffer. For example, overweight and obese adolescents are more socially isolated and have fewer friendships than those of normal weight (Strauss and Pollack 2003). This may then lead to devastating outcomes associated with psychological instability, and, in some cases, lowered academic performance (Robinson 2006).

Increased body weight is associated with decreased cognitive function in school-aged children (Li, Dai, Jackson, and Zhang 2008). Researchers have shown that overweight and obesity in children is associated with deficits in executive function, which relies on proper functioning of the part of the brain responsible for planning and judgment (Cserjesi. Luminet, Molnar, and Lenard 2007; Braet, Claus, Verbeken, and Vlierghe 2007). Poor math performance, for example, could be due to ineffective planning or the inability to shift from one mental state to another, update working memory, or inhibit impulsive behavior (St Clair-Thompson and Gathercole 2006). Given that the pathophysiological process of weight-associated complications culminates in cognitive decline and is driven by neural, cardiovascular, endocrine, musculoskeletal, renal, gastrointestinal, and pulmonary system malfunction, in addition to psychosocial problems (Kamijo *et al.* 2014; Garver *et al.* 2013), childhood obesity trends have implications for children's well-being in both the short and long term, including academic outcomes (Daniels *et al*. 2005; Freedman *et al*. 2007; see Taras and Potts-Datema 2009, for review). Importantly, academic outcomes are not driven solely by cognitive capacity (Bandura 1993), a limited pool of energy, resources, or fuel by which some cognitive processes are mobilized and maintained (Johnson and Heinz, 1978, p.422). Psychological resources such as optimism, personal control and a sense of meaning are protective for mental health (Frankl 1963; Taylor, 1989; Seligman 1998; Taylor *et al.* 2000), and these learned behaviors also assist children in educational achievement (Kolb 1984; Zimmerman 1989; Casey *et al*. 2005). Among these psychological resources, self-efficacy—typically conceptualized as perceived judgments of one's capabilities to organize and execute courses of action to attain chosen goals (Bandura 1977)—has consequences for children's psychological development, educational outcomes, and reproduction of stratification across generations (see Multon *et al.* 1991 for review; Schunk

1995; Schunk and Pajares 2004). The role of self-efficacy in shaping the connection between children's math achievement and obesity-related comorbidities has not been examined to date.

Perceived self-efficacy is the foundation of human motivation (Bandura 1993, 1994, 2006). At the individual level, symbolic processes through which knowledge is formed may be analyzed as contributing to the production of individual differences in development (Dannefer 1984). For example, the expectations communicated to, and interpreted by, a child, contribute to self-definition and to her plan of action. Bandura, and other social psychologists, suggest that individual action is driven by the core belief that we can produce desired results through our behavior. Self-efficacy moderates the effect of gender and prior experience on self-concept and mathematical problem solving (Pajares and Miller 1994). It is also becoming evident that self-efficacy may be an important mechanism in the treatment of obesity (Clark *et al*. 1991; Linde *et al*. 2006). In the present study, I examined the relationship between self-efficacy and math achievement in normal weight, overweight, and obese children.

As a measure of cognitive function, I used math achievement, and not literacy, scores from kindergarten to eighth grade, because past research indicates that stress associated with variations in physical appearance can decrease math performance in adults (Fredrickson *et al*. 1998; Gable *et al.* 2012). Also, self-efficacy has been shown to predict math performance for undergraduate college students (Siegel *et al*. 1985). I hypothesized that children with consistently heightened BMI scores will have lower math achievement, compared to those of children with lower BMI (Gable *et al.* 2012).

Further, self-efficacy has previously been shown to serve as a moderator of weight management (Bandura 2000), life stressors (Bandura 1994), and scholastic aptitude (Brown *et al.* 1989). Because self-efficacy engenders a wide range of capacities and skills that children may draw upon to support their math achievement—and potentially buffer the effects of increased weight on learning—I expected self-efficacy to factor into this linkage by moderating the extent to which children's increased weight status will affect their math achievement. Thus, I hypothesized that, compared to overweight and obese children with lower self-efficacy, those who are overweight and obese but have higher self-efficacy, would score better on math achievement assessments. I tested these hypotheses by applying multilevel growth modeling techniques (Singer and Willet 2003) to data from the Early Childhood Longitudinal Study—Kindergarten class 1998-1999 (ECLS-K).

BACKGROUND

LINKING OBESITY AND MATH ACHIEVEMENT TO SELF-EFFICACY

Early childhood health influences later life outcomes (Currie 2009; Almond and Currie 2010, 2011). The current study is predicated on the notion that weight-related comorbidities are associated with cognitive dysfunction. The negative association between obesity and cognitive function is well documented (Li *et al*. 2008; Shore *et al*. 2008; McLaren 2007), as is the positive association between self-efficacy and academic outcomes (Zimmerman 2000; Cowen *et al.* 1991; Bandura 1997). However, the direct association between self-efficacy and math outcomes among normal weight, overweight, and obese children in the United States has never been examined.

There is no consensus on the causal effect of childhood obesity on standardized test scores and academic outcomes. Cross-sectional and longitudinal studies examining the association between academic achievement and obesity are inconsistent. Researchers have found no association (Kaetner *et al.* 2009), a negative association (Averett and Stifel 2010), a mediation between obesity and self-esteem (Tershakovec *et al.* 1994), obesity and externalizing behavioral problems (Crosnoe 2007), and obesity and interpersonal skills (Klinitzke *et al.* 2013) in poor academic performance. Nonetheless, there is ample theoretical and empirical evidence indicating a likely connection. Thus, my conceptual model is that overweight and obesity in children affects cognitive function and is linked to learning, which in turn affects math academic outcomes.

Self-efficacy has emerged as an effective predictor of students' motivation and scholarship. Self-efficacious students contribute more in the classroom, work more assiduously, persevere longer, and have fewer disadvantageous reactions when faced with challenges (Bandura 1997). Furthermore, measures of self-efficacy are highly correlated with achievement in academic work and persistence (Zimmerman 2000). Evidence of the predictive ability of self-efficacy in children is demonstrated in cognitive tasks, including math performance (Cowen *et al*. 1991). For example, Schnuck *et al.* (1985) found a positive association between perceived self-efficacy and rate of accurate arithmetic solutions. Thus, research to date clearly links self-efficacy and math achievement (Bandura 1997; Shnuck *et al*. 1985; Pajares and Kranzler 1995; Adeyinka *et al.* 2007). Increased self-efficacy may, then, condition the link between overweight or obesity and children's achievement by buffering (or minimizing) the risks that increased weight status poses to children's math performance.

DATA AND METHODS

Data and Sample

Analyses are based on the Early Childhood Longitudinal Study—Kindergarten class 1998-1999 (ECLS-K), a nationally representative sample of 21,260 children from kindergarten to eighth grade, conducted by the U.S. Department of Education, National Center for Education Statistics (NCES), and designed to study the development of educational stratification among

American school children (West, Denton, and Reaney 2000). Participants were selected using a multi-stage sampling design. For a more detailed description of the ECLS-K study design see, Tourangeau *et al.* (2009).

Inclusion Criteria

Because "missingness" increased over time due to attrition in the ECLS-K data, I estimated my models using full information maximum-likelihood method (FIML), which uses data from all observations in the data set. The FIML estimation method assumes data are missing at random (MAR), wherein the conditional covariates are not associated with the propensity for missing data on the outcome measure (i.e., math achievement). This approach maximizes the statistical power for differentiating between math developmental trajectories of children with missing data on the outcome at any wave. The final sample size was 5,034. I used multiple imputation to impute missing values for children who participated in a wave but did not provide a response for a specific independent variable. This method resulted in multiple complete data sets (Allison 2001). I imputed data using the MIM command, a multivariate imputation program in Stata 13.0 (Carlin, Golati, and Royston 2008). I averaged empirical results across ten imputation samples (Rubin 1987). The estimates presented here are statistically similar to findings from analyses where I handled missing data for the independent variables using listwise deletion, indicating that estimates are robust across different missing data specifications. All multivariate analyses were conducted using HLM 7.01.

At enrollment (kindergarten fall, T1), children (51% female) were identified by parents as 71% White, 5% African American, 15% Hispanic, 5% Asian, and 5% Other Race. In the analyses, ECLS-K data were weighted to account for the multistage probability sampling that oversampled Asians and Pacific Islanders. Weights are provided in the ECLS-K for cross-sectional and longitudinal data analyses; weights were computed for children with complete data on the data points under investigation. Normalized child-level weights were used to produce representative estimates of the 1998–1999 kindergarten population of children.

MEASURES

Time

A variable based on average age at each direct assessment was created to represent time, as shown in Table 1. Time 1 (T1), kindergarten fall, is considered the baseline. At T1, average age was 5.71 (SD=0.36) years. At T2, kindergarten spring, average age was 6.23 years (SD=0.36), indicating the passage of about 6 months between T1 and T2. Beginning at T3, the time unit is defined in years, and children are about one year older, with an average age of 6.67 years (SD= 0.38). At T4, average age was 7.24 years (SD= 0.35). At T5, average age was 9.13 years (SD= 0.35). At T6, average age was 11.07 years (SD= 0.36). At T7, average age was 14.07 years (SD= 0.35).

Weight Status

ECLS-K staff assessed children's height and weight during each assessment by using a portable digital scale and stadiometer (Shorr Products, Olney, Maryland). Both weight and height measurements were recorded twice, and the average of the two measures was used in the present analyses. The overall average unweighted BMI score was 18.36, with a standard deviation of 4.53. Table 1 displays the unweighted means and standard deviations for BMI scores by gender and wave.

Using the 2000 Center for Disease Control Growth Charts: United States (Kuczmarski *et al.* 2002), I created a categorical variable based on BMI (weight [kg/height [m]^2), and classified children as underweight (<5th percentile), normal weight (>5th percentile and <85th percentile), overweight (>85th percentile to <95th percentile), or obese (≥95th percentile). I subsequently combined underweight and normal-weight categories into a single category due to the small number of underweight children across all time points (0.02; SD=0.12). Overall, 58% (SD=0.49) of male and 64% (SD=0.48) of female children were normal-weight. 21% (SD=0.21) of male and 21% (SD=0.41) of female children were classified as overweight. And, 21% (SD=0.21) of male and 15% (SD=0.36) of female children were classified as obese. Weight status was included in my analytic model in several different ways. Dummy variables indicating a child’s weight status category and a continuous measure of BMI were both included to imply that the added decrement to children’s math achievement that accrued for an additional point in BMI further decreased math achievement if the child moved from the normal weight to the overweight or from the overweight to the obese category.

Self-Efficacy

An adaptation of the Self-Description Questionnaire (SDQ) II and The Self-Concept and Locus of Control scales from the National Educational Study of 1988 (NELS:88) were administered during the eighth grade assessment session to ascertain children’s socioemotional development. Thirteen statements measuring children’s self-perceptions and amount of control they possessed throughout their life were used to assess locus of control. Children scored the items on a continuum from “strongly agree” to “strongly disagree” for each item; values ranged from -1.53 to 2.50, with higher scores indicating greater perception of control throughout their life. I dichotomized the locus of control measure into low and high levels of self-efficacy, with negative and positive values representing low and high levels of self efficacy, respectively. It is well documented that locus of control and generalized self-efficacy are indicators of the same higher order concept (Judge *et al.* 2002; Adeyinka *et al.* 2011). Internal consistency of the locus of control measure is moderate at the Cronbach Alpha level of 0.68 (Tourangeau *et al.* 2009).

Math Achievement

At each assessment period, children were evaluated in a 50-minute to 70-minute session in kindergarten and 1st grade, and in a 90-minute session in 3rd, 5th, and 8th grade. The assessment was developed specifically for the ECLS-K, and children were tested on previously used instruments (Woodcock-McGrew-Werder 1996).

The ECLS-K math assessment focused on age-appropriate mathematical knowledge and skills such as knowledge of numbers and shapes, relative size, ordinality and sequence, addition and subtraction, multiplication and division, place value, rate and measurement, fractions, and area and volume (Tourangeau *et al.* 2009, pp 2-10). The assessments yielded number right scores, standardized scores, and latent trait scores from item response theory (IRT). I used IRT scores because this assessment placed children's ability on a continuous scale by using the pattern of right, wrong, and omitted responses, and the pattern of difficulty, discriminating ability, and ability to correctly guess each item. Thus, the measure produced a score based on the items a child would have answered correctly if all the questions were answered for that particular assessment. Reliability math scores were high at Cronbach Alpha levels ranging from 0.89 to 0.94 (Tourangeau *et al.* 2009).

Covariates

Time-variant and time-invariant measures were included in the final models. Time-varying measure includes age in years and BMI. *Age* is centered on the earliest time children normally begin kindergarten (i.e., 5 years of age). *BMI* is a continuous measure of body mass index. BMI categories are indicator variables representing the child's BMI percentile classification at each time period, and includes *normal weight*, *overweight*, and *obese*, with *normal weight* as the reference. Time invariant covariates that were included represent child and family characteristics. Race is an indicator variable representing race and ethnicity, and is categorized as *White*, *African American*, *Hispanic*, *Asian*, and *Other* Race, with *White* as the reference category. *Female* is a dichotomous variable indicating whether the child is or is not female. The family characteristic included is parent's education level. Parent's education level is an indicator variable representing the highest level of education attained by either parent at any assessment period, and was classified as *high school dropout*, *high school graduate*, *attended some college*, *college degree holder*, and *advanced degree holder*, with *high school dropout* as the reference category. I included parent's education level instead of parental income because ample evidence points to parental education as a stronger indicator of child's achievement (Dubow *et al*. 2010; see Desforges *et al*. 2003, for review). In the interaction model, *Elementary* is a dichotomous variable indicating whether or not the child is in elementary school. *Middle* is a dichotomous variable indicating whether or not the child is in middle school.

Table 1 about here.
Table 2 about here.

Analytic Strategy

I estimated the effect of BMI and self-efficacy on math achievement trajectories using multilevel growth curve modeling techniques (Singer and Willet 2003). These models estimated the effect of change in BMI on change in math achievement trajectories, and allowed me to determine whether the changes in developmental trajectories coincide with BMI changes over time, and also to simultaneously determine if there is a moderating effect of self-efficacy. The estimated coefficients for BMI in these models show the change in math achievement trajectory for children who experienced an increase in BMI. All models were estimated using sampling weights that adjust for the unequal probabilities of selection for children in the ECLS-K. In these models, time points are nested within children.

The level-1 model fits BMI as a function of age across the observations for each child, and the level-2 model fits the level-1 intercepts and coefficients across all individuals as a function of children's fixed characteristics (gender, race / ethnicity, parent's highest education level, and self-efficacy). Exploratory analyses indicated that children's math achievement is most appropriately captured by a quadratic growth function due to the non-linear relationship between math and age. Consequently, I only present estimates from quadratic growth models. Model 1 summarized children's math achievement trajectories between kindergarten and 8th grade; model 2 estimated the effect of increased weight status on children's math achievement net of baseline growth trajectories; model 3 examined whether changes in weight trajectory coincide with changes in children's math achievement scores and simultaneously tests whether self-efficacy acts as a moderator of the hypothesized decline in math achievement; model 4 examined interactions between weight category and age, sex, race, elementary/ middle school, or parent's education level to assess whether their intersection is related to math achievement.

RESULTS

Model 1. Baseline Growth in Math Achievement

Level 1

$$Math_{it} = \pi_{0i} + \pi_{1i}Age_{it} + \pi_{2i}Age2 + \varepsilon_{it}$$

Level 2

$$\pi_{0i} = \gamma_{00} + \delta_{0i}$$
$$\pi_{1i} = \gamma_{10} + \delta_{0i}$$
$$\pi_{2i} = \gamma_{20} + \delta_{2i}$$

π_{0i} represents the estimated math score for a child who is five years of age and of normal weight π_{1i} represents the linear growth component for mathematics between kindergarten and eighth grade assessments, π_{2i} represents the quadratic growth component of the math achievement slope, ε_{it} is a within child error term, δ_{0i} represents random error term for the math achievement intercept, δ_{1i} represents the random error term for the linear component of the math achievement slope, δ_{2i} represents the error term for the quadratic component of the math achievement slope.

Table 3 about here.

Estimates and Interpretation

Model 1 estimates of the fixed and random effects are displayed in Table 3. The estimated coefficients for the fixed effects indicate that children's learning rates increase during early middle childhood and level off during late middle childhood (see the upper portion of Table 3). At age 5, the estimated mean math score for children is 17.19. Between the ages of 5 and 9, the average child's math score rapidly increases, evidenced by the large positive values for the liner component of the age slope for math (29.87) and the negative value for the quadratic component of the age slope for math (1.61). However, the rate of increase begins to slow by age 9, whereas by age 11, improvements in mathematics are much more modest than in early middle childhood.

The random effects indicate that patterns of growth vary significantly among children (see the lower portion of Table 3). Both initial levels of math achievement (χ^2=10,257, p < 0.001) and the linear (χ^2=7,217, p < 0.001) and quadratic components (χ^2=5,692, p < 0.001) of growth vary among children. Ranging from 0.27 for the quadratic components of the learning curves, to 0.36 for the linear component of the curve, estimated reliabilities for the math intercepts and linear and quadratic age slope components are, however, relatively low.

Model 2. Effects of Weight Status

Mean unconditional math achievement trajectories for 5 year-old sampled children were captured in the baseline model. In this next set of models, I examined the effect of changes in BMI on math achievement, with the added complexity of allowing an additional effect of children crossing into one of the weight status categories (i.e., overweight, obese). I included both dummy variables indicating a child's weight status category and a continuous measure of BMI because I hypothesized that the effect of BMI on math achievement is a complex non-linear function in which each one-point increase in BMI lowers children's math achievement, but that moving from the normal weight to the overweight or from the overweight to the obese category potentially leads to an additional reduction in math achievement.

Specification.

I estimated the effects of weight on children's development trajectories by including three covariates representing the continuous measure of BMI and categorical measures of BMI into the level-1 equation. I included both the continuous and discrete measures of BMI not to lose valid variation with discretization (Markon *et al*. 2011).

Level 1

$$Math_{it} = \pi_{0i} + \pi_{1i}Age_{it} + \pi_{2i}Age2 + \pi_{3i}BMI + \pi_{4i}Overweight + \pi_{5i}Obese + e$$

Level 2

$$\pi_{0i} = \gamma_{00} + \delta_{0i}$$
$$\pi_{1i} = \gamma_{10} + \delta_{0i}$$
$$\pi_{2i} = \gamma_{20} + \delta_{2i}$$
$$\pi_{3i} = \gamma_{30} + \delta_{3i}$$
$$\pi_{4i} = \gamma_{40} + \delta_{4i}$$
$$\pi_{5i} = \gamma_{50} + \delta_{5i}$$

At level 1, π_{0i} represents the estimated math score for a child in the normal- weight category when age, overweight, and obese are 0. The interpretation of π_{1i} and π_{2i} changes somewhat in this model; π_{1i} and π_{2i} represent the linear and quadratic components of growth controlling for weight status. π_{3i}, π_{4i}, and π_{5i} now represent, respectively, the effect of BMI increasing, being classified as overweight or obese, while controlling for baseline growth trajectories. If π_{3i} is negative, every point increase in BMI beyond normal weight gain tends to coincide with slower learning rates. If π_{4i} or π_{5i} is negative, overweight and obesity tend to coincide with a decline in children's learning rates independent of the linear BMI variable.

Estimates and Interpretation

Table 4 about here.

The estimated coefficients from this model are displayed in Table 4. The time-independent effects of overweight and obesity on children's development are negative. On average, every point increase in BMI beyond normal weight gain is associated with a decline of 0.0001 in children's math achievement trajectory ($p <0.001$). When a child is overweight, on average, their math achievement score is 5.77 points lower than we would expect if she was normal-weight at 5 years-old ($p <0.001$), and 7.97 points lower if she was obese ($p < 0.001$). Given that math achievement rates increase by about 29 points annually, over most of the period, a 5.77 and 7.97 point reduction in math scores is comparable to 2 and 3 months of math learning, respectively.

As shown in the lower portion of Table 4, the random effects estimates indicate that the effect of gaining weight on children's math trajectories varies significantly among children classified as overweight (var. = 0.33, χ^2= 488.2, $p = 0.03$) or obese (var. 0.21, χ^2 = 453.6, $p = 0.02$). The effect of increased BMI also varies significantly among children (var. 0.25, χ^2 = 485.7, $p = 0.01$). The reliability is low for all measures; 0.066, 0.017, and 0.032, respectively. Much of the variability among children in the effects of weight status on math achievement is due to sampling variability that cannot be explained by child characteristics, resulting in low reliabilities for these coefficients.

Figure 1 about here.

Model 3. Self-efficacy as Potential Moderator

In this model, I tested my second hypothesis by examining how children's level of self-efficacy influences the estimated effect of weight status on math achievement. I included indicators of children's sex, race, and parental education level as controls at level 2 because of the well-documented association between these characteristics and children's math achievement, and their potential association with children's self-efficacy. Self-efficacy is also included at level 2 as a dichotomous variable indicating whether the child scored high or low in self-efficacy. Because I was primarily interested in how self-efficacy affects math achievement scores in children of varying weight statuses, I allowed only BMI, overweight, and obesity to vary as a function of self-efficacy. Level 1 is the same as the previous model.

Level 1

$$Math_{it} = \pi_{0i} + \pi_{1i}Age_{it} + \pi_{2i}Age2 + \pi_{3i}BMI + \pi_{4i}Overweight + \pi_{5i}Obese + e$$

Level 2

$$\pi_{1i} = \gamma_{10} + \gamma_{11}Parent\ education$$
$$\pi_{2i} = \gamma_{20} + \gamma_{21}Parent\ education$$
$$\pi_{3i} = \gamma_{30} + \gamma_{31}Parent\ education\gamma +_{32}\ High\ Self - efficacy$$
$$\pi_{4i} = \gamma_{40} + \gamma_{41}Parent\ education + \gamma_{42}High\ Self - efficacy$$
$$\pi_{5i} = \gamma_{50} + \gamma_{51}Parent\ education + \gamma_{52}High\ Self - efficacy$$

Child Characteristics
$\pi_{70i} = \gamma_{60} + \gamma_{61}$*(Male)*
$+\gamma_{62}$*(African American)*
$+\gamma_{63}$*(Latino)*
$+\gamma_{64}$*(Asian)*
$+\gamma_{65}$*(Other)*

Because seven waves of data do not provide sufficient statistical power to reliably estimate the time-varying random effects of weight status, I do not allow the weight effects in this model to randomly vary. At level 1, π_{0i} still represents the estimated math score for a five-year old child in the normal-weight category. π_{1i} and π_{2i} represent the linear and quadratic components of growth controlling for BMI and BMI categories, respectively. π_{3i}, π_{4i}, and π_{5i} now represent the effect of BMI, overweight, and obesity controlling for baseline growth trajectories. γ_{11} , γ_{21} , γ_{31} , γ_{41} , γ_{51} indicate how the effects of BMI, overweight, and obesity differ by parental education level. γ_{32} , γ_{42} , γ_{52} reveal how the effects of being overweight or obese differ by self-efficacy in children's math achievement. γ_{61} indicates how the effects of overweight and obesity differ by gender. γ_{62} , γ_{63} , γ_{64} , γ_{65} indicate how the effects of increased weight differs for racial and ethnic minority children from white children. In this model, if γ_{32} , γ_{42} , or γ_{52} are positive and significant, overweight and obese children's math achievement trajectories will benefit from higher levels of self-efficacy.

Table 5 about here.

Estimates and Interpretation.

The estimates in Table 5 for this model show that the effects of overweight and obesity vary significantly among children. Partly consistent with hypothesis 2, overweight children's math achievement trajectories benefit with high levels of self-efficacy. On average, the math trajectories of overweight children with high levels of self-efficacy increase by 3.62 points more than those of overweight children with low levels of self-efficacy ($p < 0.005$). High self-efficacy, by contrast, is not significantly associated with improved math achievement trajectories in obese children ($p = 0.73$). I calculated and graphed predicted probabilities of math achievement by age and self-efficacy level by weight status (Figure 1).

Figure 1 about here.

Racial and ethnic minority children differ significantly from white children in math achievement. African American children's BMI effects on achievement, on average, are 0.00006 more negative ($p < 0.01$) than those of white children. Hispanic children BMI effects are also more negative than those of white children by about 0.00001 points, on average ($p = 0.02$). Female children have a 0.00002 more negative BMI effects on math achievement compared to male children ($p < 0.001$). Overweight racial and ethnic minority children do not differ significantly from overweight white children in math achievement. Other Race children classified as obese have math achievement scores that are 7.89 points lower than those of obese white children ($p = 0.02$). The estimated effect of being overweight differs significantly from normal-weight children based on parental education level. For overweight children whose parents have attended some college, math achievement scores are 1.84 points lower than those of overweight children whose parent's dropped out of high school ($p = 0.03$). Children who are classified as overweight and have a parent who is a college graduate are 8.23 points higher than overweight children whose parents have dropped out of high school ($p = 0.03$). Overweight children, on average, who have a parent that received an advanced degree are 9.13 points higher than overweight children whose parents dropped out of high school ($p < 0.005$). Scores for children classified as obese, by contrast, are not significantly associated with the expected benefits of parental education level from math achievement.

Model 4. Interaction Effects

To test whether the intersection between weight category and age, sex, race, elementary school, middle school, or parent's education level is related to math achievement, I incorporated multiplicative terms into model 2. At level 1, π_{0i} represents the estimated math score for a child in the normal- weight category when age, overweight, and obese are 0. π_{1i} and π_{2i} represent the linear and quadratic components of growth controlling for weight status. π_{3i}, π_{4i}, and π_{5i} now represent, respectively, the effect of BMI increasing, being classified as overweight or obese, while controlling for baseline growth trajectories. π_{6i}, π_{7i}, π_{8i} represent the interaction effects of age (shown below), sex, race, elementary school, middle school, or parent's education level on, respectively, increasing BMI, being classified as overweight, or as obese.

Level 1

$$Math_{it} = \pi_{0i} + \pi_{1i}Age_{it} + \pi_{2i}Age2 + \pi_{3i}BMI + \pi_{4i}Overweight + \pi_{5i}Obese + \pi_{6i}Age * Overweight + \pi_{7i}Age * Obese + \pi_{8i}Age * BMI + e$$

Level 2

$$\pi_{0i} = \gamma_{00} + \delta_{0i}$$
$$\pi_{1i} = \gamma_{10} + \delta_{0i}$$
$$\pi_{2i} = \gamma_{20} + \delta_{2i}$$
$$\pi_{3i} = \gamma_{30} + \delta_{3i}$$
$$\pi_{4i} = \gamma_{40} + \delta_{4i}$$
$$\pi_{5i} = \gamma_{50} + \delta_{5i}$$
$$\pi_{6i} = \gamma_{60} + \delta_{6i}$$
$$\pi_{7i} = \gamma_{70} + \delta_{7i}$$
$$\pi_{8i} = \gamma_{80} + \delta_{8i}$$

Significant interaction between obesity and age ($p = 0.002$) indicates that the impact of obesity on math achievement is stronger as children age. In contrast, I found no significant differences between overweight and gender ($p = 0.21$) or obesity and gender ($p = 0.46$).

There were no significant differences between overweight and being an African American ($p = 0.49$), Hispanic ($p = 0.85$), Asian ($p = 0.46$), or Other Race ($p = 0.44$) child or obesity and African American ($p = 0.81$), Hispanic ($p = 0.13$), Asian ($p = 0.13$), or Other Race ($p = 0.69$) child. There were also no significant differences between children in elementary school and overweight ($p =0.10$) or obesity ($p = 0.08$). There were no significant differences between middle school and overweight (0.09) or obesity ($p = 0.12$). I found no significant differences between overweight and parent's education level for high school graduates ($p = 0.23$), some college ($p = 0.38$), bachelor's degree holders ($p = 0.78$), or advanced degree holders ($p = 0.09$). I also found no difference between obesity and parent's education level for high school graduates (p = 0.49), some college (p = 0.38), bachelor's degree holders (p = 0.72), or advanced degree holders (p = 0.31).

DISCUSSION

The increasing number of overweight and obese children in the United States, coupled with the underperformance of our public education system (OECD 2013), warrants a better understanding of the mechanisms contributing to the health of children, as well as the cognitive dysfunction associated with increased weight, particularly in light of declining math achievement in the United States (OECD 2013). Overweight and obese children are more likely to suffer from low self-esteem, anxiety disorders, and other psychopathologies (see Zametkin *et al.* 2004, for review), which may lead to lowered math performance (Judge and Jahns 2007). However, the causality of this association has yet to be determined. It is possible that mental health problems associated with obesity predispose overweight or obese children to lower academic achievement (Taras and Potts-Datema 2009), or that obesity is a marker, rather than a cause of low achievement (Datar *et al.* 2004). A strong sense of self-efficacy engenders intrinsic interest and deep-seeded involvement in academic activities (Bandura 1994), and produces a sense of assurance that a child can exercise control over her life.

My findings indicate that, on average, overweight and obesity in children coincides with a few point reduction in math achievement, the equivalent of 2 to 3 months of learning. Overweight children's math achievement trajectories benefit with high levels of self-efficacy, but, in contrast, high self-efficacy does not produce the same effect in obese children. Results further indicate that the effect of obesity on math achievement is stronger as children age, showing that obese children's lowered math scores are lower relative to normal weight children at older ages than at younger ages. The effect of obesity on math achievement may increase as children age due to extended periods of institutionalized discrimination and weight-related comorbidities that are progressively more pronounced as children age (Dietz 1998). Thus, in order for self-efficacy to act as a moderator on math achievement trajectories, the onset of obesity is critical. Given that the developmental detriments of overweight on math achievement learning trajectories are moderated by self-efficacy, a learned behavior, intervention timing is crucial.

Why are children most in need of the gains associated with self-efficacy the least likely to benefit? It is possible that the stigma, affective disorders, and social isolation associated with obesity have a stronger impact on obese children, and, thus, may impede the ability of self-efficacy to act as a moderator in the child's math achievement. For example, the stresses associated with overweight are stronger for an obese child due to her higher weight status, and, thus, she may experience more social disadvantages, overwhelming the already more constrained child. In contrast, overweight children may experience less of these social disadvantages as a result of being closer to normal weight children in appearance, and are thus more likely to benefit from self-efficacy as a resource in adapting to the complexities and challenges of heightened BMI. It is also possible that because childhood obesity is stigmatized and obese children are viewed as unhealthy and lazy (Crandall and Schiffhauer 1998; Frisco *et al*. 2010), these children interpret and internalize the negative communications of others in their construction of self-definition, and lowered math achievement becomes a self-fulfilling prophecy.

Although this is the first study to systematically examine self-efficacy as a moderator of math achievement in overweight and obese children, this study has limitations. First, because of data limitations, self-efficacy was measured at a single time point even though it may fluctuate due to varied and varying psychological and physiological factors that were not measured in this data set. For example, differential sensitivity and tolerance to negative peer influences are associated with varying psychological effects, with the most socially connected children being the least negatively affected by their increased weight status (Gable *et al.* 2012). It has also been shown that weight perceptions have a stronger association with depressive symptoms than actual weight status in adolescents (Frisco *et al*. 2010). Second, only seven waves of data are available in the ECLS-K 1998-1999 cohort, and therefore, power to identify complex nonlinear relationships between overweight and obesity and child's development is limited. Third, estimated reliabilities for the weight coefficients in the individual-level equations are low. Consequently, the ability to detect significant associations between child characteristics and the estimated effects of overweight and obesity on children's developmental trajectories is attenuated. Fourth, there is no consensus on the causal effect of childhood obesity on standardized test scores and math outcomes, but, there is a clear link between obesity and cognitive function. As such, more research is necessary to find mechanisms underlying cognitive decline associated with overweight and obesity. This knowledge may help elucidate the relationship between increased weight status and lower math achievement in children. Fifth, emphasis of my research is on the "normal" weight status in children, and any interpretation of such an obscure socially constructed and variable pattern is limited in that its contribution is inevitably a by-product of the social reality it describes. Thus, interpretations are always vulnerable to overstating the importance of eventful change and to minimizing the complex continuities of people's lives. Finally, I have focused on child-level attributes as precursors for math outcomes and learning trajectories. I did not, however, consider other relevant factors of children's math outcomes such as parent-child and teacher-child relationships or educational context, despite that these factors likely influence children's math achievement and self-efficacy.

Despite these limitations, current findings illuminate the importance of psychological resources, particularly self-efficacy, on math achievement trajectories in children. Previous research has shown self-efficacy to act as a moderator across a number of outcomes (Brown *et al.* 1989; Matsui and Onglatco 1992; Bandura 1994; Bandura 2000; Brown *et al.* 2001). The current study adds to the self-efficacy literature by showing that self-efficacy acts as a moderator of lowered math achievement in overweight children. Taken together, future research is needed to help improve intervention and treatment programs, and to help implement more effective social policies targeting childhood obesity and related comorbidities, such as lowered math outcomes.

REFERENCES

Adeyinka, Tella, Adedeji, Tella, and Adeniyi Sam Olufemi. (2011). Locus of control, interest in schooling and self-efficacy as predictors of academic achievement among junior secondary school students in Osun state, Nigeria, *New Horizons in Education* 59(1), 25-38.

Allison, Paul. (2001). *Missing Data*. Thousand Oaks, CA: Sage.

Almond D, Currie J. (2010). Human capital development before age five. In *The Handbook of Labor Economics, 4b*. ed. O Ashenfelter, D Card 15, 1315-486. Amsterdam: Elsevier Science B.V.

Almond D, Currie J. (2011). Killing Me Softly: The Fetal Origins Hypothesis, *Journal of Economic Perspective* 25(3), 153-72.

Arnstein, P., Caudill, M., Mandle, C. L., Norris, A., & Beasley, R. (1999). Self efficacy as a mediator of the relationship between pain intensity, disability and depression in chronic pain patients, *Pain* 80(3), 483-491.

Averett, Susan. L. and David C. Stifel. (2010). Race and gender differences in the cognitive effects of childhood overweight, *Applied Economics Letters* 17(17), 1673-1679.

Balistreri, Kelly S. and Jennifer Van Hook. (2010). Trajectories of overweight among US school children: A focus on social and economic characteristics, *Maternal and Child Health Journal* 15, 610-619.

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change, *Psychological review*, *84*(2), 191.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning, *Educational Psychologist 28,* 117-148.

Bandura, A. (1994). *Self-efficacy*. Corsini Encyclopedia of Psychology 1-3.

Bandura, A. (2005). The primacy of self-regulation in health promotion. *Applied Psychology*, *54*(2), 245-254.

Bandura, A. (2006). *Self-efficacy Beliefs in Adolescents*. Pajares, F. and T.C. Irdan (eds). IAP-Information Age Publishing.

Baskin, M.L., Ard, J., Franlkin, F., and D.B. Allison. (2005). Prevalence of obesity in the United States, *Obesity Reiew* 6: 5–7.

Befort, C.A. Nazir, N., and M.G. Perri. (2012). Prevalence of obesity among adults from rural and urban areas of the United States: Findings from NHANES (2005–2008), *Journal of Rural Health* 28, 392–7.

Braet, C., Claus, L., S., Verbeken, and L. van Vlierberghe. (2007). Impulsivity in overweight Children, *European Child and Adolescent Psychiatry* 16(8), 473-483.

Brown, S. D., Lent, R. W., & Larkin, K. C. (1989). Self-efficacy as a moderator of scholastic aptitude-academic performance relationships. *Journal of vocational behavior*, *35*(1), 64-75.

Brownwell, K. and K.B. Horgen. (2004). *Food fight: The inside story of the food industry, America’s obesity crisis, and what we can do about it*. McGraw Hill: New York.

Casey, B. J., Tottenham, N., Liston, C., & Durston, S. (2005). Imaging the developing brain: what have we learned about cognitive development? *Trends in cognitive sciences*, *9*(3), 104-110.

Chi, S. H., Grigsby-Toussaint, D.S., Bradford, N., and J. Choi. (2013). Can geographically weighted regression improve our contextual understanding of obesity in the US? Findings from the USDA Food Atlas, *Applied Geography* 44, 134–42.

Clark, M. M., Abrams, D. B., Niaura, R. S., Eaton, C. A., & Rossi, J. S. (1991). Self-efficacy in weight management, *Journal of consulting and clinical psychology*, *59*(5), 739.

Cowen, E. L., Work, W. C., Hightower, A. D., Wyman, P. A., Parker, G. R., & Lotyczewski, B. S. (1991). Toward the development of a measure of perceived self-efficacy in children, *Journal of Clinical Child and Adolescent Psychology*, *20*(2), 169-178.

Crandall, Christian and Kristin Schiffhauer. (1998). Anti Fat Prejudice: Beliefs, Values, and American Culture, *Obesity Research* 6, 458-60.

Crisp, A.H. and B. McGuiness. (1976). Jolly fat: relation between obesity and psychoneurosis in general population, *British Medical Journal* 1, 7–9.

Crosnoe, Robert. (2007). Gender, Obesity, and Education, *Sociology of Education* 80, 241-260.

Cserjesi, R., Luminet, O., Molnar, D., and L. Lenard. (2007). Is there a relationship between obesity and mental flexibility in children?, *Appetite* 49, 675-678.

Currie, J. (2009). Healthy, Wealthy, and Wise: Socioeconomic status, poor health in childhood, and human capital development. *Journal of. Economic Literature., American Economic Association* 47(1), 87-122.

Daniels SR, Arnett DK, Eckel RH, et al. (2005). Overweight in children and adolescents: pathophysiology, consequences, prevention, and treatment, *Circulation* 111, 1999–2002.

Dannefer, D. (1984). Adult development and social theory: A paradigmatic reappraisal, *American Sociological Review* 49(1), 100-116.

Davis, C.L., Tomporowski, P.D., McDowell, J.E., Austin, B.P., Miller, P.H., Tanasak, N.E., Allison, J.D., and J.A. Naglieri. (2011). Exercise improves executive function and achievement and alters brain activation in overweight children: A randomized, controlled trial, *Healthy Psychology* 30(1), 91-98.

Desforges, Charles, and Alberto Abouchaar. (2003). *The impact of parental involvement, parental support and family education on pupil achievement and adjustment: A review of literature*. London: DFES Publications.

Dietz, W. H. (1998). Health consequences of obesity in youth: childhood predictors of adult disease. *Pediatrics*, *101*(Supplement 2), 518-525.

Dubow, E.F., Boxer, P., and Huesmann, L.R. (2010). Long-term effects of Parents' Education on Children's Educational and Occupational Success: Mediation by Family Interactions, Child Aggression, and Teenage Aspirations, *Merril-Palmer Quarterly* 55(3), 224-249.

Frankl, V. E. (1963). *Man's search for meaning.* Boston: Beacon Press.

Fredrickson, B. L., Roberts, T. A., Noll, S. M., Quinn, D. M., & Twenge, J. M. (1998). The swimsuit becomes you: Sex differences in self-objectification, restrained eating, and math performance. *Journal of Personality and Social Psychology*, 75, 269–284.

Freedman DS, Zuguo M, Srinivasan SR, Berenson GS, Dietz WH. (2007). Cardiovascular risk factors and excess adiposity among overweight children and adolescents: the Bogalusa Heart Study, *Journal of Pediatrics* 150(1), 12–17.

Gable, Sara, Krull, Jennifer L., and Yiting Chang. (2012). Boys' and girls' weight status and math performance from kindergarten entry through fifth grade: A mediated analysis, *Child Development* 83(5), 1822-1839.

Garver, W.S., Newman, S.B., Gonzales-Pacheo, D.M., Castillo, J.J., Jelinke, D., Heidenreich, R.A., and R.A. Orlando. (2013). The genetics of childhood obesity and interaction with dietary macronutrients, *Genes and Nutrition* 8, 271-287.

Hulst, A.V. Gauvin, L. Kestens Y., and T.A. Barnett. (2013). Neighborhood built and social environment characteristics: a multilevel analysis of associations with obesity among children and their parents, *International Journal of Obesity* 37, 1328–35.

Judge, S., & Jahns, L. (2007). Association of overweight with academic performance and social and behavioral problems: an update from the early childhood longitudinal study. *Journal of School Health*, *77*(10), 672-678.

Johnston, W. A., & Heinz, S. P. (1978). The flexibility and capacity demands of attention. *Journal of Experimental Psychology: General*, 707, 420-435.

Klinitzke, G., Steinig, J., Bluher, M., Kersting, A., and B. Wagner. (2012). Obesity and suicide risk in adults—A systemic review, *Journal of Affective Disorders* 145, 277-284.

Kaestner, R. Grossman, M., and B. Yarnoff. (2009). Effects of weight n adolescent educational attainment, *NBER Working Paper: National Bureau of Economic Research.*

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development* (Vol. 1). Englewood Cliffs, NJ: Prentice-Hall.

Li, Y., Dai, Q., Jackson, J. C., & Zhang, J. (2008). Overweight is associated with decreased cognitive functioning among school-age children and adolescents, *Obesity* 16(8), 1809-1815.

Linde, J. A., Rothman, A. J., Baldwin, A. S., & Jeffery, R. W. (2006). The impact of self-efficacy on behavior change and weight change among overweight participants in a weight loss trial, *Health Psychology*, *25*(3), 282.

Finkelstein, J E.A., Trogdon, J.G., Cohen, J.W., and W. Dietz. (2009). Annual medical spending attributable to obesity: payer- and service-specific estimates, *Health Affairs* 28, w822–w831.

Fredrickson, B. L., Roberts, T. A., Noll, S. M., Quinn, D. M., and J. M. Twenge. (1998). The swimsuit becomes you: Sex differences in self-objectification, restrained eating, and math performance, *Journal of Personality and Social Psychology* 75, 269–284.

Frisco, M.L., Houle, J.N., and M.A. Martin. (2010). The image in the mirror and the number on the scale: Weight perceptions and adolescents depressive symptoms, *Journal of Health and Social Behavior* 51(2), 215-228.

Giskes, K., van Lenthe, F.J., Turrell, G., Kamphuis, C.B., and J. Brug. (2008). Socioeconomic position at different srages of the life course and its influence on body weight and weight gain in adulthood: A longitudinal study with 13-year follow up, Obesity 16(6), 1377-1381.

Gopal K. Singh; Michael D. Kogan; Peter C. van Dyck. (2010). Changes in State-Specific Childhood Obesity and Overweight Prevalence in the United States From 2003 to 2007, *Archives of Pediatrics & Adolescent Medicine* 84.

Hedley, A.A., Ogden, C.L., Johnson C.L., Carroll, M.D., Curtin, L.R., and K.M. Flegal. (2004). Prevalence of overweight and obesity among US children, adolescents, and adults, 1999–2002, *Journal of American Medical Association* 291, 2847–50.

Judge, Timothy A., Erez, Amir, Bono, Joyce E., and Carl J. Thoresen. (2002). Are measures of self-esteem, neuroticism, locus of control, and generalized self-efficacy indicators of a common core construct? *Journal of Personality and Social Psychology* 83(3), 693-710.

Kamijo, K., Pontifex, M.B., Khan, N.A., Raine, L.B., Scudder, M.R., Drollette, E.S., Evans, E.M., Castello, D.M., and C.H. Hillman. (2014). The Negative Association of Childhood Obesity to Cognitive Control of Action Monitoring, *Cerebral Cortex* 24, 654-662.

Kopelman, P. (2007). Health risks associated with overweight and obesity, *Obesity Review* 8, 13–7.

Kuczmarski, R.J., Ogden, C.L., Guo, S.S., Grummer Strawn, L., Felgal, M., and S.Mei et al. (2002). 2000 CDC growth charts for the United States: Methods and development. National Center for Health Statistics, *Vital Health Statistics* 11, 246.

Li, Y., Dai, Q., Jackson, J., & Zhang, J. (2008) Overweight is associated with decreased cognitive functioning among school-age children and adolescents, *Obesity*, 16, 1809 -1815.

Linde, J. A., Rothman, A. J., Baldwin, A. S., & Jeffery, R. W. (2006). The impact of self-efficacy on behavior change and weight change among overweight participants in a weight loss trial. *Health Psychology*, *25*(3), 282.

Ludwig, D. S. (2007). Childhood obesity—the shape of things to come. *New England Journal of Medicine*, *357*(23), 2325-2327.

McLaren, L. (2007). Socioeconomic status and obesity, *Epidemiological Rev*iew 29, 29–48.

Markon, K.E., Chmielewski, M., and C.J. Miller. (2011). The reliability and validity of discrete and continuous measures of psychopathology: A quantitative review, *Psychological Bulletin* 137, 856-879.

Marlow, M.L. (2013). Determinants of state laws addressing obesity, *Applied Economic Letters*.21, 84–9.

McCabe, M. P., & Ricciardelli, L. A. (2005). A longitudinal study of body image and strategies to lose weight and increase muscles among children, *Applied Developmental Psychology* 26, 559–577.

Multon, K. D., Brown, S. D., & Lent, R. W. (1991). Relation of self-efficacy beliefs to academic outcomes: A meta-analytic investigation. *Journal of counseling psychology*, *38*(1), 30.

OECD; Organization for Economic Cooperation and Development (2013), Education at a Glance 2013: OECD Indicators, OECD Publishing. http://dx.doi.org/10.1787/eag-2013-en.

Ogden, C.L., Carroll, M.D., Kit, B.K., and K.M. Flegal. (2014). Prevalence of childhood obesity in the United States, 2011-2012. *Journal of the American Medical Association*, 311(8), 806-14.

Ogden, C.L., Carroll, M.D., Kit, B.K., and K.M. Flegal. (2012). Prevalence of childhood obesity in the United States, 1999-2010. *Journal of the American Medical Association*, 307(5), 806-14.

Pajares, F., & Miller, M.D. (1994). Role of self-efficacy and self-concept beliefs in mathematical problemsolving: A path analysis. *Journal of educational psychology, 86*(2), 193.

Pajares, F., & Kranzler, J. (1995). Self-efficacy beliefs and general mental ability in mathematical problem-solving. *Contemporary Educational Psychology*, 20, 426-443.

Power, C., Manor, O., and S. Matthew. (2003). Child to adult socioeconomic conditions and obesity in a national cohort. *International Journal of Obesity and Related Metabolic Disorders*, 27(9), 1081-1086.

Robinson, S. (2006). Victimization of obese adolescents. *The Journal of school nursing*, *22*(4), 201-206.

Scott, K.M., Bruffaerts, R., Simon, G.E., Alonso, J., Angermeyer, M., de Girolamo, Demyttenaere, G. K., Gasquet, I., Haro, J.M., Karam, E., Kessler, R.C., Levinson, D., Mora, M.E.M., Browne, M.A. O., Ormel, Villa, J. J.P., Uda, H., and M. Von Korff. (2008). Obesity and mental disorders in the general population: results from the world mental health surveys, *International Journal of Obesity* 32, 192–200.

Schunk, D. H. (1995). Self-efficacy and education and instruction. In *Self-efficacy, adaptation, and adjustment* pp. 281-303, Springer US.

Schunk, D. H., & Pajares, F. (2004). Self-efficacy in Education revisited. *Big theories revisited*, 15-138.

Seligman, M. E. P. (1998). *Learned optimism: How to change your mind and your life* (2nd ed.). New York: Pocket Books.

Shore, S., Sachs, M., Lidicker, J., Brett, S., Wright, A., & Libonati, J. (2008). Decreased scholastic achievement in overweight middle school students. *Obesity*, 16, 1535-15.

Siegel, R. G., Galassi, J. P., & Ware, W. B. (1985). A comparison of two models for predicting mathematics performance: Social learning versus math aptitude–anxiety. *Journal of Counseling Psychology*, *32*(4), 531.

Singer, J. D., and J. B. Willett. (2003). *Applied longitudinal analysis. Modeling change and event occurrence*. New York: Oxford University Press.

St Clair-Thompson, H.L. and S.E. Gathercole. (2006). Executive functions and achievements in school: Shifting, updating, inhibition, and working memory. *The Quarterly Journal of Experimental Psychology* 59(4), 745-59.

Strauss, R.S. and H.A. Pollack. (2003). Social marginalization of overweight children. *Archives of Pediatric and Adolescent* Medicine, 157(8), 746-752.

Taras, H., & Potts-Datema, W. (2005). Obesity and student performance at school. *Journal of School Health, 75*(8), 291-295.

Taylor, S. E. (1989). *Positive illusions: Creative self-deception and the healthy mind.* New York: Basic Books.

Taylor, S. E., Kemeny, M. E., Reed, G. M., Bower, J. E., & Gruenewald, T. L. (2000). Psychological resources, positive illusions, and health. *American psychologist*, *55*(1), 99.

Tershakovec, A.M. Weller, S.C., and P.R. Gallagher. (1994). Obesity, school performance and behavior of black, urban elementary school children. *International Journal of Obesity and Related Metabolic* Disorders, 18(5), 232-7.

Tomporowski, P.D., Davis, C.L., Miller, P.H., and J.A. Nagliri. (2008). Exercise and children's intelligence, cognition, and academic achievement, *Education Psychology Review* 20, 111-131.

Tourangeau, K., Nord, C., Lê, T., Sorongon, A. G., and Najarian, M. (2009). *Early Childhood Longitudinal Study, Kindergarten Class of 1998–99 (ECLS-K), Combined User's Manual for the ECLS-K Eighth-Grade and K–8 Full Sample Data Files and Electronic Codebooks* (NCES 2009–004). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

United States Census Bureau. (2013). Accessed April 5, 2014 at http://www.census.gov/population/intmigration.

Wadden, T.A., Foster, G.D., Stunkard, A.J., and J.R. Linowitz. (1989). Dissatisfaction with weight and figure in obese girls: discontent but not depression, *International Journal of Obesity* 13, 89–97.

Wang, J., Sereika, S.M., Styn, M.A., and L.E. Burke. (2013). Factors associated with health-related quality of life among overweight or obese adults, *Journal of Clinical Nursing* 22, 2172–82.

West, J., Denton, K., Reaney, L. M., Campbell, J. R., Hombo, C. M., Mazzeo, J., ... & Angeles,

J. (2000). Kindergarten. *National Center for Education Statistics, 2*(4), 25.

Woolf, S. H., and Aron, L. (Eds.). (2013). *US Health in International Perspective: Shorter Lives, Poorer Health*. National Academies Press.

Woodcock, R. W., McGrew, K. S., and J. K. Werder. (1996). *Woodcock-McGrew-Werder Mini-Battery of Achievement*. Itasca, IL: Riverside.

Yanovski, S.Z. and J.A. Yanovski. (2011). Obesity prevalence in the United States – Up, down, or sideways? *New England Journal of Medicine* 364, 987–9.

Zametkin AJ, Zoon CK, Klein HW, Munson S. (2004). Psychiatric aspects of child and adolescent obesity: a review of the past 10 years. *Journal of American Academy of Child Adolescent Psychiatry*, 43(2), 134- 1 SO.

Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of educational psychology*, *81*(3), 329.

Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary educational psychology*, *25*(1), 82-91.

Table 1: Means and Standard Deviations for Time Varying Covariates, by Wave

		Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 6	Wave 7
Age								
	M	5.71	6.23	6.67	7.24	9.13	11.07	14.07
	SD	0.36	0.36	0.38	0.35	0.35	0.36	0.35
BMI of Males								
	M	16.33	16.45	16.64	16.87	18.57	20.35	22.36
	SD	2.14	2.23	2.50	2.77	3.77	4.61	5.61
BMI of Females								
	M	16.07	16.24	16.40	16.70	18.34	20.06	22.58
	SD	2.11	2.23	2.56	2.69	3.67	4.46	7.30

Source: Data are from the Early Childhood Longitudinal Study Kindergarten Class 1998-1999.

Table 2. Weighted Means and Standard Errors for Time Invariant Covariates, by Weight Status

	Normal-weight		Overweight		Obese	
Variable	M	(SE)	M	(SE)	M	(SE)
Demograhics						
Gender						
Male	0.52	(0.01)	0.53	(0.02)	0.61	(0.02)
Female	0.48	(0.01)	0.47	(0.02)	0.39	(0.02)
Race/ethnicity						
White	0.75	(0.02)	0.69	(0.03)	0.63	(0.03)
African American	0.04	(0.01)	0.06	(0.01)	0.06	(0.01)
Hispanic	0.15	(0.01)	0.19	(0.03)	0.24	(0.02)
Asian	0.03	(0.01)	0.02	(0.01)	0.02	(0.01)
Other Race	0.04	(0.01)	0.04	(0.01)	0.05	(0.01)
Self-efficacy						
Low	0.47	(0.01)	0.48	(0.02)	0.53	(0.01)
High	0.53	(0.01)	0.52	(0.02)	0.47	(0.01)
Parent Education Level						
Highschool Dropout	0.03	(0.01)	0.08	(0.02)	0.08	(0.01)
Highschool Graduate	0.13	(0.01)	0.16	(0.01)	0.21	(0.02)
Some College	0.05	(0.01)	0.06	(0.01)	0.08	(0.01)
College Graduate	0.26	(0.01)	0.21	(0.02)	0.02	(0.01)
Advanced Degree	0.27	(0.01)	0.21	(0.02)	0.15	(0.01)
N	3,090	3090	1,061		922	

Source: Data are for children from 1998-2007 ECLS-K

Note: SE indicates Standard Error

Table 3. Estimated Coefficients for Quadratic Growth Model of Math Achievement Scores				
Fixed Effects	Coefficient	SE	t ratio	p
Intercept, $\pi 0i$	17.19	0.15	116.75	<0.001
Age, $\pi 1i$	29.87	0.07	455.06	<0.001
Age2, $\pi 2i$	-1.61	0.01	-266.32	<0.001
Random Effects	Variance Com	df	$\chi 2$	p
Level 1				
ε_{it}	6.01			
Level 2				
Intercept, $\pi 0i$	7.57	4925	10,257.73	<0.001
Age, $\pi 1i$	2.9	4925	7,217.56	<0.001
Age2, $\pi 2i$	0.24	4925	5,692.63	<0.001
Source: Data are for children between 1998-2007, ECLS-K.				
Note: SE indicates Standard Error				

Table 4. Estimated Coefficients for Quadratic Growth Model of Math Achievement Scores with Time-varying Indicator of Weight Status				
Fixed Effects	Coefficient	SE	t ratio	p
Intercept, π0i	14.8	0.25	58.41	<0.001
Age, π1i	29.74	0.07	449.2	<0.001
Age2, π2i	-1.60	0.01	-262.54	<0.001
BMI, π3i	-0.0001	0.00	-26.41	<0.001
Overweight, π4i	-5.77	0.07	-8.46	<0.001
Obesity, π5i	-7.97	0.69	-11.59	<0.001
Random Effects	Variance Com	df	χ2	p
Level 1				
ε_{it}	35.66			
Level 2				
Intercept, π0i	34.85	4925	7,907.35	<0.001
Age, π1i	8.81	4925	7,326.05	<0.001
Age2, π2i	0.06	4925	5,781.46	<0.001
BMI, π3i	0.25	4925	485.70	0.01
Overweight, π4i	0.33	4925	488.20	0.03
Obesity, π5i	0.21	4925	453.60	0.02
Source: Data are for children between 1998 - 2007, ECLS-K.				
Note: SE indicates Standard Error				

Table 5. Estimated Effects of Self-efficacy on Math Achievement for Overweight and Obese Children by Selected Characteristics			
	BMI	Overweight	Obese
Intercept	-0.0002***	-6.61***	-7.21***
Child Variables			
Female	-0.00002***	1.09	-0.0003
SE	0.000004	1.20	1.32
Race			
African American	-0.000006***	-5.82	-0.87
SE	0.00001	5.12	2.46
Hispanic	-0.00001*	-2.90	-2.53
SE	0.000005	2.48	2.94
Asian	0.00002	3.62	5.09
SE	0.00001	2.49	2.99
Other	0.000004	-1.72	-7.88
SE	0.000007	2.59	3.25
Child Characteristics			
High Self-efficacy	0.000001	3.62**	0.43
SE	0.000002	1.26	1.25
Family Charcateristics			
HS Graduate	-0.00001	-1.36	-2.69
SE	0.00008	2.07	1.91
Some College	-0.00002	-6.23**	-3.68
SE	0.00001	2.84	2.52
College Graduate	0.00002***	3.79*	0.60
SE	0.000006	1.75	1.77
Advanced Degree	0.00003***	4.68**	1.87
SE	0.000005	1.62	1.72

Source: Data are from the ECLS-K (1998-1999).
Note: SE indicates Standard Error.
Note: * p <0.05 ** p <0.005 ***p < 0.001.

Figure 1: Effect of Age and High Self-efficacy on Math Achievement, by Weight Status