Personal, Behavioral, and Environmental Risk and Protective Factors for Adolescent Overweight

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Abstract

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Objective: The objective was to examine a breadth of personal, behavioral, and socio-environmental factors as potential risk and protective factors of overweight among male and female adolescents.

Research Methods and Procedures: A longitudinal study was conducted with an ethnically and socio-economically diverse sample of 2516 adolescents who completed surveys at both Time 1 (1998 to 1999) and Time 2 (2003 to 2004) of the Project Eating Among Teens (EAT) study.

Results: In 1998 to 1999, 335 (25.7%) girls and 282 (26.4%) boys met the age-adjusted criteria for overweight. During the 5-year study period, 236 (70.5%) of the overweight girls and 185 (65.7%) of the overweight boys remained overweight and 115 (12.0%) girls and 77 (9.9%) boys originally not overweight became overweight. Although differences by sex were found, a number of personal, behavioral, and socio-environmental factors were associated with overweight among both male and female adolescents. Body dissatisfaction and weight concerns at Time 1 predicted overweight at Time 2 for both male and female adolescents. Dieting and use of unhealthy weight control behaviors at Time 1 also predicted overweight at Time 2. Greater frequency of breakfast consumption at Time 1 was protective against overweight. Higher levels of weight-related teasing and parental weight-related concerns and behaviors at Time 1 were positively associated with Time 2 overweight.

Discussion: Body dissatisfaction, weight concerns, use of unhealthy weight control behaviors, weight-related stigmatization, and parental concern about the child's weight may increase risk for adolescent overweight. Interventions that enhance adolescents' body satisfaction while providing them with skills to avoid dieting and to engage in more effective weight-control behaviors should be developed and tested.

Key words: adolescents, longitudinal

Introduction

In the past 3 decades, the prevalence of overweight among adolescents has nearly tripled (1). In 1971 to 1974, the National Health and Nutrition Examination Survey (NHANES)[1] reported that 6.1% of adolescents 12 through 19 years of age were overweight (BMI ≥95th percentile) (1). Prevalence estimates from the 2003 to 2004 NHANES indicate that 17% of adolescents were overweight and an additional 17% were at risk for overweight (BMI ≥85th percentile) (2). The rapid increase in the prevalence of overweight implicates personal, behavioral, and socio-environmental factors, rather than genetic factors, as the primary factors responsible for this increase. Thus, the focus of this article is to examine the influence of modifiable personal, behavioral, and socio-environmental factors on obesity risk in youth.

Although it is well understood that the causes of overweight are multi-factorial, including socio-environmental, personal, behavioral, and genetic factors, etiologic research has typically focused on factors within a single domain (i.e., behavioral) (3). Few studies have examined a range

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[1] Nonstandard abbreviations: NHANES, National Health and Nutrition Examination Survey; EAT, Eating Among Teens; SD, standard deviation; YAQ, Youth and Adolescent Food Frequency Questionnaire; SES, socioeconomic status.

of factors from the personal, behavioral, and socio-environmental domains as predictors of overweight in adolescents (4,5). A broad examination of risk and protective factors of overweight can help to inform a comprehensive approach to obesity prevention by identifying key risk and protective factors within each domain. The present study contributes to the literature by examining a breadth of personal, behavioral, and socio-environmental factors as potential predictors of overweight among adolescents using a large and ethnically diverse population-based sample.

The putative risk and protective factors of adolescent overweight examined in this study are theoretically derived based on the Social Cognitive Theory (6,7), with many having been examined previously in etiologic studies on overweight among youth. Social Cognitive Theory posits that health behavior is influenced by a complex interplay of individual, behavioral, and environmental factors. Given that weight status is influenced by factors at both the individual and environmental levels, Social Cognitive Theory is an appropriate framework for exploring potential risk and protective factors of adolescent overweight.

Researchers have found that personal factors, such as depression (8) or body dissatisfaction (8,9), are associated with increased risk of binge eating behavior, which can lead to increased weight gain. It has been posited that some individuals may eat in an effort to provide comfort and distraction from negative emotions (4).

Diet-related behavioral factors that have been hypothesized as influencing energy intake and, therefore, weight status, include fat intake (10), fruit and vegetable intake (11), sugar-sweetened beverages (12,13), milk consumption (14), snack foods (15,16), fast foods (17,18), and breakfast (5,19). Hours spent engaging in physical and sedentary activities have been hypothesized as the key behavioral factors affecting expenditure, although research findings have been mixed (20–25).

Other behavioral factors that may have relevance for obesity risk include dieting and use of unhealthy weight control behaviors. Paradoxically, dieting and use of unhealthy weight control behaviors (e.g., vomiting or laxatives) have been found to increase weight gain among youth (4,26–28). One explanation of this seemingly contradictory association is that engaging in behaviors that involve a severe restriction of calories may lead to binge eating, which has been identified as a risk factor for obesity onset in adolescents (8,28,29).

Socio-environmental factors that have been shown to impact the use of unhealthy weight control behaviors among youth, such as peer dieting behaviors (30), weight-related teasing (31,32), and parental pressure to diet (33,34), may be associated with obesity risk in adolescence. Research has also found that factors in youth's home environment, such as food availability, may influence dietary intake and, therefore, obesity risk (35,36), although these findings have not been consistent (37).

Parental overweight has also been hypothesized to be positively associated with child's risk for becoming overweight as a result of shared genetic and family-level environmental factors (3,38). Parental weight has been found to be associated with child's risk of overweight (4,39,40); however, this finding is not consistent across studies (24).

The primary aim of this study is to examine a breadth of personal, behavioral, and socio-environmental factors as potential risk and protective factors of overweight among adolescents using a large and ethnically diverse population-based sample. A secondary aim of the study is to identify if these factors differ among adolescents who became overweight over the 5-year study period (incident cases) and those that remained overweight over the study period (persisters). This knowledge will elucidate factors to be examined further using experimental research designs and may identify modifiable factors that can be used to inform the development of effective obesity primary and secondary prevention interventions.

Research Methods and Procedures

Study Design

Project Eating Among Teens (EAT) is a prospective, observational study of the socio-environmental, personal, and behavioral predictors of dietary intake and weight status among a large and ethnically diverse population (41,42). Project EAT-I surveyed 4746 middle and high school students in 31 Minnesota schools (of 55 recruited to participate) during the 1998 to 1999 academic year. Participants completed in-class surveys and anthropometric measures. Five years later (2003 to 2004), Project EAT-II aimed to re-survey original participants to examine changes in their eating patterns and weight status as they progressed from early adolescence to middle adolescence and from middle adolescence to late adolescence/young adulthood. For Project EAT-II, surveys were sent by mail to the address provided by the participant during EAT-I. Internet tracking services were used to identify correct addresses when mail was returned. Non-responders were sent 2 reminder postcards and 3 additional survey packets. Of the original study population, 1074 (22.6%) were lost to follow-up for various reasons, primarily due to missing contact information at EAT-I ($n = 411$) and no address at follow-up ($n = 591$). Of the remaining 3672 participants contacted by mail, 2516 completed the surveys, representing 53.0% of the original cohort and 68.4% of participants contacted for Project EAT-II. Study protocols were approved by the University of Minnesota's Institutional Review Board Human Subjects Committee.

Sample Population

The final EAT sample consisted of 1386 girls (55.1%) and 1130 boys (44.9%) who completed surveys for both EAT-I (Time 1) and EAT-II (Time 2). Approximately one third of the participants (32.0%) were in middle school during EAT-I (younger cohort); at Time 1 their mean age was 12.8 years [standard deviation (SD) = 0.8], and at Time 2 their mean age was 17.2 years (SD = 0.6 years). Two-thirds of the participants (68.0%) were in high school during EAT-II (older cohort); at Time 1 their mean age was 15.8 years (SD = 0.8 years), and at Time 2 their mean age was 20.4 years (SD = 0.8 years).

Survey Tools and Development

Project EAT-I survey is a 221-item self-report instrument. The development of the survey was guided by focus group discussions with adolescents (43), a theoretical framework (Social Cognitive Theory) for understanding factors influencing weight-related behaviors (6,7), a review of existing instruments (44–48), reviews by experts in the area, and several pilot tests of the survey. The Project EAT-I survey was revised for use in Project EAT-II. Two versions were developed for Project EAT-II: one for younger adolescents of high school age and one for older adolescents/young adults who were post-high school. Approximately two thirds of the items in the high school version and 55% of the items in the older adolescent/young adult version remained as they were in the original survey or with minor alterations (e.g., change in response options for age).

Measures

Outcome Measure. BMI was based on self-reported height and weight measures and calculated with the formula weight in kilograms divided by squared height in meters. Although at Time 1 both measured and self-reported height and weight were collected, at Time 2 only self-reported measures were collected. Thus, in the current analyses, self-reported values are used. Correlations between reported and measured BMI at Time 1 were $r = 0.85$ for girls and $r = 0.89$ for boys (49). In cases in which self-reported BMI data at Time 1 were not available, but measured BMI data were available ($n = 117$), item imputation was carried out based on measured BMI, age, race, and socio-economic status, within gender. For weight status, the Must et al. (50,51) classification was used because it provides contiguous values from childhood to adulthood based on the first NHANES (NHANES I), and in the current analysis, adolescents were followed through late adolescence/young adulthood. Although adolescents with BMI values above the 85th percentile for age and gender are considered at risk for overweight (85th to 95th percentile) and those above the 95th percentile are overweight, in these analyses we refer to adolescents whose BMI exceeded the 85th as "overweight."

Personal Variables

Body satisfaction was assessed with a modified version of the Body Shape Satisfaction Scale (46) (Cronbach's $\alpha = 0.92$). Depressive symptoms were assessed using a 6-item scale developed by Kandel and Davies (52) (Cronbach's $\alpha = 0.82$). Weight concern was assessed with the question "How strongly do you agree with the following statements? a) I think a lot about being thinner; and b) I am worried about gaining weight." Response options ranged from "strongly disagree" to "strongly agree" on a 4-point Likert scale.

Behavioral Variables

Dietary Intake and Eating Patterns. The dietary intake variables (energy, total fat, daily servings of fruits and vegetables, sugar-sweetened beverages, diet soda, snacks, milk) were assessed with the 149-item, semiquantitative Youth and Adolescent Food Frequency Questionnaire (YAQ) (53). Details on the foods included within each food group (fruits and vegetables, sugar-sweetened beverages, snacks, and milk) are described in the appendix. The YAQ has been tested for reproducibility and has been compared with averages from three 24-hour dietary recalls and findings have been within acceptable ranges for dietary assessment tools (53,54). Fast food consumption per week was assessed with the question, "In the past week, how often did you eat something from a fast food restaurant?" The responses (never, 1 or 2 times, 3 or 4 times, 5 or 6 times, 7 times, and >7 times) were coded with 0, 1.5, 3.5, 5.5, 7, and 10, respectively. Breakfast consumption per week was assessed with the question, "During the past week, how many days did you eat breakfast?" The responses (never, 1 or 2 days, 3 or 4 days, 5 or 6 days, everyday) were coded using the midpoints of each category (0, 1.5, 3.5, 5.5, and 7 days per week).

Physical Activity. Moderate-to-vigorous physical activity was assessed with a modified version of the Leisure Time Exercise Questionnaire (55). Two questions were asked to assess how many hours were spent in strenuous or moderate physical activity behaviors in a usual week. The responses (0, <0.5, 0.5 to 2, 2.5 to 4, 4.5 to 6, and >6 hours per week) for each activity were coded using the mid-points of each category (0, 0.3.1.3, 3.3, 5.3, and 8 hours per week), and these values were summed to create the hours-per-week variable.

Sedentary Behaviors. Hours spent participating in three sedentary activities was assessed by the questions, "In your free time on a average weekday (Monday to Friday), how many hours do you spend: a) watching TV and videos; 2) reading or doing homework; or c) using a computer (not for homework)?" A similar question was asked for an average weekend day (Saturday or Sunday). An hours-per-week variable was created by calculating a weighted sum of weekday and weekend day use based on the responses

(0, ½, 1, 2, 3, 4, 5+ hours-per-day) for each sedentary behavior.

Disordered Eating Behaviors. Unhealthy weight-control behaviors were assessed with the question, "Have you done any of the following things to lose weight or keep from gaining weight in the past year?" (yes/no for each method). Response options included: fasted, ate little food, used a food substitute (e.g., Slim Fast), used laxatives, skipped meals, smoked more cigarettes, took diet pills, made myself vomit, and used diuretics. Dieting was assessed with the question, "How often have you gone on a diet during the last year? By 'diet' we mean changing the way you eat so you can lose weight." Response ranged from 'never' to 'I'm always dieting' on a 5-point scale. Binge eating with loss of control was assessed with two questions (yes/no for each question), "In the past year, have you ever eaten so much food in a short period of time that you would be embarrassed if others saw you (binge eating)? During the times when you ate this way did you feel you couldn't stop eating or control what or how much you were eating?" Respondents who answered affirmatively to both of these questions were classified as engaging in binge eating with loss of control.

Socio-environmental Variables

Home availability of healthy foods was assessed with the question, "How often are the following things true? a) Fruits and vegetables are available in my home; b) Milk is served at meals at my home; c) We have fruit juice in my home; d) Vegetables are served at dinner in my home." Response options ranged from "never" to "always" on a 4-point Likert scale. Home availability of low-nutrient, high-calorie snack foods was assessed with the question, "How often are the following things true? a) We have junk food in my home; b) Potato chips and other salty snacks are available in my home; c) Chocolate or other candy is available in my home; d) Soda pop is available in my home." Response options ranged from "never" to "always" on a 4-point Likert scale. Weight-related teasing was assessed with the item, "How often did any of the following things happen to you: You are teased about your weight." Response categories ranged from "never" to "at least once a week." Parental weight-related concerns and behaviors were assessed with the questions: "My mother: a) diets to lose weight or keep from gaining weight; b) encourages me to diet to control my weight" (similar questions for father). Response options ranged from "not at all" to "very much" on a 4-point Likert scale. Peer dieting behaviors were assessed with the question, "Many of my friends diet to lose weight or keep from gaining weight." Response options ranged from "not at all" to "very much" on a 4-point Likert scale. Perceived parental overweight was assessed with the question, "Which of the following best describes your biological mother's weight?" A similar question was asked for biological father's weight. Respondents were classified as having overweight parents if they reported that at least one of their biological parents was "overweight" or "very overweight."

Demographic Variables

Sex, ethnicity/race, age, and socioeconomic status (SES) were based on self-report at Time 1. Ethnicity/race was assessed with the question, "Do you think of yourself as: 1) White, 2) Black/African-American, 3) Hispanic or Latino, 4) Asian-American, 5) Hawaiian/Pacific Islander, 6) American-Indian?" Level of SES was based primarily on the highest educational level completed by either parent for most respondents. Other factors taken into account in assessing SES included eligibility for public assistance, eligibility for free or reduced-cost school meals, and parental employment status (42).

Statistical Analyses

All analyses were stratified by gender and conducted using SAS software (version 9.1, 2003; SAS, Inc., Cary, NC). Multiple logistic regression was used where overweight status at Time 2 was regressed on each specific personal, behavioral, and socio-environmental factor measured at Time 1 as well as the change in the factor over time (Time 2 minus Time 1) while controlling for Time 1 overweight status and demographic variables, race/ethnicity, SES, and age. Separate models were fit for each specific factor. The resulting estimate for the Time 1 factor and the estimate for the change in the factor over time represent, respectively, the effect of the factor on overweight status 5 years later and the effect of recent (over past 5 years) increases or decreases in the factor on overweight status. Hence, both estimates are of interest and can be obtained with this longitudinal dataset. For dietary variables measured using the YAQ as the predictor, caloric intake was included as a covariate in the logistic regression to help adjust for reporting biases (56).

Analyses were performed using the total sample and then separately using only adolescents who were not overweight at Time 1. The analyses using the total sample yield odds ratios representing the overall risk of being overweight (prevalence) at Time 2, which combines the risk of becoming overweight during the study period (incidence) with the risk of remaining overweight during the study period (persistence). The analyses using only those individuals not overweight at Time 1, yields odds ratios specifically representing the risk of becoming overweight (incidence). An additional analysis of the total sample was performed that included an interaction term between Time 1 weight status and each specific factor and the difference in the factor over time. The tests for these interactions indicate whether the odds ratio for incidence cases is significantly different from the odds ratio for persistent cases.

To account for differential response rates across demographic characteristics in the longitudinal sample, in all

Table 1. Prevalence of overweight in adolescents in the Project EAT (Eating Among Teens) study

	Time 2 overweight status*			
	Girls		Boys	
Time 1 overweight status	Normal-weight	Overweight	Normal-weight	Overweight
Normal-weight				
n	849	115	708	77
(%)	(88.1)	(12.0)	(90.2)	(9.9)
Overweight				
n	99	236	97	185
(%)	(29.5)	(70.5)	(34.3)	(65.7)

* Overweight defined as BMI above the 85th percentile for age and sex.

analyses, the data were weighted using the response propensity method (57), where the inverse of the estimated probability that an individual responded at Time 2 is used as the weight. Response propensities (i.e., the probability of responding to the EAT-II survey) were estimated using a logistic regression of response to EAT-II (yes/no) on a large number of predictor variables available from the EAT-I survey (Time 1 survey). The weighting method results in estimates representative of the demographic make-up of the original Project EAT-I sample. The weighted ethnic/racial and SES proportion were: 48.3% white, 18.9% black, 19.6% Asian, 5.8% Hispanic, 3.6% Native American, and 3.8% mixed or other race. Thirty-seven percent of the sample were of low or low-middle SES.

Results

Prevalence and Incidence of Overweight

At Time 1, 335 (25.7%) girls and 282 (26.4%) boys met the age-adjusted criteria for overweight. Of these, 70.5% of the girls and 65.7% of the boys also met the criteria for overweight at Time 2 (Table 1). Of the 1749 non-overweight boys and girls at Time 1, 12.0% of the girls and 9.9% of the boys became overweight by Time 2 (Table 1). The mean BMIs for girls at Time 1 was 22.4 and at Time 2 was 23.9. For boys, the mean BMI was 22.5 and 24.6 at Time 1 and Time 2, respectively.

Female Subjects

Personal Factors. Body satisfaction at Time 1 was negatively associated with Time 2 overweight, and weight concern at Time 1 was positively associated with Time 2 overweight, in analyses adjusted for age cohort, SES, race/ethnicity, and Time 1 overweight status (Table 2). In addition, the level of change in these predictor variables (calculated as Time 2 − Time 1 value) was also found to be associated with Time 2 overweight, such that increases in body satisfaction over time was protective for overweight at Time 2 and increasing weight concern was a risk factor for overweight at Time 2 (significance identified in Table 2). Depressive symptoms were not significantly associated with Time 2 overweight. Similar associations were found between these Time 1 personal variables and Time 2 overweight in the analyses that included only incident cases of overweight (Table 2).

Behavioral Factors. Hours spent engaged in sedentary behaviors, servings of sugar-sweetened beverages, servings of diet soda, use of unhealthy weight control behaviors, dieting, and binge eating at Time 1 were positively associated with Time 2 overweight, after controlling for age cohort, SES, race/ethnicity, and Time 1 overweight status (Table 2). Servings of fruits and vegetables and breakfast consumption at Time 1 were negatively associated with Time 2 overweight, adjusted for demographic factors and Time 1 overweight status. Contrary to expectations, caloric intake and fast food consumption at Time 1 were also negatively associated with Time 2 overweight, adjusted for demographic factors and Time 1 overweight status. Increases over the study period in caloric intake and breakfast consumption were negatively associated with overweight at Time 2, and increases over the study period in binge eating, dieting, and unhealthy weight control behaviors were positively associated with Time 2 overweight. Levels of moderate-to-vigorous physical activity, total fat intake, servings of milk, and servings of snack foods at Time 1, as well as their changes over time, were not significantly associated with Time 2 overweight.

Unlike the analyses that included all individuals, analyses focusing only on incident cases of overweight did not find a significant association between caloric intake, servings of fruit and vegetables, servings of regular soda, and fast food consumption per week at Time 1 and incident overweight

Table 2. Personal, behavioral, and socio-environmental determinants of overweight in female adolescents in the Project EAT (Eating Among Teens) study ($n = 1380$)

Variable	Mean (SD) or prevalence (SD)	Overweight at Time 2 [OR (95% CI)]‡	Incidence [OR (95% CI)]§
Personal factors			
Body satisfaction	31.9 (9.8)	0.93 (0.91, 0.95)*†	0.93 (0.91, 0.96)*†
Depressive symptoms	12.7 (3.2)	1.02 (0.96, 1.09)	1.05 (0.97, 1.14)
Weight concerns	2.8 (0.9)	2.18 (1.73, 2.74)*†	2.71 (1.99, 3.69)*†
Behavioral factors			
Moderate and vigorous physical activity (hrs/wk)	5.8 (4.7)	1.00 (0.95, 1.05)	1.00 (0.95, 1.07)
Sedentary behaviors (hrs/wk)	43.6 (21.6)	1.01 (1.00, 1.01)†	1.01 (1.00, 1.02)†
Energy intake (kcal)	1994 (1047)	0.98 (0.95, 1.00)*†	0.98 (0.96, 1.02)*
Total fat (g/d)¶	65.9 (38.7)	1.01 (0.99, 1.03)	1.01 (0.99, 1.03)
Fruits and vegetables (servings/d)¶	4.2 (2.9)	0.88 (0.79, 0.98)†	0.89 (0.77, 1.03)
Sugar-sweetened beverages (servings/d)¶	0.6 (0.6)	1.34 (1.00, 1.81)†	1.41 (0.95, 2.12)*
Diet soda (servings/d)¶	0.2 (0.4)	1.74 (1.13, 2.69)†	1.99 (1.14, 3.50)†
Milk (servings/d)¶	1.4 (1.4)	1.11 (0.93, 1.33)	1.31 (0.99, 1.73)
Snack foods (servings/d)¶	2.5 (2.4)	0.93 (0.79, 1.10)	1.02 (0.81, 1.29)
Fast food (times/week)	1.7 (1.8)	0.88 (0.79, 0.98)†	0.93 (0.80, 1.09)
Breakfast (times/week)	3.5 (2.6)	0.89 (0.83, 0.97)*†	0.84 (0.74, 0.96)*†
Unhealthful weight control behaviors	1.5 (1.6)	1.17 (1.04, 1.30)*†	1.25 (1.08, 1.45)*†
Dieting	1.9 (1.1)	1.36 (1.15, 1.62)*†	1.44 (1.15, 1.80)*†
Binge eating behavior with loss of control [% yes (n)]	11.3 (31.2)	1.93 (1.03, 3.60)*†	2.66 (1.18, 5.99)*†
Socio-environmental factors			
Home availability of healthful foods	12.4 (2.4)	0.98 (0.90, 1.06)	0.97 (0.88, 1.08)
Home availability of high-caloric snack foods	11.0 (2.7)	0.89 (0.83, 0.95)*†	0.92 (0.84, 1.01)
Parental weight-related concerns and behaviors	6.9 (3.0)	1.20 (1.13, 1.28)*†	1.20 (1.10, 1.31)*†
Weight-related teasing	1.9 (1.3)	1.48 (1.25, 1.75)*†	1.38 (1.11, 1.71)*†
Peer dieting behaviors	2.3 (1.0)	0.86 (0.72, 1.03)	0.87 (0.69, 1.10)
Perceived parental overweight (% yes)	43.7	1.23 (0.89, 1.72)	1.34 (0.80, 2.26)

SD, standard deviation; OR, odds ratio; CI, confidence interval; SES, socioeconomic status. Separate models were fit for each factor.

* Difference in predictor (Time 2 − Time 1) was statistically significant ($p < 0.05$).

† Statistical significance for the estimates shown.

‡ Adjusted for age cohort, SES, race/ethnicity, and Time 1 overweight status.

§ Adjusted for age cohort, SES, and race/ethnicity.

¶ Adjusted for energy intake.

(Table 2). However, the change from Time 1 to Time 2 for caloric intake and servings of sugar-sweetened beverages was significantly associated with incident overweight (increases in caloric intake was protective and increases of servings of sugar-sweetened beverages was a risk factor), suggesting that for these variables it was level of change, not baseline level, that were significant predictors of incident overweight. Similar associations were found for the other behavioral variables examined in the analyses that included only incident cases of overweight as were found in the analyses that included both the prevalent and incident cases of overweight.

Socio-environmental Factors. Parental weight-related concerns and behaviors and weight-related teasing at Time 1, as well as increases in these variables over the study period, were positively associated with Time 2 overweight, adjusted for demographic factors and Time 1 overweight status. Contrary to expectations, home availability of high-caloric snack foods at Time 1 as well as increases in this variable from Time 1 to Time 2 were both negatively associated with Time 2 overweight. Home availability of healthy foods, peer dieting behaviors, and perceived parental overweight (as reported by their child) were not associated with female adolescents' Time 2 overweight.

In the analyses that examined only incident cases, similar associations were found between these Time 1 socio-environmental variables and Time 2 overweight status, with the exception of home availability of high-caloric snack foods no longer being significantly associated with Time 2 overweight (Table 2).

Male Subjects

Personal Factors. Body satisfaction at Time 1 and increases in body satisfaction over time were both found to be negatively associated with overweight at Time 2, whereas depressive symptoms and weight concerns (and increases in weight concern over time) were found to be positively associated with Time 2 overweight, adjusted for age cohort, SES, race/ethnicity, and Time 1 overweight status (Table 3). In the analyses examining only incident cases of overweight, similar associations were found between the Time 1 personal variables and Time 2 overweight, with the exception that Time 1 depression was no longer found to be significantly associated with Time 2 overweight status (Table 3).

Behavioral Factors. Use of unhealthy weight control behaviors and dieting at Time 1 were positively associated with Time 2 overweight, adjusted for demographic factors and Time 1 overweight status (Table 3). Servings of snack foods per day and breakfast consumption at Time 1 were negatively associated with Time 2 overweight, adjusted for demographic factors and Time 1 overweight status. Increases over the study period in use of unhealthy weight control behaviors, dieting, and diet soda intake were positively associated with overweight at Time 2. Increases over the study period in hours of moderate-to-vigorous physical activity was negatively associated with overweight at Time 2.

In the analyses that examined only incident cases of overweight, similar associations were found between the Time 1 behavioral variables and Time 2 overweight, with the additional finding that Time 1 milk intake was found to be negatively associated with Time 2 incident overweight (Table 3). Increases over the study period in use of unhealthy weight control behaviors and dieting were positively associated with Time 2 incident overweight. Increases over the study period in hours of moderate to vigorous physical activity, milk intake, snack food intake, breakfast consumption, and binge eating were negatively associated with Time 2 incident overweight.

Socio-environmental Factors. Parental weight-related concerns and behaviors, weight-related teasing, and peer dieting behaviors at Time 1 were positively associated with Time 2 overweight, adjusted for age cohort, SES, race/ethnicity, and Time 1 overweight status (Table 3). In addition, increases over the study period in parental weight-related concerns and behaviors and peer dieting were positively associated with Time 2 overweight. Home availability of high caloric snack foods, home availability of healthy foods, and perceived parental overweight at Time 1 were not associated with male adolescents' Time 2 overweight.

In the analyses that examined only incident cases of overweight status, similar associations were found between these Time 1 socio-environmental variables and Time 2 overweight status, with the exception of weight-related teasing no longer being significantly associated with Time 2 incident overweight (Table 3).

Analyses examining tests for interaction between Time 1 weight status and each specific factor revealed significant interactions for weight concern, dieting, and weight teasing among boys and for fast food among girls (results not shown), suggesting that for these factors the odds ratios for incident overweight are significantly different than the odds ratios found for persistent overweight. In particular, in boys, weight concern and dieting at Time 1 have a stronger association with incident overweight than with persistent overweight; and weight teasing at Time 1 has a stronger association with persistent overweight than it does with incident overweight. For girls, fast food shows up (oddly) as a protective factor for persistent overweight, while it is not associated with incident overweight.

Discussion

The primary aim of this study was to examine the longitudinal associations between a number of personal, behavioral, and socio-environmental factors and overweight among adolescents. To achieve this aim, we examined the

Table 3. Personal, behavioral, and socio-environmental determinants of overweight in male adolescents in the Project EAT (Eating Among Teens) study ($n = 1119$)

Variable	Mean (SD) or prevalence (SD)	Overweight at Time 2 [OR (95% CI)]‡	Incidence [OR (95% CI)]§
Personal factors			
Body satisfaction	36.8 (8.8)	0.92 (0.90, 0.95)*†	0.92 (0.89, 0.97)*†
Depressive symptoms	11.0 (3.0)	1.08 (1.01, 1.16)†	1.07 (0.98, 1.18)
Weight concerns	2.1 (0.9)	3.26 (2.43, 4.36)*†	4.44 (2.94, 6.70)*†
Behavioral factors			
Moderate to vigorous physical activity (hrs/wk)	7.4 (4.7)	0.97 (0.93, 1.02)*	0.95 (0.89, 1.03)*
Sedentary behaviors (hrs/wk)	45.8 (24.4)	1.00 (0.99, 1.01)	1.00 (0.99, 1.01)
Energy intake (kcal)	2249 (1216)	1.00 (0.98, 1.02)	0.99 (0.96, 1.02)
Total fat (g/d)¶	76.7 (46.0)	0.99 (0.97, 1.01)	1.00 (0.97, 1.03)
Fruits and vegetables (servings/d)¶	3.8 (2.9)	0.99 (0.89, 1.12)	0.99 (0.84, 1.18)
Sugar-sweetened beverages (servings/d)¶	0.7 (0.7)	0.82 (0.58, 1.17)	0.63 (0.37, 1.07)
Diet soda (servings/d)¶	0.1 (0.4)	1.58 (0.84, 2.99)*	0.72 (0.21, 2.42)
Milk intake (servings/d)¶	1.9 (1.5)	0.90 (0.75, 1.07)	0.77 (0.60, 0.99)*†
Snack foods (servings/d)¶	2.8 (2.8)	0.83 (0.69, 0.99)†	0.75 (0.58, 0.98)*†
Fast food (times/week)	1.8 (1.6)	1.03 (0.90, 1.17)	1.04 (0.87, 1.25)
Breakfast (times/week)	4.3 (2.6)	0.89 (0.82, 0.97)†	0.84 (0.74, 0.96)*†
Unhealthful weight control behaviors	0.6 (1.1)	1.53 (1.28, 1.84)*†	1.72 (1.35, 2.19)*†
Dieting	1.4 (0.7)	1.82 (1.35, 2.44)*†	2.44 (1.63, 3.67)*†
Binge eating behavior with loss of control [% yes (n)]	2.4 (17.7)	2.90 (0.83, 10.20)	0.46 (0.03, 7.78)*
Socio-environmental factors			
Home availability of healthful foods	12.5 (2.3)	0.97 (0.88, 1.03)	1.01 (0.88, 1.15)
Home availability of high-caloric snack foods	11.0 (2.7)	0.94 (0.86, 1.02)	0.95 (0.84, 1.08)
Parental weight-related concerns and behaviors	7.2 (3.1)	1.16 (1.08, 1.25)*†	1.20 (1.10, 1.32)*†
Weight-related teasing	1.7 (1.2)	1.36 (1.12, 1.64)†	1.05 (0.79, 1.40)
Peer dieting behaviors	1.4 (1.1)	1.28 (1.02, 1.61)*†	1.40 (1.02, 1.92)*†
Perceived parental overweight [% yes (n)]	43.4	1.42 (0.98, 2.08)	1.59 (0.89, 2.81)

SD, standard deviation; OR, odds ratio; CI, confidence interval; SES, socioeconomic status. Separate models were fit for each factor.

* Difference in predictor (Time 2 − Time 1) was statistically significant ($p < 0.05$).

† Statistical significance for the estimates shown.

‡ Adjusted for age cohort, SES, race/ethnicity, and Time 1 overweight status.

§ Adjusted for age cohort, SES, and race/ethnicity.

¶ Adjusted for energy intake.

association between the baseline level of these factors and overweight 5 years later, as well as the association between the change in these factors over the study period and overweight at follow-up. Our findings indicate that factors within all 3 domains (personal, behavioral, and socio-environmental) were significantly associated with overweight among both male and female adolescents. In general, similar findings were found for both genders. However, fewer behavioral factors were found to be significantly associated with overweight in boys as compared with girls.

Key personal factors that were consistently shown to be associated with and predictive of obesity risk in both male and female adolescents included body dissatisfaction and weight concern, with particularly strong associations found for weight concern. Dissatisfaction with one's body and concern about one's weight may lead to overweight via two possible mechanisms. First, body dissatisfaction and weight concern may lead to dieting and other restrictive behaviors, which have been posited by the Dietary Restraint Theory, to lead to hunger, followed by overeating (8,32,58). Second, body dissatisfaction has been shown in previous analyses of the Project EAT data to be predictive of lower levels of physical activity among both male and female adolescents (59). Depressive symptoms were not significantly associated with obesity among girls. Among boys, significant associations were found between higher levels of depressive symptoms at Time 1 and prevalent Time 2 overweight, but no significant associations were found between Time 1 depressive symptoms and incident overweight or in change in depressive symptoms over time and prevalent or incident overweight. Previous studies have found a null association between depressive symptoms and overweight (60–62), while others have found a positive association (4,63). One possible explanation for these inconsistent findings is that the assessment of depressive symptoms has differed across the studies. The different ages of the participants studied may also contribute to the inconsistent results given that the prevalence of depressive symptoms increases with age (64).

Among the behavioral factors, a strong, consistent, and particularly noteworthy finding is that male and female adolescents who engaged in dieting and unhealthy weight control behaviors (and those who increased their use of these behaviors over the study period) were more likely to be overweight at Time 2 (examined as both prevalent and incident overweight) than their non-dieting peers, which is consistent with previous research (26,28). Dieting in this study was defined for participants as "change the way you eat to lose weight." Therefore, it is possible that our findings may not be generalizable to individuals who are dieting to maintain weight or to prevent weight gain. However, similar associations between dieting and weight gain have been shown among adolescents in a study that assessed dieting behavior for weight loss or maintenance (26). Binge eating was also positively associated with prevalent and incident overweight among girls. Among boys, an increase over the study period in binge eating was positively associated with incident overweight.

In general, the dietary and activity behavioral variables most commonly identified as putative risk factors for obesity (e.g., caloric intake, fat intake, fruit and vegetable intake, physical activity behaviors) were not as strong or as consistent as those found for many of the other behavioral factors examined and were often in unanticipated directions. For example, among girls, a higher caloric intake at Time 1 and increases in caloric intake over the study period were found to be protective against Time 2 overweight, with no significant association between caloric intake and Time 2 overweight among boys. Although unexpected, other studies have found similar associations between caloric intake and risk of overweight (5,65). A second example of unanticipated findings was the results for diet soda; a higher intake of diet soda at Time 1 was positively associated with prevalent and incident overweight at Time 2 among girls. Among boys, an increase in diet soda intake over the study period was positively associated with prevalent overweight at Time 2. Similar findings were found for boys in a large, prospective observational study of youth 9 to 14 years of age (13). One possible explanation for these results is that obtaining reliable estimates of these dietary behaviors is difficult because these behaviors are extremely variable over time. Second, although the analyses that examined dietary variables assessed with the YAQ were adjusted for caloric intake to help adjust for reporting bias, residual confounding due to reporting bias may still be present, particularly among overweight respondents. Underreporting of dietary intake has been found to be positively associated with weight status among youth (66,67). Third, the findings for dietary intake may be confounded by the adolescents' level of physical activity. However, when we re-ran the regression models to include both caloric intake and physical activity simultaneously, the direction and significance of the calories and physical activity on prevalence and incidence of obesity do not change, suggesting that these results may not be confounded by activity level.

One diet-related variable that was shown to be associated with prevalent and incident overweight among both boys and girls was breakfast eating. Greater frequency of breakfast consumption at Time 1, as well as an increase in breakfast consumption over the study period, was protective against adolescent overweight, which replicates results from other studies with adolescents (5,19,68). Because breakfast consumption is a discrete behavior that is relatively easy to assess (Did you eat breakfast today? Yes or no?), it may be more reliably measured than other dietary variables assessed in this study (e.g., overall caloric intake), which may explain why more consistent results were shown for breakfast eating.

Relatively consistent results were found for boys and girls for the socio-environmental factors examined. Among both boys and girls, a higher level of parental weight-related concerns and behaviors at Time 1, as well as an increase in this variable over the study period were positively associated with Time 2 prevalent and incident overweight, suggesting that pressure from parents to lose weight is not effective in helping teens manage their weight and may actually be harmful. More frequent weight-related teasing at Time 1 was predictive of prevalent overweight at Time 2 among boys and girls and of incident overweight among girls. Perceived parental overweight was not significantly associated with adolescent overweight. This is contrary to previous research that has found that parental obesity has predicted obesity in youth (5,40,69). A possible explanation for this inconsistent finding is that our study used adolescents' report of their parents weight rather than direct observation or parental self-report and some of the overweight adolescents may have incorrectly classified their overweight parents as normal-weight.

A secondary aim of the study was to identify if these risk and protective factors of overweight differ among adolescents who became overweight over the 5-year study period and those that remained overweight over the study period. In general, the risk and protective factors that were associated with prevalent overweight were similar to those associated with incident overweight, suggesting that primary and secondary prevention interventions should address similar personal, behavioral, and socio-environmental factors. The main difference between these analyses is that fewer factors were significantly associated with incident overweight than with prevalent overweight, which is likely the result of reduced power due to the smaller sample size in the incident analyses. Among girls, factors that were significantly associated with prevalent overweight only included fast food intake, caloric intake, servings of sugar-sweetened beverages, servings of fruit and vegetables, and home availability of high caloric snack foods. Among boys, depressive symptoms and weight-related teasing were significantly associated with prevalent overweight only.

Strengths and Limitations

Strengths of the current study that enhance our ability to draw conclusions from the findings include the prospective study design, which is preferable to cross-sectional or retrospective studies because there is reduced likelihood of differential recall of past events and reverse causal inference. A second strength of the study that improves our ability to generalize our findings to a broad population of adolescents is the large ethnically and socio-economically diverse sample of both male and female adolescents. The breadth of putative predictors of adolescent overweight examined in this study is also a strength of this study. This broad examination allows for the identification of key influences on adolescents' weight within the personal, behavioral, and socio-environmental domains.

Limitations of this study should be considered when interpreting the findings. Although multiple attempts were made to reach the original sample, study attrition may introduce bias to the findings. Compared with the original sample, adolescents who completed both the baseline and follow-up survey were more likely to be white and in the upper SES categories. Sampling weights correcting for nonresponse bias were used in all analyses to help address this limitation. Second, this study used brief, self-report measures of the outcome and putative predictor variables. It would have been preferable to assess these behaviors and the study outcome (BMI) with an objective measure whenever possible or via interviews to improve validity of the measures. However, the high correlations between Time 1 self-reported and measured values for weight and BMI lessen potential concerns about the use of a self-reported measure for the study outcome variable (49). Third, although this study had the benefit of examining these associations using prospective data with a 5-year follow-up, this design does not provide data on how the personal, behavioral, and socio-environmental factors examined or the participants' weight status may have changed during the intervening years. Therefore, it is possible that for some of the estimates for the change in the factors over the study period, the temporality of the association is not clear (i.e., some factors, such as body satisfaction or dietary intake, may have changed over the study period in response to an increase in weight). Finally, many variables were examined and statistically tested for their association with overweight, which means that, with a type 1 error of 0.05 for each of these multiple tests, it is possible that 5% of the significant associations found are, indeed, spurious. To build support for each finding, similarities and differences between these empirical results and findings from other studies were made wherever possible.

Implications

Findings from the current study have implications for the design of future research studies. While this study had the advantage of examining a breadth of risk and protective factors, a more in-depth examination of the etiologic association between these factors and risk of adolescent overweight, including an examination of the potential mediators and moderators of these associations, would be informative and may help to elucidate how best to intervene on these factors. Furthermore, because a number of the risk factors examined in this study could be markers for being at risk for overweight (e.g., diet soda, weight concerns, and dieting), results from experimental research are needed to provide stronger evidence of causality for these associations than can be obtained in prospective observational studies.

Because these analyses focused on modifiable risk and protective factors of adolescent overweight, the present findings also have implications for the development of prevention interventions. Our findings suggest that interventions that increase adolescents' discomfort with their bodies and their weight, and that pressure them to lose weight, diet, or use other unhealthy weight control behaviors are not likely to be effective. Instead, interventions should be developed and tested that enhance body satisfaction as a way to motivate adolescents toward behavioral change, in addition to providing them with the skills and support to avoid unhealthy dieting and to engage in healthier and more effective weight-control behaviors, such as eating breakfast regularly.

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Appendix

Food Items on the Youth Adolescent Food Frequency Questionnaire by Food Group

- Fruits: raisins, grapes, bananas, melons, apples, pears, oranges, strawberries, peaches, plums, orange juice, apple juice
- Vegetables: tomatoes, tomato or spaghetti sauces, string beans, broccoli, beets, corn, peas, mixed vegetables, spinach, greens or kale, peppers, yams, zucchini or squash, carrots, lettuce, coleslaw, potatoes (mashed and baked, not fried).
- Snack foods: potato chips, corn chips/Doritos, Nachos with cheese, popcorn, pretzels, peanuts/nuts, fruit rollups, graham crackers, crackers, Pop Tarts, cake, snack cakes, Danish/sweet rolls/pastry, donuts, cookies, brownies, pie, chocolate/candy bars, candy, Jello, pudding, frozen yogurt, ice cream, milkshakes/frappes, popsicles, granola bars, seeds, power bars, rice cakes, cereal bars, tapioca, dried fruit and nuts.
- Sugar-sweetened beverages: gatorade, regular soda pop, Hawaiian Punch/lemonade/Kool-Aid/other non-carbonated fruit drinks.
- Milk: white milk (skim, 1%, 2% or whole), chocolate milk.

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