Changes in Obesity Between Fifth and Tenth Grades: A Longitudinal Study in Three Metropolitan Areas

AUTHORS: Mark A. Schuster, MD, PhD,a,b,c Marc N. Elliott, PhD,d Laura M. Bogart, PhD,a,b David J. Klein, MS,a Jeremy Y. Feng, AB,a,b Jan L. Wallander, PhD,d Paula Cuccaro, PhD,c and Susan R. Tortolero, PhDd

aDivision of General Pediatrics, Department of Medicine, Boston Children’s Hospital, Boston, Massachusetts; bHarvard Medical School, Boston, Massachusetts; cRAND Corporation, Santa Monica, California; dPsychological Sciences, University of California, Merced, California; and eCenter for Health Promotion and Prevention Research, School of Public Health, University of Texas Health Science Center at Houston, Houston, Texas

KEY WORDS obesity, childhood, adolescence, BMI, longitudinal study

BACKGROUND: Despite epidemic childhood obesity levels, we know little about how BMI changes from preadolescence to adolescence and what factors influence changes.

METHODS: We studied 3961 randomly selected public school students and 1 parent per student in 3 US metropolitan areas in fifth and again in tenth grades. In each grade, we measured child and parent height/weight and calculated BMI category. We examined whether baseline sociodemographic characteristics, child health-related factors, and parental obesity were significantly associated with exit from and entry into obesity from fifth to tenth grade.

RESULTS: Fifth- and tenth-graders were 1%/2% underweight, 53%/60% normal weight, 19%/18% overweight, and 26%/20% obese, respectively. Among obese tenth-graders, 83% had been obese as fifth-graders and 13% had been overweight. Sixty-five percent of obese fifth-graders remained obese as tenth-graders, and 23% transitioned to overweight. Multivariately, obese fifth-graders who perceived themselves to be much heavier than ideal (P = .01) and those who had lower household education (P = .006) were less likely to exit obesity; by contrast, overweight fifth-graders were more likely to become obese if they had an obese parent (P < .001) or watched more television (P = .02).

CONCLUSIONS: Obese fifth-graders face challenges in reducing obesity, especially when they lack advantages associated with higher socioeconomic status or when they have a negative body image. Clinicians and others should educate parents on the importance of preventing obesity very early in development. Children who are not yet obese by fifth grade but who have an obese parent or who watch considerable television might benefit from monitoring, as might children who have negative body images.

abstract

WHAT’S KNOWN ON THIS SUBJECT: Obesity among youth can have immediate health effects as well as longer-term consequences during adulthood. Overweight/obese children and adolescents are much more likely than normal-weight children to become overweight/obese adults.

WHAT THIS STUDY ADDS: This large, multisite longitudinal study examines patterns of exit from and entry into obesity between childhood and adolescence. Socioeconomic factors, body image, television habits, and parental obesity were important predictors of whether children remained obese or became obese.
Obesity prevalence has increased substantially among children, adolescents, and adults over the past 3 decades.\textsuperscript{1,2} Obese youth experience not only immediate health effects but also longer-term consequences during adulthood.\textsuperscript{3} Overweight children are at least twice as likely as normal-weight children to be overweight during adulthood, and 24% to 90% of obese adolescents become overweight/adult obese adults.\textsuperscript{4-6} However, little is known about the relationship between BMI in childhood and in early adolescence and factors associated with change between these 2 periods. A study of US children, which found that overweight kindergarteners were much more likely than their normal-weight peers to become obese in middle school,\textsuperscript{7} highlights the importance of intervening in early childhood to prevent later obesity. Understanding factors associated with the transition into and out of obesity would inform efforts to address the obesity epidemic.

We conducted a 2-wave longitudinal study of exit from and entry into obesity from fifth to tenth grades in a large, non-clinical sample from 3 US metropolitan areas with high representation of children who are black or Latino or from low-SES households.\textsuperscript{8} This age range starts at 10 to 11 years of age, before most children have begun their pubertal growth spurt (which can be associated with rapid shifts in BMI\textsuperscript{9}), and ends at 15 to 16 years of age, after most have finished it.\textsuperscript{10} We also examined sociodemographic characteristics\textsuperscript{11} and potentially modifiable factors that have been previously associated with BMI (and are thus potential targets of interventions), including child behaviors (ie, consumption of fast food and soda,\textsuperscript{12,13} vigorous exercise,\textsuperscript{14} and TV viewing\textsuperscript{15}), child body image discrepancy (the difference between a child's self-report of the ideal and his/her own body size),\textsuperscript{16,17} and parental obesity.\textsuperscript{6} We analyzed data from Healthy Passages, a longitudinal study of fifth-graders (mean [SD] age, 11.1 [0.5] years) recruited through public schools in and around Birmingham, AL, Houston, TX, and Los Angeles County, CA from 2004 to 2006.\textsuperscript{8,18} We randomly sampled schools with probabilities designed to provide a balanced sample of children who were non-Latino black, Latino (regardless of race), and non-Latino white. Parents/guardians (hereafter referred to as parents) of 6663 out of 11 532 children in sampled schools permitted us to contact them; 5147 (77%) participated in the study, and 6.7% of the parents were male. Parents provided written informed consent; children provided written assent. For students who participated at baseline, follow-up interviews were collected for 4448 (86%) 5 years later in 2009 to 2011, when most were in 10th grade (age 16.1 [SD, 0.5] years). BMI was unavailable at fifth or tenth grade for 487 students (10.9%), leaving a sample of 3961; most missing anthropometric measures were attributable to lack of parental permission for anthropometric measurement. White children were less likely to be missing BMI than were other children; race/ethnicity was controlled in regressions and non-response weights. Relevant institutional review boards approved the study.

Child and Parent BMI

Child and parent BMI calculations were based on weight and standing height obtained according to standard anthropometric protocols\textsuperscript{19-21} by trained and certified interviewers. Weight was measured to the nearest 0.1 kg using a Tanita electronic digital scale. Calibration of the scale was checked regularly. Height was measured (with the participant in bare feet or socks) to the nearest millimeter using a portable stadiometer. Two independent measurements were taken for each participant, and if the measurements differed by $\geq 0.2$ kg for weight or $\geq 0.5$ cm for height, a third measurement was taken.\textsuperscript{16} The 2 measurements of weight and of height that were closest in agreement were averaged and used to calculate BMI.

BMI percentiles for youth were calculated using standard gender-specific growth charts\textsuperscript{22} and categorized as underweight ($<$5th percentile), normal weight ($\geq$5th to $<$85th percentile), overweight ($\geq$85th to $<$95th), and obese ($\geq$95th).\textsuperscript{25} Parental BMI $\geq 30$ kg/m$^2$ was categorized as obese.\textsuperscript{24} A “missing” category was included in analyses for 273 parents who had unknown baseline obesity status, generally because they declined measurement of their weight and height.

Measures

Each child and 1 parent per child completed computer-assisted personal interviews and audio computer-assisted self-interviews (for sensitive questions) in English/Spanish. Parents reported demographics; children reported other information used in the analysis. We assessed 4 BMI-related factors: (1) Body image discrepancy, for which children identified which of 7 outline drawings of bodies, ranging from thinner to heavier, looked most like them and which drawing “a boy (girl) your age should look like”\textsuperscript{16,25} “much heavier” indicates those whose self-image was $\geq 2$ levels heavier than their ideal image, “somewhat heavier” indicates those whose self-image was 1 level heavier than ideal, and “thinner” indicates those whose self-image was thinner than ideal. Although it is not necessarily possible to infer a child’s BMI from such drawings, they can be used to compare on the same scale an individual’s body image self-perception and perception of the ideal body image. (2) Fast-food and soda consumption, which were measured as number of days in the past 7 days and number of times per day.\textsuperscript{26} “High” consumption indicates the top quartile for...
frequency of consumption for days or times. (3) Vigorous exercise, which was measured as number of days in the past 7 days in which the child engaged in vigorous exercise for ≥ 20 minutes.26 (4) TV viewing, which was derived from categorical responses for viewing duration on Monday through Friday after school before 7 PM, Monday through Thursday after 7 PM, Friday after 7 PM, Saturday, and Sunday27 (measure details appear in Table 2). To examine whether there was variation in the effect of body image discrepancy based on a child’s choice of ideal body size drawing, we conducted a sensitivity analysis additionally adjusting for the child’s reported ideal body size, which was not significant. Because school/neighborhood characteristics can be confounders in the relationship between change in BMI category and BMI-related factors,28–30 we obtained school-wide indicators of fifth-grade obesity prevalence and household educational level; we also collected and validated child-perceived neighborhood safety and observations of physical characteristics related to commercial activity and decay, residential decay, and residential security.51

Statistical Analysis

We used ordinal logistic regressions to assess differences in fifth-grade BMI category across categorical child and parent characteristics, and we used linear regressions to assess differences across BMI categories for continuous BMI-related factors. We used bivariate and multivariate logistic regressions to assess patterns of exit from and entry into obesity from fifth to tenth grade by baseline child and parent characteristics. Models predicting exit from obesity were restricted to children who were obese at fifth grade. Models predicting entry into obesity were restricted to children who were overweight at fifth grade, as the risk factors for normal-weight or underweight children may differ from those for overweight children. Because no underweight children and only 2% of normal-weight children became obese at 10th grade, we could not adequately determine whether and how much their risk factors differ from those of overweight children; omitting underweight and normal-weight children allowed for more precise estimation of the risk factors for overweight children, who are at greatest risk. Probability weights were created to reflect the sampling design and nonresponse associated with school, race/ethnicity, and gender. We accounted for design and nonresponse weights, clustering of children within schools, and site stratification using a sandwich estimator and a Taylor series linearization, as implemented by PROC SURVEYLOGISTIC and PROC SURVEYREG in SAS 9.3 (SAS Institute, Inc, Cary, NC). Multivariate model fit was evaluated with the c-statistic, with higher values indicating greater agreement between predicted probabilities and observed exit from/entry into obesity. Examples illustrating the model results were presented as predictive margins33 (ie, predicted proportions of exit from and entry into obesity for hypothetical children with specified covariate values, holding the distribution of all other respondent covariates unchanged). We also conducted additional regression models incorporating school and neighborhood factors as potential confounders in the relationship between change in BMI category and BMI-related factors. Because the marginal risk/benefit of a change in BMI percentile depends on a child’s initial BMI status and is greatest for the obese category, which has been shown to be associated with substantial short- and long-term health problems,34–36 we assessed changes in obesity status. We adjusted for continuous baseline child BMI percentile in multivariate analyses to ensure that other multivariate results did not merely reflect a factor’s association with exact baseline BMI within a BMI category.

RESULTS

Sociodemographic Differences Across BMI Categories at Fifth Grade

In fifth grade, 1% of students were underweight, 53% were normal weight, 19% were overweight, and 26% were obese (Table 1). There were significant differences in BMI category by sociodemographic characteristics. Latino (31%) and black (28%) students were more likely than white (17%; P = .01 for each comparison) students to be obese. Distribution of BMI category also varied by education, with 30% of children from households with no 4-year college graduate being obese, compared with 19% of those from households with 4-year college graduates (P < .001). Students who had an obese parent were more likely to be obese (37%) than those who had an overweight parent (24%) or a parent who was normal/underweight (12%) (P < .001) (Table 1).

Unadjusted Differences in Body Image Discrepancy and Obesity-Related Behaviors by BMI Category at Fifth Grade

Students’ body image discrepancy was related to their BMI category (P < .001) (Table 2). For example, obese (15%) students were more likely than overweight and normal-weight (2% each) students to identify as being much heavier than ideal, and obese (55%) and overweight (42%) students were more likely than normal-weight (12%) students to identify as being somewhat heavier than ideal. Students’ BMI category was also positively related to hours of television watched per week, with underweight students watching the least (mean, 18 hours) and obese students watching the most (24 hours; P < .001).

Changes in BMI Category From Fifth to Tenth Grade

BMI distribution at 10th grade was 2% underweight, 60% normal weight, 18%
obese (Table 3). Among obese fifth-graders, 12% became normal weight, 23% transitioned to overweight, and 65% remained obese. Overweight fifth-graders had the highest probability of becoming obese, with 14% doing so by 10th grade. Normal-weight fifth-graders were particularly stable, with 87% remaining at normal weight. Looking backward, obese and overweight fifth-graders accounted for 83% and 13%, respectively, of obese tenth-graders (not shown in table).

**Predictors of Exit From Obesity**

Table 4 provides odds ratios (OR) from models assessing differences between obese fifth-graders who exited obesity (35%) and who remained obese at 10th grade. Examining OR from bivariate models and adjusted ORs (aOR) from multivariate models of exit from obesity, we found that students who had the same baseline BMI were less likely to exit obesity if they perceived themselves as being much heavier than ideal (OR, 0.30; 95%
confidence interval [CI], 0.18–0.48, *P < .001; aOR, 0.54; 95% CI, 0.33–0.87, *P = .01) or if they had lower household education (OR, 0.47; 95% CI, 0.36–0.63, *P < .001; aOR, 0.60, 95% CI, 0.42–0.86, *P = .006). The following were significant in bivariate but not multivariate analysis: students were less likely to exit if they were Latino (OR, 0.58; 95% CI, 0.38–0.89 vs non-Latino whites, *P = .01) or had an obese parent (OR, 0.54; 95% CI, 0.39–0.74, *P < .001).

To illustrate the magnitude of significant covariates in the multivariate model, we examined predicted probabilities of exiting obesity for hypothetical obese students who differ only in certain specific characteristics from the average obese student. For example, otherwise similar obese fifth-graders would have a 37% probability of exiting obesity by 10th grade if they did not perceive themselves as much heavier than ideal but only a 26% chance if they did. Likewise, otherwise similar obese fifth-graders would have a 43% chance of exiting obesity if their household had a college graduate, but a 33% chance if it did not.

A bivariate sensitivity test showed that exit from obesity was significantly less likely in schools with higher proportions of obese fifth-graders (OR, 0.23; 95% CI, 0.06–0.89; *P = .03) and in schools with lower proportions of households with someone with a 4-year college degree (OR, 0.39; 95% CI, 0.25–0.62, *P < .001). These predictors were no longer significant after adjusting for other variables in the model.

Neighborhood characteristics were not significant bivariate or multivariate predictors of exit from obesity.

Predictors of Entry Into Obesity

We assessed differences between overweight fifth-graders who became obese at 10th grade (14%) and those who did not (Table 4). In analyses of entry into obesity, overweight fifth-graders were more likely to become obese if they watched more TV (OR, 1.47 per 10 hours; 95% CI, 1.22–1.77, *P < .001; aOR, 1.26; 95% CI, 1.03–1.53, *P = .001) or if they had lower household education (OR, 0.47; 95% CI, 0.36–0.63, *P < .001; aOR, 0.60, 95% CI, 0.42–0.86, *P = .006). The following were significant in bivariate but not multivariate analysis: students were less likely to enter if they were Latino (OR, 0.58; 95% CI, 0.38–0.89 vs non-Latino whites, *P = .01) or had an obese parent (OR, 0.54; 95% CI, 0.39–0.74, *P < .001).
that in the sample was recruited from public schools in 3 metropolitan areas that over-represented lower-income and non-white children, which may have led to a higher obesity rate in the sample than the national average. Second, all measures besides child BMI and neighborhood observations were gathered through self-report, and parent BMI was obtained for only 1 parent per child (although spouses tend to have similar BMI\(^2\)). Furthermore, we conducted sensitivity analyses of baseline school and neighborhood environmental factors but could not control for change in such factors over time.

**CONCLUSIONS**

Addressing adolescent obesity, which is associated with adult obesity, may be best done at younger ages. This is consistent with evidence that interventions that target younger children (age 6 to 12 years) tend to be more effective than later ones.\(^37\) In addition, addressing behavior-related health issues before adolescence has the advantage of reaching youth during a period when parents still have substantial influence and peer influence is only starting to increase.\(^42\) Furthermore, strategies most supported by research evidence include school-based programs that emphasize physical activity and nutrition education, as well as parent-centered programs that promote physical activity and reduction in screen time;\(^37\) it is also important to avoid strategies that further stigmatize obese children.\(^43\) If children can maintain their BMI at a level that is associated with better health outcomes and if, regardless of their BMI, they can adopt healthful eating and activity habits,\(^44\) benefits may be experienced long into adulthood, both because of childhood antecedents of adult disease\(^2\) and because patterns established in childhood may persist through adolescence and into adulthood.\(^4\)

**ACKNOWLEDGMENTS**

We thank the Healthy Passages team, staff, and participants for making the study possible and Isabel L. I. Janmey, BS, for research assistance.


Changes in Obesity Between Fifth and Tenth Grades: A Longitudinal Study in Three Metropolitan Areas
Mark A. Schuster, Marc N. Elliott, Laura M. Bogart, David J. Klein, Jeremy Y. Feng, Jan L. Wallander, Paula Cuccaro and Susan R. Tortolero

*Pediatrics*; originally published online November 10, 2014;
DOI: 10.1542/peds.2014-2195

The online version of this article, along with updated information and services, is located on the World Wide Web at:
/content/early/2014/11/05/peds.2014-2195