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Obesity and Developmental Functioning Among Children Aged 2-4 Years

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Obesity and Developmental Functioning Among Children Aged 2-4 Years

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Abstract

In developed countries, obesity tends to be associated with worse labor market outcomes. One possible reason is that obesity leads to less human capital formation early in life. This paper investigates the association between obesity and the developmental functioning of children at younger ages (2-4 years) than ever previously examined. Data from the German Socio-Economic Panel Study are used to estimate models of developmental functioning in four critical areas (verbal skills, activities of daily living, motor skills, and social skills) as a function of various measures of weight (including BMI and obesity status) controlling for various child and family characteristics. The findings indicate that, among boys, obesity is a significant risk factor for lagged development in verbal skills, social skills, and activities of daily living. Among girls, weight generally does not have a statistically significant association with these developmental outcomes. Further investigations show that the correlations exist even for those preschool children who spend no time in day care, which implies that the correlation between obesity and developmental functioning cannot be due to discrimination by teachers, classmates, or even day care providers.

JEL Codes: I12, J24

Keywords: obesity, human capital, children, child development, Germany, gender

Introduction

In developed countries, obesity tends to be associated with worse labor market outcomes; in particular, lower wages or earnings (Cawley, 2004; Brunello and d'Hombres 2007; Lundborg et al. 2007) and a lower probability of employment (Paraponaris et al. 2005; Lundborg et al. 2007; Morris, 2007; Burkhauser and Cawley, 2008). Several papers have found evidence that the relationship is causal; i.e. that weight worsens labor market outcomes (e.g. Cawley, 2004; Cawley et al. 2005; Morris 2007).

Obesity may worsen labor market outcomes for several reasons, including discrimination by employers or lower productivity due to worse health. Another possibility is that childhood obesity, which is a strong predictor of adult obesity[1], leads to less human capital formation and therefore lower productivity in adulthood (Sabia 2007; Lobstein et al. 2004). An obese child might acquire less human capital for several reasons; e.g. obesity-related illness may impair human capital acquisition, there may be discrimination by teachers or day care providers, or parents may invest less in obese than healthy-weight children.

This paper explores the association of childhood obesity with developmental functioning at younger ages (2-4 years) than previously examined. This research question is timely because the prevalence of childhood obesity has risen rapidly in many countries (Lobstein et al. 2004; Kurth and Schaffrath, 2007; Ogden et al. 2002; WHO, 2005), which has led some to describe childhood obesity as a pandemic (Malecka-Tendera, 2006; Kimm, 2002).

[1] Roughly 20% of obese adults were obese as children (estimates range from 5-44%) and the probability of becoming an obese adult is roughly 400% greater for obese children than non-obese children (estimates range from 200% to 650%); see Freedman et al. (2005) and Serdula et al. (1993).

Previous studies of whether childhood overweight is associated with impaired developmental functioning have focused largely on children of elementary school age (Datar and Sturm,2006; Cairney et al. 2006; Datar et al. 2004; Graf et al. 2004; Mo-suwan et al. 1999) or those about to enter elementary school (Mond et al., 2007). To our knowledge, this is the first study of overweight and developmental functioning to study children as young as 2 to 4 years old. Knowing whether obesity is associated with delayed development in pre-school (as opposed to school-age) children is important because it would suggest a different mechanism than if the association was limited to school-age children. For example, if obesity is associated with developmental delays prior to school entry, it suggests that the association cannot solely be due to discrimination by schoolteachers or classmates after school entry.

Several studies have examined how childhood obesity correlates with academic outcomes. A study of nationally representative U.S. data on kindergarten and third-grade children found that girls who became overweight between kindergarten and third grade had significantly lower scores on reading tests and math tests, and rated lower on teacher-assessed interpersonal skills, than girls who were never overweight (Datar and Sturm, 2006). Becoming overweight was not associated with worse outcomes for boys, nor was continuing to be overweight between kindergarten and third grade associated with worse outcomes for either girls or boys. Analysis of the same sample when they were still in kindergarten found a negative correlation between overweight status and test scores on math and reading exams, but these differences (except for the gap in math test scores among boys) became insignificant after controlling for socioeconomic and behavioral characteristics (Datar et al., 2004). A study of children and adolescents in Thailand

(mean age = 13.8 years) found that overweight was associated with significantly lower grade point average among young adolescents (grades 7-9) but not younger children (grades 3-6) (Mo Suwan et al. 1999). A study of nationally representative Icelandic data on 14- and 15-year old schoolchildren found that BMI was significantly and negatively correlated with grades in three language classes and mathematics (Sigfusdottir et al., 2007). Among older youths (aged 14-17) in the U.S., a negative relationship between BMI and grade point average has been documented among white girls, but not nonwhite girls or males (Sabia, 2007).

Other research has examined the relationship between childhood overweight and motor skills. A study of first-grade children (mean age = 6.7 years) in the Cologne region of Germany found that obesity was associated with impaired motor development for both boys and girls (Graf et al., 2004). A study of elementary school children aged 9-14 years in a city in Ontario, Canada found that Developmental Coordination Disorder is a risk factor for overweight and obesity for boys but not girls (Cairney et al., 2005). A study of children aged 4.4 – 8.6 years in Lower Bavaria in Germany found that obese male (but not obese female) children were more likely to have impaired gross motor skills (Mond et al. 2007).

This paper documents the association between childhood obesity and developmental functioning on four dimensions: verbal skills, activities of daily living, motor skills, and social skills. To our knowledge, our sample of children (between the ages of two and four years) is younger than that used in any previous study of the relationship between childhood obesity and developmental functioning. In contrast to previous studies based on German data, a nationally representative data set is used.

Data and Methods

The sample consists of 451 children aged between the ages of 26 and 44 months (mean age = 33.3 months). These children are the offspring of respondents to the German Socio-Economic Panel Study (SOEP). The SOEP is a wide-ranging nationally representative longitudinal study of private households that includes information on all household members and includes Germans living in West and East Germany, foreigners, and recent immigrants (Wagner et al. 2007). The Panel was started in 1984. In 2006, it included more than 20,000 individuals in nearly 11,000 households. Since 2003, mothers of newborns have been surveyed regarding the central indicators of their children's development. This study uses data from the questionnaires on child development that were administered in 2005 to the parents of the "2003 cohort" of newborns and those administered in 2006 to the parents of the "2004 cohort" of newborns. (The cohort year refers to when the mother was interviewed, not necessarily the year that the child was born.)

Weight and height are reported by the mother, who is well-informed about the children's weights and heights because in Germany, preventive medical check-ups for very young children are offered on a regular basis starting at birth and are free of charge. Three anthropometric measures (weight, height, and head circumference) from each check-up are documented in a medical record booklet that is kept by the family. 98% of SOEP children had such check-ups, so reporting error in weight and height are presumed to be small. BMI below 10 (one observation) and above 36 (two observations) were considered implausible so these three observations were dropped from the analysis.

Clinical weight classifications were defined using the standard reference values for German children (Kromeyer at al., 2001): very underweight is below the historic 3rd percentile of BMI, underweight is below the historic 10th percentile, overweight is above the historic 90th percentile, and obesity is above the historic 97th percentile of BMI.

The outcomes are measures of developmental functioning. Collectively they are a modification of the German Vineland scale (Tietze, 1998; Sparrow et al., 1984) that has been developed and used by researchers studying child development in Germany (Tietze, 1998; Coneus and Pfeiffer 2007). In each of four areas of developmental functioning (verbal skills, activities of daily living, motor skills, and social skills), mothers were asked to rate their child's ability to perform each of five tasks as either yes, to some extent, or no. Yes was scored as two points, to some extent was scored as one point, and no was scored as 0 points. Scores were summed across the five tasks to create an index that ranged from 0 to 10 indicating the child's developmental functioning in each of the four areas (verbal skills, activities of daily living, motor skills, and social skills). The Appendix provides the full text (English translation) of the SOEP questions that were used to create the measures of developmental functioning used in this paper.

Ordinary least squares regression models were used to examine the association between developmental outcomes and either a) BMI or b) indicator variables for clinical weight classification (very underweight, underweight, overweight, and obese, with healthy weight the omitted reference category), while controlling for the following characteristics: age of child in months, age of mother in years, household income, number of other children in the household, and indicator variables for: whether in day care four or more hours a week, mother has completed vocational training, mother has completed

university degree, single parent household, mother or others in the household speak only German to child, living in West Germany, living in urban area, living in rural area, missing income data, missing education data, and year. Models are estimated separately by gender. All analyses were conducted using STATA version 9.2 (StataCorp, College Station, TX, USA).

Results

Table 1 lists the summary statistics by gender. Roughly 13% of boys and 14% of girls are classified as very underweight, and an additional 5% of boys and 9% of girls are underweight but not very underweight. 8% of boys and 6% of girls are overweight but not obese, and 7% of boys and 10% of girls are obese. Scores on the verbal skills, social skills, and motor skills developmental scales are high; the mean score is greater than 8 (on a scale of 10) for both boys and girls. The average score on activities of daily living is lower: 5.8 for boys and 6.7 for girls.

Associations between BMI and developmental functioning are shown in Table 2, and differ considerably by gender. Among boys, higher BMI is associated with significantly lower developmental functioning with respect to verbal skills ($P<0.10$), social skills ($P<0.05$), and motor skills ($P<0.10$). The magnitudes of the associations are substantial. For example, weighing one unit of BMI more than the mean is associated with scoring one point lower on the social skills scale, equivalent to a shift from "to some extent" to "no" on one of the five questions. In contrast, among girls BMI is not correlated with lower developmental functioning on any dimension.

Nonlinearities in the association between BMI and developmental functioning are explored in Table 3, which shows the results of multivariate regressions of the developmental scales on the set of indicator variables for clinical weight classification (healthy weight is the omitted reference category). Again, the results differ considerably by gender. Obesity among boys is associated with significantly lower developmental functioning on three scales: verbal skills ($P<0.01$), social skills ($P<0.01$), and activities of daily living ($P<0.05$). Again, the magnitude of the association is substantial; relative to healthy weight, obesity is associated with greater than a one unit deficit in developmental functioning on a ten-unit scale (equivalent to a shift from "to some extent" to "no" on one of the five questions) for three of the four measures of development. None of the other clinical weight classifications (very underweight, underweight, overweight) is associated with significantly lower developmental functioning for boys.

Among girls, obesity is associated with lower developmental functioning on only one scale: verbal skills ($P<0.10$). The point estimate for girls is half that for boys, implying that obesity is associated with scoring one-half-point lower on the ten-point scale (relative to a healthy-weight girl). In addition, none of the other clinical weight classifications (very underweight, underweight, overweight) is associated with significantly lower developmental functioning for girls.

Discussion

This paper provides new evidence on the association between childhood obesity and developmental functioning. It finds that, among boys in Germany, obesity is associated with impaired developmental functioning at younger ages than previously

appreciated (two to four years). Moreover, the magnitude of the association is substantial; on three out of four measures, obesity is associated with a one-unit deficit in developmental functioning on a ten-unit scale, equivalent to a shift from "to some extent" to "no" on one of the five questions.

This finding is significant because the developmental functioning of young children is correlated with subsequent educational and labor market outcomes (Currie and Early, 2001). The finding of this paper that obesity is associated with developmental delays among boys may explain why youth obesity is associated with lower eventual educational attainment in men (Karnehed et al., 2006).

The finding that obese boys suffer developmental delays prior to school entry is informative about the mechanisms of the association. For example, it suggests that the association cannot solely be due to discrimination by schoolteachers or classmates because the association exists prior to school entry. However, one might argue that it is due to discrimination by day care providers. To test this possibility, we re-estimated our models using only the children who spend zero hours per week in day care; such children represent 61.3 percent of the total sample used to estimate the models described earlier in this paper. The results are presented in Table 4. For boys, obesity is associated with a one-unit decrease in the score on each of the four measures of development; in each case the coefficient is statistically significant at the 10 percent level or better. For girls, obesity is associated with a one-unit decrease on the index of verbal skills, which is statistically significant at the 10 percent level. This extension confirms that the correlation of obesity with developmental delays cannot be due to discrimination by day care providers (or, for that matter, by schoolteachers or classmates) – it can be found

among extremely young preschool children (age 2-4 years) who spend no time in day care.

Our findings also indicate that the association between obesity and developmental functioning is gender specific; relative to boys, the correlations for girls are smaller and generally not statistically significant. This is consistent with two previous studies that found that obesity was associated with impaired developmental functioning or worse academic performance in boys but not girls (Datar et al. 2004; Mond et al. 2007). The labor market penalty for adult obesity is generally greater for women than men (Averett and Korenman 1996; Cawley, 2004; Lundborg et al. 2007); this paper finds little if any evidence that the greater penalty is due to less human capital accumulation. Future research should explore what other factors, such as employer discrimination, may be responsible for the adult labor market disparities.

Some previous studies of developmental functioning and weight found different patterns across gender. One study found that BMI was associated with delayed developmental functioning in both boys and girls (Graf et al. 2004) and two studies have found that excess weight is associated with worse academic performance among girls but not boys (Datar and Sturm, 2006; Sabia, 2007). Resolving and better understanding gender differences in such associations are important areas for future research.

A strength of this study is that it is the first to study the association between overweight and developmental functioning in children as young as 2-4 years of age. The youngest children previously examined in this context were aged 4.4 – 8.6 years (Mond et al. 2007). Another strength of the analysis is that a range of developmental functioning

is considered – verbal skills, activities of daily living, motor skills, and social skills. Furthermore the results are based on a nationally representative sample.

The study has the following limitations. The measures of child development are assessed by the mother rather than a professional; however, the measures are designed to be answered by non-professionals. These measures of developmental functioning are a modification of the Vineland scale (Sparrow et al. 1984) that has been used by other researchers studying child development in Germany (Tietze 1998; Coneus and Pfeiffer, 2007).

Another limitation is that weight and height are reported by parents. A substantial body of research has studied the accuracy of parental reports of child weight; in general, this literature finds that parents tend to underreport the weights of relatively heavy children and therefore obesity is underestimated (Scholtens et al. 2007; Wing et al. 1980; Davis and Gergen, 1994). However, several studies conclude that parental reports are sufficiently accurate to be used in research (Garcia-Marcos et al. 2006; Sekine et al. 2002; Goodman et al. 2000). Parental reports of child weight in Germany may be more accurate than in other societies; German children receive regular medical check-ups that include measurements of weight and height that are recorded in booklets for the parents. Nevertheless some unknown amount of reporting error exists (which would have the effect of biasing estimates toward zero, leading to underestimates of the association between overweight and developmental functioning). Still, future studies should seek to collect data that include measured weight and height.

Another limitation is that body mass index is a poor measure of fatness, as it does not distinguish fat from muscle (Burkhauser and Cawley, 2008). More accurate measures

of fatness include total body fat or percent body fat, which can be assessed using methods such as Bioelectrical Impedance Analysis (Ibid). However, none of these measures are available in the SOEP so we are limited to BMI. A direction for future research is to find data that include the more accurate measures and use them to test the robustness of this paper's findings that are based on the use of BMI and clinical weight classifications defined by BMI.

Finally, we are unable to make causal inferences; among boys, obesity may cause developmental delays, slow development may result in obesity, or both obesity and developmental delays may be caused by unobserved factors. For example, boys who are stigmatized for being obese may lack opportunities to develop their social skills. Alternatively, it may be that boys with poor social skills have a hard time finding playmates and therefore play less, raising the risk of obesity. A third possibility is that unobserved physical health problems led to both obesity and impaired social skills. One possible candidate is Prader-Willi syndrome, which is associated with both early onset of obesity and emotional and behavior problems (Curry and Early, 2001).

Despite these limitations, this paper contributes to the literature by establishing that the association of childhood obesity with developmental delays exists for boys at younger ages (2-4 years) than previously appreciated, that the association is strongly gender-specific, and that it cannot be due solely to discrimination by teachers, classmates, or day care providers.

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Table 1: Descriptive Statistics by Gender

	Boys (N=232)		Girls (N=219)	
Variable	**Mean**	**Std. dev**	**Mean**	**Std. dev**
Verbal Skills	8.73	1.69	8.99	1.49
Social Skills	8.52	1.69	9.02	1.36
Motor Skills	8.14	1.71	8.16	1.94
Activities of Daily Living	5.76	2.48	6.71	2.40
Body Mass Index	15.98	2.57	15.89	3.23
Very Underweight	.13		.14	
Underweight	.05		.09	
Healthy Weight	.67		.62	
Overweight	.08		.06	
Obese	.07		.10	
Age of child (in months)	33.70	4.06	32.90	3.65
Number of other children in the household	.91	.98	.97	.98
Child in day care center (more than 4 hours per week)	.36		.34	
Age of mother (in years)	32.88	5.87	33.24	5.01
Mother completed vocational training	.62		.71	
Mother completed university degree	.22		.20	
Single Parent Household	.09		.10	
Net monthly income (in 1,000 Euro)	2.61	1.63	2.62	1.53
Only German spoken to child	.78		.83	

Household in West Germany	.77		.78	
Household in urban area	.31		.34	
Household in rural area	.22		.21	
Survey year 2006	.45		.48	
Education of mother missing	.05		.04	
Income missing	.04		.05	

Table 2: Child BMI and Developmental Functioning

	Boys	**Girls**
	BMI	**BMI**
Verbal Skills	-.071* (-1.68)	-.041 (-1.41)
Social Skills	-1.05** (-2.45)	-.029 (-1.00)
Motor Skills	-.081* (-1.95)	-.035 (-.89)
Activities of Daily Living	-.084 (-1.49)	.024 (.53)

Notes:

1) Figures in the table represent estimates of the relationship between BMI and developmental functioning, controlling for child and family characteristics.
2) Table cells list OLS coefficient and the associated t statistic in parentheses.
3) Asterisks indicate statistical significance: * = significant at 10%, ** = significant at 5%, *** = significant at 1%.
4) Results are shown only for BMI. The regression models also included the following controls: age of child in months, age of mother in years, household income, number of other children in the household, and indicator variables for whether in day care 4 or more hours a day, mother has completed vocational training, mother has completed university degree, single parent household, mother or other household members speak only German to child, living in West Germany, living in urban area, living in rural area, missing income data, missing education data, and year. Full regression results are available upon request.

Table 3:
Child Clinical Weight Classification and Developmental Functioning

	Boys				Girls			
	Very Under-weight	**Under-weight**	**Over-weight**	**Obese**	**Very Under-weight**	**Under-weight**	**Over-weight**	**Obese**
Verbal Skills	-.083 (-.26)	.624 (1.23)	-.252 (-.63)	-1.236*** (-2.87)	-.011 (-.04)	.025 (.08)	-.263 (-.65)	-.581* (-1.84)
Social Skills	-.058 (-.18)	.218 (.42)	-.072 (-.18)	-1.502*** (-3.42)	-.203 (-.72)	.100 (.30)	-.172 (-.42)	-.484 (-1.52)
Motor Skills	.158 (.49)	.820 (1.63)	.427 (1.07)	-.699 (-1.63)	.160 (.42)	.164 (.36)	-.150 (-.27)	-.437 (-1.02)
Activities of Daily Living	-.016 (-.04)	.741 (1.08)	-.208 (-.38)	-1.280** (-2.20)	-.251 (-.58)	-.293 (-.56)	.033 (.05)	.024 (.05)

Notes:

1) Figures in the table represent estimates of the relationship between clinical weight classification and developmental functioning, controlling for child and family characteristics.
2) Table cells list OLS coefficient and the associated t statistic in parentheses.
3) Asterisks indicate statistical significance: * = significant at 10%, ** = significant at 5%, *** = significant at 1%.
4) Results are shown only for clinical weight classification. The regression models also included the following controls: age of child in months, age of mother in years, household income, number of other children in the household, and indicator variables for whether in day care 4 or more hours a day, mother has completed vocational training, mother has completed university degree, single parent household, mother or other household members speak only German to child, living in West Germany, living in urban area, living in rural area, missing income data, missing education data, and year. Full regression results are available upon request.

Table 4:
Obesity and Developmental Functioning
Sample Limited to Children Who Spend Zero Hours Per Week in Day Care (141 Boys, 134 Girls)

	Obese Boys	**Obese Girls**
Verbal Skills	-1.257** (-2.29)	-.783* (-1.75)
Social Skills	-1.186** (-2.10)	-.726 (-1.54)
Motor Skills	-1.014* (-1.75)	-.905 (-1.55)
Activities of Daily Living	-1.431** (-1.96)	-.443 (-0.64)

Notes:

1) Figures in the table represent estimates of the relationship between clinical weight classification and developmental functioning, controlling for child and family characteristics.
2) Table cells list OLS coefficient and the associated t statistic in parentheses.
3) Asterisks indicate statistical significance: * = significant at 10%, ** = significant at 5%, *** = significant at 1%.
4) Results are shown only for the clinical weight classification of obesity. (There were no statistically significant results for very underweight, underweight, or overweight.) The regression models also included the following controls: age of child in months, age of mother in years, household income, number of other children in the household, and indicator variables for whether in day care 4 or more hours a day, mother has completed vocational training, mother has completed university degree, single parent household, mother or other household members speak only German to child, living in West Germany, living in urban area, living in rural area, missing income data, missing education data, and year. Full regression results are available upon request.

Appendix

Female respondents to the SOEP who are mothers of 2-3 year old children were asked to evaluate their children's developmental functioning in survey years 2005 and 2006. In each of four areas of developmental functioning (verbal skills, activities of daily living, motor skills, and social skills), mothers were asked to rate their child's ability to perform each of five tasks as either yes, to some extent, or no. A yes was scored as 2 points, to some extent was scored as 1 point, and a no was scored as 0 points. Scores were added across all five tasks within each area to create an index that ranged from 0 to 10 indicating the child's developmental functioning in each of the four areas.

Below is the full text (English translation) of the SOEP questions that were used to create the measures of developmental functioning used in this paper.

For parents, it is always a big event when their child learns something new.
Please tell us what those new things in the case of your child.
(Rate child's ability to perform each task as either "Yes", "To Some Extent" or "No")

Verbal Skills:

Understands brief instructions such as "go get your shoes"

Forms sentences with at least two words

Speaks in full sentences (with four or more words)

Listens attentively to a story for five minutes or longer

Passes on simple message such as "dinner is ready"

Activities of Daily Living:

Uses a spoon to eat, without assistance and without dripping

Blows his/her nose without assistance

Uses the toilet to do “number two”

Puts on pants and underpants the right way around

Brushes his/her teeth without assistance

Motor Skills:

Walks forwards down the stairs

Opens doors with the door handle

Climbs up playground climbing equipment and other high playground structures

Cuts paper with scissors

Paints/draws recognizable shapes on paper

Social Skills:

Calls familiar people by name; for example, says “mommy” and “daddy” or uses the father’s first name

Participates in games with other children

Gets involved in role-playing games (“playing pretend”)

Shows a special liking for particular playmates or friends

Calls his/her own feelings by name, e.g. “sad”, “happy”, “scared”