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The Ecology of Childhood Overweight: A 12-Year Longitudinal Analysis

Marion O'Brien¹, Philip R. Nader², Renate M. Houts³, Robert Bradley⁴, Sarah L. Friedman⁵, Jay Belsky⁶, Elizabeth Susman⁷, and the NICHD Early Child Care Research Network

¹ University of North Carolina at Greensboro, Greensboro, NC, USA

² University of California, San Diego, San Diego, CA, USA

³ RTI International, Research Triangle Park, NC, USA

⁴ University of Arkansas at Little Rock, Little Rock, AR, USA

⁵ Institute for Policy Research, The CNA Corporation, Alexandria, VA, USA

⁶ Birkbeck University of London. London, UK

⁷ Pennsylvania State University, University Park, PA, USA

Abstract

Objective—To investigate ecological correlates of the development of overweight in a multisite study sample of children followed from age 2 to age 12.

Design—Longitudinal examination of covariates of overweight status throughout childhood, with covariates drawn from three ecological levels: sociocultural or demographic, quality of the child's home environment, and proximal child experience that could directly affect the balance between energy intake and energy expenditure.

Subjects—960 children participating in a long-term longitudinal study provided growth data at least once; 653 of the children had complete data on covariates.

Measurements—Height and weight measured 7 times between ages 2 and 12 were converted to a Body Mass Index (BMI) and entered into a Latent Transition Analysis to identify patterns of overweight across childhood. Ecological correlates measured longitudinally included demographic characteristics obtained by maternal report, home environment quality obtained by observation and maternal report, and proximal child experience factors obtained by observation, maternal report, and child report.

Results—Four patterns of overweight were found: never overweight, overweight beginning at preschool age, overweight beginning in elementary school, and return to normal weight after being overweight at preschool age. The weight status groups differed on home environment quality and proximal child experience factors but not on demographics. Children overweight at preschool had less sensitive mothers than never overweight children. Children overweight at school age had fewer opportunities for productive activity at home than did never overweight children. School-age overweight children also watched the most TV after school. Multivariate logistic regression analyses further indicated the significance to children's weight status of proximal child experience variables. Less physically active children and those who watched more television after school were more likely to become overweight. Results did not vary by child sex.

Conclusion—The results support the idea that childhood overweight is multiply determined. The one potentially important and changeable factor identified as a target for intervention centers on how children spend their time, especially their after-school time. Children who are more physically active and spend less time watching TV after school are less likely to become overweight by age 12.

Keywords

children; growth patterns; ecological framework; environment; television watching; physical activity

Concern over the rapid increase in childhood obesity in the U.S. has been widely expressed in the medical literature (1,2), the social policy arena (3,4), and the popular press (5,6). The rapidity with which overweight has become a major health concern suggests that the driving factors are environmental and behavioral as well as genetic (1). A constellation of social changes, including the rise in the use of pre-prepared and fast food (7,8) as well as soft drinks (7), the decline in everyday activity such as walking to school (9), the extensive availability of computers and videogames (10,11), and increased amount of television viewing (12), has been linked to the increase in obesity among children and youth. It is also known, however, that family demographic factors such as ethnicity and income are related to overweight in both children and adults (13) and that children who receive less positive parenting are more likely to become overweight (14,15,16).

The NICHD Study of Early Child Care and Youth Development (SECCYD) is one of very few longitudinal databases available that allow examination of the large number of demographic, family, and environmental factors that have been proposed as influences on the development of obesity in children and adolescents. The children in the NICHD SECCYD study cohort (N = 1,364), recruited from ten different locations across the country, were born in 1991. Thus, they have grown up during a period of time that has been termed an “obesity epidemic” (17) when the prevalence of obesity in U.S. children has nearly tripled (13,18). Furthermore, growth data have been collected on this cohort from birth through age 12, and extensive observational and questionnaire data are available to be examined as potential correlates of patterns of growth. Therefore, this cohort provides us with an opportunity to examine demographic, family, and experiential correlates of patterns of development of overweight over time.

Childhood obesity is defined by age, height, and gender percentile distributions that were developed during the 1970s, well before the onset of increasing rates of obesity in U.S. children (19). According to the standards of the CDC and terminology proposed by the Institute of Medicine (2), children are considered at risk for obesity if their body mass index (BMI) is equal to or greater than the 85th percentile and obese if their BMI is equal to or greater than the 95th percentile. Data from the National Health and Nutrition Examination Studies (NHANES) from the 1970's through 2002 show that the proportion of obese children remained fairly stable at around 5% from the early 1970s to the mid-1980s but increased to nearly 15% from 1988–94 and from 1999–2002 (3).

In the present study, we use an ecological framework based on the model described by Sallis and Owen (21) to investigate correlates of overweight in childhood. From an ecological perspective, health-related behavior is seen to be influenced by factors operating concurrently at different levels: sociocultural, intra- and inter-personal, and environmental. The sociocultural level is represented in the present analyses by demographic factors – family income, education levels, ethnicity, family structure, and child sex. The intra- and inter-personal level is represented by aspects of the child's home environment that are known to relate broadly to overall wellbeing – maternal psychological health and parenting quality. The environmental level is represented by proximal factors in the child's past or current experience

that have the potential to link directly to the balance between energy intake and energy expenditure – center-based child care, level of physical activity, time spent watching television, and the safety of the child's neighborhood.

By including all these aspects in a single study, it is possible to examine the relative importance of each ecological level. For example, sociocultural or demographic characteristics of families that have been linked to childhood obesity may, in fact, operate through family processes or through the day-to-day experiences of children. It may also be that family processes or environments that tend to lead to overweight in one group of children – boys, for example – may not play the same role for another group – in this case, girls.

The primary goal of the study was to examine links between these three levels of ecological covariates and patterns of growth indexed by BMI measured from age 2 to age 12. Both prior research on the development of obesity (22) and a previous report of children's growth in this study cohort (23) suggest that children who become overweight during the preschool period are at particular risk for obesity throughout childhood. Thus, we divided the total study sample into overweight pattern groups based on the age at which children moved above the 85% percentile cutoff for overweight and the persistence of overweight after that time. We then examined demographic characteristics of children and their families, the quality of children's home environments, and more proximal child experience factors expected to be related to energy expenditure in order to identify variables that differentiated these groups. Of particular interest from the viewpoint of potential intervention approaches were comparisons between children who never became overweight and children who did, as these can suggest contextual factors that may help to prevent weight gain in childhood.

Our hypotheses, based on prior literature, were: (a) Children from ethnic minority families, single parent families, and families with low education levels will be more heavily represented in the overweight groups rather than the always normal weight group; (b) With demographic factors controlled, children whose mothers are less sensitive and more strict and controlling and whose homes provide less cognitive stimulation and opportunities for positive, productive activity are more likely to become overweight; and (c) Proximal child experiences – especially those involving more physical activity and less sedentary activity -- are linked to a lower likelihood of becoming overweight. To determine whether covariates of weight status groups differed by gender, we also examined interactions between child sex and the parenting and proximal child experience factors.

Method

Participants

Participants for the study were recruited in 1991 from designated hospitals at 10 data collection sites: Little Rock, AR; Irvine, CA; Lawrence, KS; Boston, MA; Philadelphia and Pittsburgh, PA; Charlottesville, VA; Seattle, WA; Hickory and Morganton, NC; and Madison, WI. A total of 1,364 families with healthy newborns were enrolled. Recruitment and selection procedures are described in detail in several publications (23) and on the study website (<http://secc.rti.org>). Of the initial pool of 3,015 eligible mothers contacted at 2 weeks for participation, 1,364 (45%) completed the 1-month home visit and became study participants. These 1,364 families were very similar to the eligible hospital sample on major demographic characteristics (years of maternal education, ethnicity, and presence of partner in home). The resulting sample was diverse, including 24% ethnic minority children (13% African American, 6% Hispanic, 2% Asian or Native American, and 3% who reported Other), 11% mothers who had not completed high school, and 14% single-parent mothers. Mothers had an average of 14.4 years of education, and 51.7% of the children were boys. Eligibility requirements specified that mothers be 18 years or older, English-speaking, and not have known or acknowledged substance abuse; and

that infants not be hospitalized at birth for more than 7 days nor have any obvious disabilities. This had the effect of screening out very low birth weight, premature, or sick infants.

After 13 years of study, 1,042 of the children (76.4%) have been retained in the sample. In the analyses describing longitudinal patterns of growth, 960 children who had height and weight data at any point between 2 and 12 years were included. The participants did not differ from those not included ($N = 404$) in child gender ($\chi^2(1, 1364) = 0.07, p = .80$) or ethnicity (white vs non-white, $\chi^2(1, 1364) = 0.05, p = .82$) but were more likely to have two parents in the home at the time of birth ($\chi^2(1, 1364) = 4.33, p = .04$) and to have mothers with more education ($F(1, 1362) = 6.82, p = .01$). The analyses of covariates of weight patterns include 653 children with complete data on all variables; these participants did not differ from those in the earlier analyses in child sex ($\chi^2(1, 960) = 1.56, p = .21$), but were more likely to be white ($\chi^2(1, 960) = 14.17, p < .001$), to be from two-parent families ($\chi^2(1, 960) = 15.68, p < .001$), and to have mothers with more education ($\chi^2(1, 960) = 10.52, p = .001$).

Overview of Data Collection

Children at 10 different geographic sites were followed from birth to sixth grade. Mothers were interviewed at home when infants were 1 month old. When children were 6, 15, 24, 36, and 54 months old and in first, third, and fifth grade, we assessed the home and family environment, and beginning at 15 months we also brought children to the lab where measures of height and weight were collected along with other observational and questionnaire measures. At each age prior to school entry, we observed children's child care environments and obtained data on their hours in non-maternal care, and in grades 1, 3, and 5 we observed children at school. When children were in grades 3, 5, and 6, their physical activity was monitored for one week. Complete descriptions of the data collection procedures used can be found in the Manuals of Operation for the NICHD Study of Early Child Care, which are available at <http://public.rti.org/secc>.

Measures

Height and Weight—Standardized procedures were used to measure height and weight at 24, 36, and 54 months, and when children were in first, third, fifth, and sixth grades. Height was measured with children standing with shoes off, feet together, and their backs to a calibrated 7-foot measuring stick fastened to a wall. Height was measured to the nearest 1/8 inch (0.32 cm) and recorded two times. If the first two height measures differed by more than 1/4 inch (0.64 cm), two more height measurements were taken. Weight was measured using a physician's 2-beam scale. Scales were calibrated monthly using certified calibration weights. Weight was measured with children in minimal clothing (i.e., no shoes, no outer layers of clothing and other items that could add weight such as belts, keys, or watches). As with height, weight was measured twice, each time to the nearest 1/4 pound (0.1 kg). If the two weight measurements differed by more than 4 ounces, two more measurements were taken. BMI was calculated by dividing weight (kg) by height (m) squared.

Demographic Characteristics—Child gender and ethnicity were recorded at 1 month. In this study, ethnicity was recoded as white/nonwhite because the numbers within individual ethnic minority groups were not large enough to allow analyses of the groups separately. Maternal education in years was obtained by interview at 1 month. Family income was reported by mothers at each major data collection time point, and an income-to-needs ratio was calculated by dividing income by the poverty level for that family size. The average family income-to-needs ratio from 6 months after the child's birth through either 54 months or sixth grade was used in analyses. Partner status (resident husband or partner vs. no resident partner) was obtained by maternal interview during telephone calls or in-person interviews at every age; the proportion of times the child was living in a two-parent home was used in analyses.

Home Environment Characteristics—The quality of children's home environments was indexed by maternal psychological well-being and observed and reported parenting practices. Mean scores across relevant time periods were used in analyses.

Maternal depression Maternal depressive symptoms were measured using the Center for Epidemiological Studies – Depression Scale (CES-D) (24) at 6, 15, 24, 36, and 54 months and at first, third, fifth, and sixth grades. The CES-D provides an index of depressive symptoms and is appropriate for use in a non-clinical population (α ranged from .90 to .91). Correlations across adjacent time points ranged from .46 to .58.

Opportunities for productive activity A subset of items from the Home Observation for the Measurement of the Environment (HOME) Inventory (25) were used at 6, 15, 36, and 54 months and in third and fifth grades to measure the quality of the home environment in terms of the opportunities provided for children to be engaged with and learn from their environment. Items included the availability to the child of books, games, and sports equipment and whether the child has been to a museum, a performance, or a sports event in the last year. The HOME Inventory is an observational and interview measure that captures a picture of the child's experiences at home. Observers were trained and certified on the use of the measure by experienced interviewers at one site. The subscale included 20 items at 6 and 15 months, $\alpha = 0.67$ at 6 months and 0.73 at 15 months; 23 items at 36 and 54 months, $\alpha = 0.82$ at 36 months and 0.73 at 54 months; 21 items at grade 3, $\alpha = 0.72$; and 18 items at grade 5, $\alpha = 0.77$.

Maternal sensitivity Mother-child interaction was videotaped in semi-structured 15-minute observations using age-appropriate toys and activities at 6, 15, 24, 36, and 54 months and at first, third, and fifth grades (26). Videotapes were coded by raters who were unaware of other information about the families. Inter-coder reliability was determined by independent coding of 20% of the tapes at each assessment period. Inter-coder reliability was calculated as the intraclass correlation (28) and ranged from .84 to .91 for the maternal sensitivity ratings used in the present study. A maternal sensitivity composite variable was constructed at each age. At 6, 15, and 24 months, maternal sensitivity was calculated as the sum of 4-point ratings of sensitivity to non-distress, positive regard, and intrusiveness (reversed). At 36 and 54 months and at first, third, and fifth grade, 7-point ratings of supportive presence, respect for autonomy, and hostility (reversed) were combined ($\alpha > .70$ at every age). Total scores were transformed into z-scores for analysis. Correlations across adjacent time points ranged from .40 to .51.

Controlling parenting At 54 months and again at first and third grade, mothers completed the Raising Children Checklist (29) which assesses three types of parenting strategies controlling, responsive, and lax. Only the controlling-parenting score is used in this report. The items in this scale include indicators of parental expectations for obedience and respect for parental authority (“Do you expect your child to obey the first time you say something?”). At 54 months and first grade, the scores were the mean of responses to six items on the questionnaire, with higher scores reflecting greater parental control. Internal reliability (Cronbach's alpha) was .71 at 54 months and .69 at first grade. At third grade, the measure was the mean of responses to 9 items, proportionally weighted and somewhat overlapping with items included at earlier ages (Cronbach's alpha = .75). Correlations across time ranged from 0.68 to 0.75.

Proximal Child Experience Factors—Characteristics of the children's experiences that could potentially directly affect the balance between energy intake and energy expenditure included type of child care, reported and measured activity, time spent in active and sedentary pursuits, and neighborhood safety. When measures were administered at more than one time point, the mean across time was used in analyses.

Child care history Almost all the children in the sample experienced some non-parental child care before starting school. Because center-based child care is the type of care that is most different from at-home care, and because it is likely that larger groups of children are more active than children playing alone or in dyads, we used the proportion of time children spent in center-based care to examine the potential relation between child care experience and the development of obesity. At 3- to 6-month intervals from 6 to 54 months, mothers were asked about the type of child care their child was receiving. The proportion of time points (out of 16) the mother reported the child to be attending center-based care was used in analyses.

Reported activity level in the preschool period At 54 months, mothers completed a reduced version of the Child Behavior Questionnaire (30), a parent-report measure of child temperament. The 10-item activity level subscale (Cronbach's $\alpha = .70$) was used in this study; higher scores indicate higher levels of gross motor activity.

Monitored physical activity The amount of physical activity each child engaged in across a typical week was measured when the children were in third, fifth, and sixth grades using an accelerometer (Computer Science Application - The CSA accelerometer Computer Science and Applications, Inc., Shalimar, FL) that provides a continuous recording of minute-by-minute movement counts. Participants were asked to wear the monitor on a belt around the waist during waking hours for 7 days, including both two weekend and five weekdays, excluding showering, bathing, water sports, or contact sports, in order to obtain as reliable an estimate of usual physical activity as possible. Following earlier research on monitored physical activity (31), the index of activity used in the present study was the mean percentage of time children spent in moderate or vigorous physical activity (MVPA). Correlations across time points ranged from 0.35 to 0.52.

Time in school physical education classes At third, fourth, fifth, and sixth grades, teachers were asked to report the weekly minutes children spent in physical education (PE) classes. Correlations across grades ranged from 0.14 to 0.51.

After-school activities At third, fourth, and fifth grades children were interviewed by phone using a guided recall format (32) to describe their activities from school dismissal until 6:00 p.m. in 15-minute intervals. Data were scaled to 12 intervals per interview to obtain comparable time estimates for all children. From these interviews, the number of after-school intervals children spent engaged in physical activities or sports was obtained. Interviewer reliability was assessed by calculating agreement between interviewers and a master coder for audiotaped interviews; agreement on coding categories for children's activities ranged from 91 to 100%. Correlations across time points ranged from 0.17 to 0.23.

Television watching Two different measures of children's time spent watching television were used. At 36 months, mothers completed a Television Viewing Questionnaire developed for this study in which they estimated the amount of time children were awake and in a room where the television was turned on for two weekdays and both weekend days in a typical week. The average for the two weekdays was multiplied by 3 and added to the total reported time to obtain a measure of the hours per week a child was exposed to television. At third, fourth, and fifth grades the after-school activities interview (described above) was used to obtain the child's own report of television watching after school. Correlations of the number of intervals spent watching TV across time points ranged from 0.24 to 0.30.

Neighborhood safety At first, third, and fifth grades, mothers completed the Neighborhood Questionnaire (33) including 5 items describing their perceptions of the safety of the neighborhood in which the family lived. Cronbach's alphas were .74 at first grade, .76 at third grade, and .77 at fifth grade. Correlations ranged from 0.57 to 0.68.

Analyses

Latent Transition Analysis (LTA) (34,35) was used to define patterns of moving into and out of overweight status ($\text{BMI} \geq 85\%$) between ages 2 and 12 years. After groups were created, a multivariate analysis of variance (MANOVA) was used to examine differences across all four groups, and a series of logistic regression analyses were conducted to identify covariates from three levels of analysis – demographic characteristics, quality of parenting, and proximal environmental factors – that discriminated between specific weight status groups.

Results

Patterns of overweight

The proportion of the sample that was overweight ($\text{BMI} > 85\%$) increased with child age. At 24 months, approximately 15% of the sample was considered overweight; this percentage increased to 18% at 36 months, 25% at 54 months, 26% at first grade, 31% at third grade, and 34% at fifth and sixth grades.

For the latent transition analysis defining groups based on patterns of the development of overweight, children who had data at any of the data collection points ($N = 960$) were included, and the analysis controlled for whether or not children had entered puberty at age 11 or 12. This analysis initially resulted in 30 groups with N 's varying from 1 to 573. These groups were further collapsed by age periods to create five groups: (a) the “never overweight” group ($n = 573$, 59.7%) had BMI 's $< 85\%$ at all ages; (b) the “preschool overweight” group ($n = 183$, 19.1%) became overweight at 24, 36, or 54 months of age and remained overweight; (c) the “elementary overweight” group ($n = 98$, 10.2%) became overweight after age 54 months and remained overweight; (d) the “return to normal weight” group ($n = 71$, 7.4%) experienced at least one overweight period between 24 and 54 months, but then returned to a normal weight status and remained so for at least three measurement periods; and (e) the “variable” group ($n = 35$, 3.6%) moved between normal and overweight status in no discernable pattern. These “variable” children were not included in any additional analyses.

Before conducting analyses to address the key questions of interest, we examined whether there were differences in weight status group membership as a function of data collection site and child sex. No differences were found, and therefore analyses include both boys and girls.

Descriptive Data on Group Differences

Means for demographic characteristics, home environment variables, and proximal child experience factors by weight status group are shown in Table 1. Multivariate analysis of each set of variables showed significant weight status group differences for home environment variables, $F(12, 1944) = 2.23$, $p = 0.009$, and proximal child experience factors, $F(24, 1932) = 1.57$, $p = 0.04$, but not for demographics.

Within the set of home environment variables, univariate analyses indicated that both the Opportunities for Productive Activity subscale from the HOME, $F(3, 653) = 3.78$, $p = 0.01$, and maternal sensitivity, $F(3, 653) = 4.47$, $p = 0.004$, differed significantly by group. Children who first became overweight in elementary school had fewer opportunities for productive activity at home than did children who were never overweight, and children who first became overweight at preschool age and remained overweight thereafter had less sensitive mothers than the children who were never overweight. There were no group differences in maternal depressive symptoms or mothers' reported controlling parenting. Within the set of child experience factors thought to have relatively direct effects on children's weight, only time spent watching television after school significantly differed by weight status group, $F(3, 653) =$

4.74, $p = 0.003$. Children who became overweight in elementary school watched more TV during their after-school time than the children who never became overweight.

Differentiating Weight Status Groups

Logistic regression analyses were used for multivariate examination of covariates in three planned comparisons: never vs ever overweight, never vs elementary overweight, and never vs preschool overweight. (The return to normal and variable groups were too small to be included in these analyses.) For each comparison, hierarchical models were tested in which demographic characteristics were entered in the first block, home environment variables in the second block, and proximal child experience factors in the third block. To determine whether covariates of overweight group status differed for boys and girls in the sample, we also entered interactions between child sex and each of the home environment and child experience covariates. Of the 36 interactions tested, only two were significant ($p < 0.05$) and one was marginally significant ($p < 0.10$), and these few interactions reflected no consistent pattern. Given the low frequency of significant results relative to the number of tests run, the interactions were not interpreted further. Results of the logistic regression analyses are shown in Tables 2 and 3.

Never overweight vs. ever overweight—Results of the analysis comparing children who were never overweight versus those who became overweight at any point and remained so until age 12 indicated that the block of proximal child experience variables significantly differentiated the groups above and beyond demographic characteristics and home environment factors. As shown in Table 2, the amount of physical activity children engaged in and the time they spent watching television after school were the factors that differentiated the children who became overweight at any point from those who did not. Children who were more active between third and sixth grade were more likely to be in the “never overweight” weight status group, while children who watched more TV after school between third and sixth grade were more likely to be in the “overweight” group. The full model accounted for approximately 6% of the total variance.

Never overweight vs. elementary overweight—Results of the analysis comparing children who were never overweight with those who first became overweight in the elementary school years (Table 2) showed a marginally significant effect for the block of variables representing the home environment. Within that block, maternal reports of controlling parenting practices differentiated the children who became overweight from those who did not. For every one point increase in mothers' reported controlling parenting, children were 2.6 times more likely to become overweight. The block of proximal child experience variables also significantly differentiated these groups. Child-reported TV watching after school was the single factor that most clearly separated the groups, with children watching more TV being significantly more likely to be in the overweight group. The full model accounted for approximately 7% of the total variance.

Never overweight vs. preschool overweight—The analysis comparing the never overweight children with those who became overweight during the preschool period and remained overweight examined only the contextual factors measured during the preschool period (Table 3). None of the covariate blocks contributed significantly to differentiating the groups, and the overall model accounted for only 3% of the total variance.

Discussion

The purpose of this study was to examine, concurrently, a range of ecologically relevant factors that have been proposed to relate to excessive weight gain in childhood. The longitudinal nature

of the data available allowed us to make comparisons across four groups of children: those who were never overweight up to age 12, those who became overweight during the preschool years and remained so to age 12, those who first became overweight in the elementary school years, and those who were overweight prior to school age but returned to normal weight thereafter.

When these four groups were compared on demographic, home environment, and proximal child experience factors, home environment and proximal child experience factors both differentiated the groups. Follow-up univariate tests indicated that children who first became overweight in preschool differed from the never overweight group in the amount of sensitivity their mothers showed in interaction with them. Observed sensitivity in interaction with the child may be a marker for mothers who are also more involved with their preschool-age children, engage in activities with them, and eat meals together as a family, thus promoting children's overall health and well being. Sensitivity may also be a characteristic of mothers who are more attuned to children's nutritional needs and more likely to provide a healthful diet during the preschool period, when children are not yet selecting their own snack foods.

Children who first became overweight during the elementary school years differed from other groups in two respects. Their home environments provided fewer opportunities for productive activity than the "never overweight" group, and they spent more of their after-school time watching television. These findings suggest the possibility of a pattern in which children who have few toys or adult-structured activities to engage them at home tend to rely on television to fill their time, and such a pattern would be highly likely to result in an overweight child.

The fact that the groups did not differ on demographic variables contrasts with other research on childhood overweight (3) indicating that family background characteristics such as ethnicity and income tend to be linked to overweight status. Perhaps childhood overweight has become more pervasive and now affects all social classes. Further research is needed to examine the distribution of overweight in children nationally and temporal changes in that distribution.

The overweight groups were also compared with the never overweight group using logistic regression analyses that allowed a multivariate approach. Although the factors examined in these analyses are those highlighted by many other researchers as important in the development of childhood obesity (3,36,37), we did not find that the full model accounted for much of the variance between groups. Some sets of variables appeared to be more important in differentiating certain groups. Proximal child experience factors – especially activity and TV watching – reliably differentiated children who were never overweight from those who became overweight at some point before age 12. It is not surprising to find that children who are more active and who watch less television are also less likely to be overweight; however, prior results examining these factors have not yielded consistent findings (3). Thus, these results add to the growing literature supporting a focus on the balance between active and sedentary pursuits in interventions designed to prevent overweight in childhood (e.g., 38,39).

By contrast, the quality of the child's home environment, particularly the presence of controlling parents, differentiated the children who became overweight in elementary school from those who did not. In an earlier study using the NICHD SECCYD dataset, Rhee and colleagues (40) reported a link between parenting style in the preschool years and child overweight status at first grade. Mothers who were highly sensitive and who held high expectations for child self control were least likely to have overweight children two years later. These earlier findings, specific to the preschool-first grade period, show results similar to those found in the present study across a longer time frame. The results of both studies indicate the need for more research into family processes associated with childhood obesity.

One strength of the present study is the wide range of ecologically relevant variables studied over time in terms of family, school, and after-school characteristics. The study is unique in that it includes children from ten locations around the U.S. growing up in the early 1990s, at the beginning of the rise in childhood obesity. In addition, the findings are based on longitudinal data, with height and weight measured frequently across the children's first 12 years. The limitations of the study include the fact that ethnic minority groups are not well enough represented in the sample to allow separate analyses for African American or Hispanic children. Secondly, although growth was thoroughly studied, no other anthropometric measures of adiposity, such as skin fold measurements or waist circumference, were obtained at all data points. As BMI does not directly measure body fat, it is recognized as a practical surrogate for adiposity (41). We did not have access to parental weight data or to dietary intake of the children; thus, neither genetic factors nor the role of energy intake could be examined. Finally, the measure of physical activity excluded periods of time when children participated in highly active sports or swimming and therefore underestimated activity in some children.

The results of this study support the idea that overweight is multiply determined. We did not find one single factor that was consistently linked to overweight status. This result is not surprising given the many societal and life-style changes that have occurred during the period of increasing obesity in the U.S. population. The present study is correlational in nature and therefore the factors identified as related to overweight cannot be interpreted as causal. The results do suggest one potentially important and changeable factor that might usefully be examined in further research using intervention approaches: how children spend their time, especially their after-school time. Children who were more physically active and spent less time watching TV after school were less likely to be overweight by age 12. From our results, it is not possible to determine the direction of this effect; overweight children may prefer more sedentary activity. Still, these findings suggest that parents might consider the nature of the after-school arrangements they make for their children and select those that emphasize active play and exercise rather than sedentary activity. Furthermore, educators and recreation specialists who organize and manage after-school programs might take note of these results in selecting activities.

It is clear from the patterns of overweight among children in this sample that intervention to prevent obesity needs to begin early. More than twice as many overweight preschoolers remained in that category until age 12 as returned to normal weight once they reached school age. These findings support and extend those from an earlier study with this same sample showing that the risk of overweight at age 12 was increased fivefold for children who attained the 85th percentile for BMI during the preschool period compared to children who never crossed into the "at risk" BMI category in preschool (23). Even though effect sizes of the covariates studied are relatively small, these small effects, noted among families who were not selected because of their involvement in intervention programs, suggest that the contextual factors examined here may be contributing to a population shift in body weight. Professionals and parents who are aware of the likely persistence of overweight from early childhood onward would do well to take steps to reduce energy intake and increase energy output in all young children, and especially when children show disproportional gains in weight. Efforts to keep children's weight within normal limits need to be maintained throughout children's growing years.

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Table 1
Means (SD) for Demographic Characteristics, Quality of Parenting, and Proximal Environmental Factors by Weight Status Group.

	Never overweight N = 406		Preschool overweight N = 111		Elementary overweight N = 80		Return to normal weight N = 56	
	M	SD	M	SD	M	SD	M	SD
Demographic Characteristics								
Child sex (Male = 1, Female = 0)	0.48	0.50	0.53	0.50	0.54	0.50	0.55	0.50
Ethnicity (White = 1, Nonwhite = 0)	0.81	0.39	0.76	0.43	0.78	0.42	0.84	0.37
Maternal education	14.65	2.37	14.24	2.23	14.14	2.59	14.75	2.71
Income-to-needs (6m — G6)	4.14 ^{a,b}	2.82	3.50 ^{a,b}	2.46	3.27 ^a	2.36	4.66 ^b	3.51
Two-parent family (6m — G6)	0.87	0.24	0.82	0.30	0.80	0.29	0.83	0.29
Quality of Parenting								
Maternal depression (6m — G6)	8.36	5.58	9.90	6.19	9.60	7.02	8.81	6.18
Opp. for prod. activity (6m-G5)	0.79 ^a	0.10	0.77 ^{a,b}	0.11	0.75 ^b	0.13	0.79 ^{a,b}	0.13
Mat. sensitivity (6m — G5)	3.27 ^a	0.32	3.17 ^b	0.31	3.17 ^{a,b}	0.36	3.29 ^{a,b}	0.35
Controlling parenting (54m — G3)	2.66	0.37	2.73	0.39	2.65	0.40	2.61	0.36
Proximal Environmental Factors								
% time in center care (6–54m)	0.22	0.27	0.24	0.27	0.22	0.26	0.29	0.31
CBQ Activity (54m)	4.77	0.72	4.87	0.79	4.89	0.81	4.76	0.66
Monitored phys. act. (G3-G6)	17.17	4.94	15.91	4.59	16.42	4.52	17.21	5.56
Min/wk in PE (G3-G6)	80.23	32.43	76.99	39.50	84.83	45.34	78.40	28.00
After school activity (G3-G5)	2.12	1.61	2.08	1.57	1.80	1.49	2.08	1.52
Hours/week TV (36 m)	24.41	16.23	27.00	20.42	28.47	20.32	24.38	18.90
After school TV (G3-G5)	1.68 ^a	1.44	1.98 ^{a,b}	1.59	2.36 ^b	1.84	1.81 ^{a,b}	1.73
Neighborhood safety (G1-G5)	8.26	1.27	7.98	1.33	8.08	1.30	8.14	1.35

Note: N = 653; M = mean, SD = standard deviation, m = months, G = grade, CBQ = Child Behavior Questionnaire, PE = physical education Means with different superscripts are significantly different from each other.

Table 2

Logistic Regression Analyses Differentiating the Never Overweight and the Elementary Overweight Groups.

	Never overweight vs. ever overweight				Never overweight vs. elementary overweight			
	b^a	Odds ratio	R^2 total (df) ^b	Sig. $\Delta\chi^2$ (df)	b^a	Odds ratio	R^2 total (df) ^b	Sig. $\Delta\chi^2$ (df)
Demographic Characteristics			0.02 (5)				0.02 (5)	
Child sex (Male = 1, Female = 0)	-0.29	0.75			-0.36	0.70		
Ethnicity (White = 1, Nonwhite = 0)	-0.13	0.88			-0.12	0.88		
Maternal education	-0.04	0.96			-0.08	0.93		
Income-to-needs (6m — G6)	0.07	1.07			0.10	1.11		
Two-parent family (6m — G6)	0.27	1.31			0.28	1.32		
Quality of Parenting			0.03 (9)	0.19 (4)			0.04 (9)	0.07 (4)
Maternal depression (6m — G6)	-0.01	0.99			0.00	1.00		
Opp. for prod. activity (6m-G5)	0.74	2.10			3.17	23.74		
Maternal sensitivity (6m — G5)	0.67	1.95			0.42	1.52		
Controlling parenting (54m — G3)	0.34	1.40			0.97*	2.64		
Proximal environmental factors			0.06 (17)	0.02 (8)			0.07 (17)	0.04 (8)
% time in center care (6–54m)	-0.35	0.70			-0.25	0.78		
CBQ activity (54 m)	-0.11	0.90			-0.11	0.90		
Monitored phys. act. (G3-G6)	0.07**	1.07			0.06	1.05		
Min/wk in PE (G3-G6)	0.00	1.00			-0.01	1.00		
After school activity (G3-G5)	0.00	1.00			0.08	1.08		
Min/wk TV (36 m)	0.00	1.00			-0.01	0.99		
After school TV (G3-G5)	-0.14*	0.87			-0.21*	0.81		
Neighborhood safety (G1-G5)	0.02	1.02			-0.03	0.97		

Note: df = degrees of freedom, m = months, G = grade, CBQ = Child Behavior Questionnaire, PE = physical education

^aThe betas are reported for the final model.

^bThe first R^2 is for the block of demographic characteristics variables; subsequent R^2 's are the contribution of the demographic block and each subsequent block.

Table 3
Logistic Regression Analyses Differentiating the Never Overweight from the Preschool Overweight Group.

	Never overweight vs. Preschool overweight (n = 585)			
	b^a	Odds ratio	R^2 total (df) ^b	Sig. $\Delta\chi^2$ (df)
Demographic Characteristics			0.02 (5)	
Child sex (Male = 1, Female = 0)	-0.19	0.83		
Ethnicity (White = 1, Nonwhite = 0)	-0.15	0.86		
Maternal education	-0.01	0.99		
Income-to-needs (6m — G6)	0.02	1.02		
Two-parent family (6m — G6)	0.51	1.66		
Quality of Parenting			0.03 (9)	0.12 (4)
Mat. depression (6m — 54m)	-0.02	0.98		
Opp. for prod. activity (6m — 54m)	-1.02	0.36		
Mat. sensitivity (6m — 54m)	0.64	1.90		
Controlling parenting (54m)	-0.19	0.83		
Proximal environmental factors			0.03 (12)	0.41 (3)
% time in center care (6–54m)	-0.28	0.75		
CBQ activity (54 m)	-0.13	0.88		
Min/wk TV (36 m)	-0.01	0.99		

Note: m = months, G = grade, CBQ = Child Behavior Questionnaire

^aThe betas are reported for the final model.

^bThe first R^2 is for the block of demographic characteristics variables; subsequent R^2 's are the contribution of the demographic block and each subsequent block.