Relation Between Dieting and Weight Change Among Preadolescents and Adolescents

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ABSTRACT. *Objective.* **To assess whether dieting to control weight was associated with weight change among children and adolescents.**

Methods. **A prospective study was conducted of 8203 girls and 6769 boys who were 9 to 14 years of age in 1996, were in an ongoing cohort study, and completed at least 2 annual questionnaires between 1996 and 1999. Dieting to control weight, binge eating, and dietary intake were assessed annually from 1996 through 1998 with instruments designed specifically for children and adolescents. The outcome measure was age- and sex-specific *z* score of body mass index (BMI).**

Results. **In 1996, 25.0% of the girls and 13.8% of the boys were infrequent dieters and 4.5% of the girls and 2.2% of the boys were frequent dieters. Among the girls, the percentage of dieters increased over the following 2 years. Binge eating was more common among the girls, but in both sexes, it was associated with dieting to control weight (girls: infrequent dieters, odds ratio [OR]: 5.10; frequent dieters, OR: 12.4; boys: infrequent dieters, OR: 3.49; frequent dieters, OR: 7.30). During 3 years of follow-up, dieters gained more weight than nondieters. Among the girls, frequency of dieting was positively associated with increases in age- and sex-specific *z* scores of BMI ($\beta = 0.05$ and $\beta = 0.04$ for frequent and infrequent dieters vs nondieters). Among the boys, both frequent and infrequent dieters gained 0.07 *z* scores of BMI more than nondieters. In addition, boys who engaged in binge eating gained significantly more weight than nondieters.**

Conclusions. **Although medically supervised weight control may be beneficial for overweight youths, our data suggest that for many adolescents, dieting to control weight is not only ineffective, it may actually promote weight gain.** *Pediatrics* **2003;112:900–906;** ***adolescents, weight gain, dieting, bingeing, girls, boys.***

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ABBREVIATIONS. GUTS, Growing Up Today Study; BMI, body mass index; OR, odds ratio.

Obesity is a growing and serious public health problem among both children and adults in the United States. During the past 2 decades, the prevalence of overweight has increased by 100% among adolescents in the United States.[1] Preadolescents and adolescents who are overweight are likely to become overweight adults[2]; thus, the prevalence of overweight in adulthood and its consequences can be expected to increase markedly during the next several decades unless active measures are taken to combat excessive pediatric weight gain.

Although the prevalence of overweight and obesity is increasing, the desire to be thin or to have well-defined or toned muscles is still very widespread. Dieting to lose weight is common among preadolescent and adolescent girls,[3–5] as well as among adult women.[6] Although dieting is less common among males,[7,8] recent data suggest that weight concerns may be becoming more prevalent.[9] In cross-sectional studies, researchers have observed a strong association between dieting and being overweight or obese.[10]

It is possible that the cross-sectional association between dieting and weight status is attributable to overweight individuals' being more likely than their normal-weight peers to go on diets to lose weight. Because most dieting efforts are not successful—or at least not successfully maintained—overweight individuals may remain overweight despite, not because of, their dieting attempts. Only prospective analyses can help to determine whether dieting leads to great weight gain or is simply an ineffective strategy to lose and maintain weight.

Unfortunately, there are few prospective investigations of this topic in children and adolescents. Stice et al[11] followed 692 adolescent girls for 4 years. Girls who labeled themselves as dieters at baseline were approximately 3 times more likely than nondieters to become overweight. However, there was no measure of dietary intake, so it was unclear whether the association was attributable to or independent of actual dietary intake. To assess whether children and adolescents who diet to lose or maintain weight gain more weight, relative to height, than nondieters, independent of their activity, inactivity, and caloric

intake, we analyzed data from 16 882 participants in an ongoing prospective cohort study.

METHODS

The Growing Up Today Study (GUTS) was established in 1996 by recruiting children, who were 9 to 14 years of age, of women who were participating in the Nurses' Health Study II. Using the Nurses' Health Study II data, we identified mothers who had children aged 9 to 14. We wrote them a detailed letter, explaining that the purpose of GUTS was to study the predictors of weight change during adolescence and sought parental consent to enroll their children. Additional details have been reported previously.[12] Approximately 68% of the girls ($N = 9039$) and 58% of the boys ($N = 7843$) returned completed questionnaires, thereby assenting to participate in the cohort. The project and this study were approved by the Human Subjects Committees at Brigham and Women's Hospital.

Measures

Self-reported dietary intake, physical activity, inactivity, Tanner stage of development, weight control behaviors (including frequency of dieting), weight, and height were assessed annually from 1996 through 1999. We calculated body mass index (BMI) using self-reported weight and height information (wt [kg]/ht [m]^2) and calculated z scores based on the Centers for Disease Control and Prevention/National Center for Health Statistics growth charts (www.cdc.gov/growthcharts/), which are age and sex specific. BMI values >3 standard deviations above the mean were excluded as outliers. In addition, BMI values <12 for preadolescents or 12.5 for adolescents were excluded because of being biologically implausible. Drawings of the 5 Tanner stages of development of pubic hair were used for assessing pubertal development.

Dieting was assessed with a question adapted from the Youth Risk Behavior Surveillance System questionnaire.[13] The question asks, "During the past year, how often did you diet to lose weight or to keep from gaining weight?" The response categories for the frequency of dieting to control weight during the past year were "never," "less than once a month," "1–3 times a month," "once a week," "2 to 6 times per week," or "every day." Children who reported that they had dieted "less than once a month," "1–3 times a month," or "once a week" were grouped together as infrequent dieters, whereas children who reported dieting to lose or maintain weight "2 to 6 times per week" or "every day" were labeled as frequent dieters. We developed and validated questions on binge eating.[14] Participants were asked about the frequency during the past year of eating a very large amount of food. Children who reported at least occasional episodes of overeating were asked whether during these episodes they felt out of control, like they could not stop eating even if they wanted to. Binge eating was defined as at least monthly eating a very large amount of food in a short amount of time and feeling out of control during the eating episode.

Dietary intake was assessed with the Youth/Adolescent Questionnaire, a self-administered semiquantitative food frequency questionnaire assessing intake over the past year.[15] The questionnaire asks participants how often, on average, they consumed of each of the 131 foods listed. Response categories for foods ranged from less than once per month to 4 or more per day. Nutrient intake was computed by multiplying the frequency of consumption of the foods by nutrient content, estimated from standard food composition sources. Glycemic index, which is a property of carbohydrate-containing food that describes the rise of blood glucose after a meal, was calculated. Glycemic load, which, unlike glycemic index, is not divided by total carbohydrate intake so it measures the glucose response induced by the total carbohydrate intake, was also calculated from the food frequency questionnaire. The 17 items on snack foods (eg, cookies, popcorn) were combined to estimate the average number or snack foods consumed per day.

Physical activity was assessed with 18 questions on hours per week within each of the 4 seasons that a participant engaged in a specific activity (eg, volleyball, soccer). A summary score of average hours per week of physical activity was computed. Reports of an average of >40 hours per week were considered implausible and therefore set to missing and not used in the analysis. Inactivity was estimated by asking participants the average number of hours per week spent watching TV, watching videos or VCR, reading/homework, or playing Nintendo/Sega/computer games. Reports of an average of >80 hours per week of inactivity were considered implausible and therefore set to missing and not used in the analysis. Approximately 1% to 2% of the participants reported implausible activity or inactivity on all of their questionnaires.

Reliability and Validity of Self-Reported Height and Weight

The validity of self-reported weight and height among preadolescents and adolescents has been investigated by several groups of researchers. High correlations have been observed between measured and self-reported weight ($r = 0.84–0.94$).[16–18] In 2 large studies, the use of self-reported weight and height resulted in the correct classification of weight status of 94% to 96% of adolescents.[15,16] Thus, the results suggest that preadolescents and adolescents provide information on weight and height that is as valid as the information provided by adults.

The outcome was annual (1996–1997, 1997–1998, and 1998–1999) weight change. The difference in relative weight over a 1-year interval was modeled with the age- and sex-specific z score of BMI (using the Centers for Disease Control and Prevention/National Center for Health Statistics growth charts) at the beginning of the interval as a predictor and the age- and sex-specific z score of BMI at the end of the 1-year interval as the outcome. Z scores were used instead of raw BMI values because the former had a lower correlation with height (Spearman $r = 0.09–0.12$ vs $r = 0.25–0.40$) and therefore considered the better weight metric to use in the analysis. As part of normal development, both weights and heights are expected to increase during this age range; thus, a z score of 0 is not equivalent to no weight change. For example, girls with no change in z score over a year gained a mean of 9.4 lb. The weight change associated with no change in z score was larger for younger participants. Girls with a z score change of 1 gained a mean of 19.7 pounds.

Sample

Participants included 8203 girls and 6769 boys who were 9 to 14 years of age in 1996 and completed at least 2 GUTS questionnaires between 1996 and 1999. A total of 926 girls and 1102 boys completed 2, 1759 girls and 1738 boys completed 3, and 5518 girls and 3929 boys completed all 4 questionnaires.

Analysis

All analyses were stratified by sex and conducted with SAS software.[19] Conditional linear models, which allow for variation in the time between exposure assessments, were used for all multivariate analyses (SAS proc nlin).[20] All models assessing the association between dieting to control weight and weight change over a 1-year period controlled for age, age^2, Tanner stage of pubic hair development, activity, inactivity (eg, television viewing, computer games), caloric intake, age- and sex-specific z score of BMI at the beginning of the 1-year interval, and height change over the 1-year interval. Three 1-year periods were assessed: 1996–1997, 1997–1998, and 1998–1999. Participants contributed information to at least 1 of the time periods. Children who returned all 3 questionnaires were represented in all 3 time periods, whereas children with incomplete data contributed only to 1 to 2 time periods.

Dieting to lose or maintain weight was modeled with dichotomous variables for infrequent and frequent dieting. Children who reported that they had never dieted to lose or maintain weight during the past year were the reference group with which infrequent and frequent dieters were compared. To ensure that any associations with dieting were not attributable to residual confounding by composition of dietary intake, we assessed several diet composition models. In 1 model, in addition to total caloric intake, percentage of calories from fat and percentage of calories from carbohydrate were included as covariates. In another model, glycemic index, a property of carbohydrate-containing food that describes the rise of blood glucose after a meal, was substituted percentage of calories from fat and percentage of calories from carbohydrate because there are some data to suggest that a high glycemic diet is predictive of greater weight gain in youths.[21] Average daily intake of snack foods and frequency of binge eating were evaluated as possible nonnutrient-based dietary predictors of weight gain that could confound the dieting-weight change

association. All P values are 2-sided, with $P < .05$ considered statistically significant.

RESULTS

In 1996, the age range of the sample was from 9 to 14 years. The mean age (girls: 12.0 [1.6]; boys: 11.9 [1.5]) and mean BMI (girls: 19.0 [3.3]; boys: 19.1 [3.3]) were similar in girls and boys. In contrast, there was a large sex difference in the prevalence of dieting to lose or maintain weight. In 1996, 25% of the girls and 13.6% of the boys were infrequent dieters and 4.5% of the girls and 2.2% of the boys were frequent dieters. Among the girls, the percentage of dieters increased during the following 2 years (Fig 1a) but remained relatively constant among the boys (Fig 1b). Cross-sectionally, girls and boys who reported dieting to lose or maintain weight were significantly heavier and older than nondieters. For example, among the girls, the mean age in 1996 was 11.7 years for never dieters, 12.4 for infrequent dieters, and 12.8 years for frequent dieters, and the mean BMI was 18.1 kg/m^2 for never dieters, 20.5 for the infrequent dieters, and 21.8 for the frequent dieters. Similar differences were observed among the boys (data not shown). The difference in BMI remained even after adjustment for age and Tanner stage of development (Table 1).

Binge eating was more common among the girls (Fig 1), but in both sexes it was much less common than dieting to lose or maintain weight, and the prevalence of binge eating was similar in 1996, 1997, and 1998. Dieters were also significantly more likely than nondieters to report binge eating (Fig 2). After adjusting for age, age- and sex-specific z score of BMI, and Tanner stage of development, infrequent female dieters were 5 times more likely (odds ratio [OR]: 4.81; 95% confidence interval: 3.60–6.42) and frequent female dieters were 12 times more likely (OR: 12.25; 95% confidence interval: 8.62–17.41) than nondieters to reporting binge eating (Fig 2). The association between binge eating and dieting was slightly weaker among the boys (OR: 3.96 for infrequent; OR: 8.63 for frequent dieting).

In addition to difference in body weight and binge eating, there were significant cross-sectional differences between non-, infrequent, and frequent dieters in terms of physical activity and dietary intake. Dieters reported more hours per week of physical activity and lower energy intake than nondieters, as well as a higher percentage of energy from carbohydrate and lower percentage of energy from fat (Table 1). For example, among the girls, frequent dieters consumed 1.5% more of their calories from carbohydrate than did never dieters. In addition, even after statistically adjusting for energy intake, dieters reported consuming fewer snack foods per day (Table 1).

During 3 years of follow-up, dieters gained more weight than nondieters. Tanner stage was a stronger predictor than age of weight, but both were statistically significant (data not shown). Even after statistical adjustment for age, Tanner stage of development, and age-specific z score of BMI in the previous year, the effect of dieting on weight gain remained significant (Tables 2 and 3). Among the girls, frequent dieters and infrequent dieters gained more

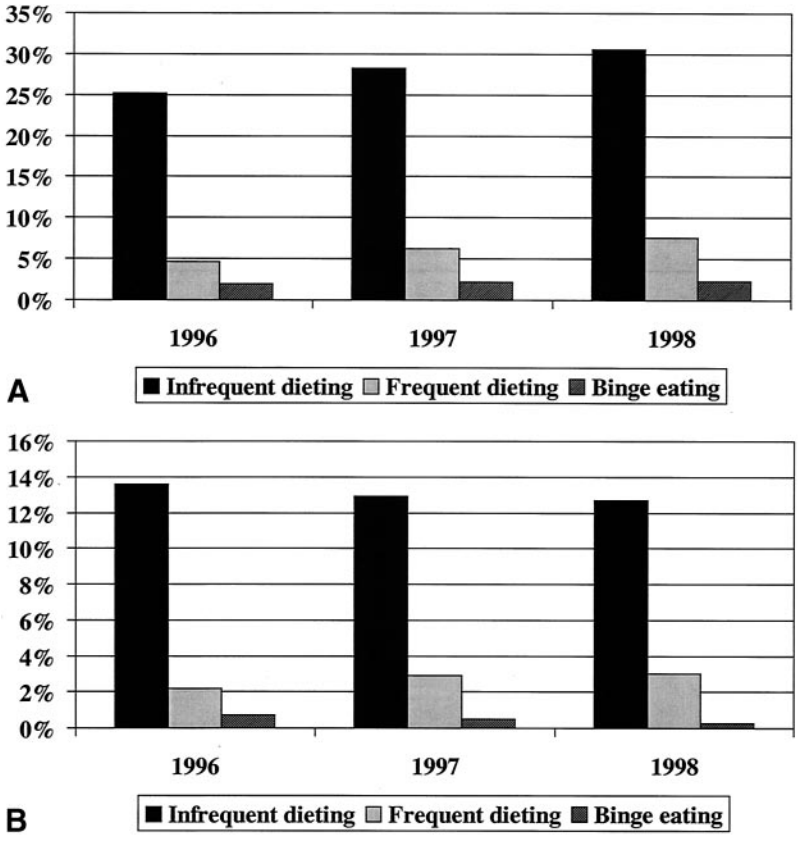

Fig 1. A, Frequency of dieting to lose or maintain weight and binge eating among girls in GUTS. The black bars represent the percentage of girls who dieted infrequently, the gray bars represent the percentage who dieted frequently, and the striped bars represent the percentage who engaged in binge eating. B, Frequency of dieting to lose or maintain weight and binge eating among boys in GUTS. The black bars represent the percentage of boys who dieted infrequently, the gray bars represent the percentage who dieted frequently, and the striped bars represent the percentage who engaged in binge eating.

TABLE 1. Cross-Sectional Differences* in Weight, Dietary Intake, and Binge Eating by Frequency of Dieting to Lose or Maintain Weight in the GUTS

	Girls			Boys		
	Infrequent Dieters	Frequent Dieters	*P* for Trend	Infrequent Dieters	Frequent Dieters	*P* for Trend
BMI*	0.57	0.64	.001	1.25	1.17	.001
z score of BMI*	0.18	0.19	.001	0.40	0.41	.001
Log energy (kcal)†	−0.04	−0.06	.001	−0.03	−0.06	.001
Physical activity (log hrs/wk)	0.11	0.21	.001	0.05	0.16	.001
Inactivity (log h/wk)	0.08	0.09	.001	0.11	0.00	.001
% of energy from protein‡	−0.03	0.16	.30	−0.01	0.39	.88
% of energy from fat‡	−0.50	−1.65	.001	−0.19	−1.33	.003
% of energy from carbohydrate‡	0.54	1.51	.001	0.20	0.99	.03
Snacks per day‡	−0.00	−0.08	.001	−0.04	−0.17	.001
Caffeine (mg)‡	4.60	12.35	.001	4.26	9.52	.001
Glycemic index‡	0.16	19.41	.001	−2.44	22.20	.14
Glycemic load‡	62.21	397.45	.001	0.25	535.95	.03

* Compared with never dieters. Models adjusted for age, age^2, and Tanner stage of public hair development.
† Models adjusted for age, age^2, Tanner stage of pubic hair development, and age- and sex-specific *z* score of BMI.
‡ Models adjusted for age, age^2, Tanner stage of pubic hair development, energy intake, and age- and sex specific *z* score of BMI.

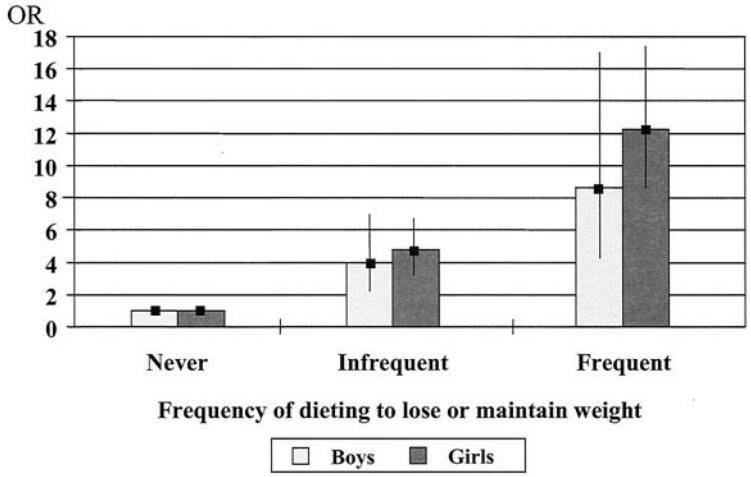

Fig 2. The cross-sectional association, measured by ORs, between frequency of dieting to lose or maintain weight and binge eating. The light gray bars represent the ORs among the boys, and the dark gray bars represent the ORs among the girls. Models adjusted for age- and sex specific *z* score of BMI, age, and Tanner stage of development. ORs for infrequent versus never and frequent versus never dieters were significant ($P < .001$).

than nondieters (0.058 and 0.042 BMI *z* scores, respectively; Table 2). Among the boys, there was little difference between frequent and infrequent dieters: both gained approximately 0.073 *z* scores of BMI more than nondieters. The excess weight gain was not explained by differences in caloric intake, percentage of energy from fat, percentage of energy from protein, or intake of snack foods. When each of these predictors was included in the statistical model (Tables 2 and 3), dieting remained a significant predictor of weight change. Although glycemic index (both sexes) and glycemic load (boys only) were significant predictors of changes in BMI *z* scores, the effect was extremely small and not clinically meaningful (data not shown). In addition, among boys but not girls, binge eating was an independent predictor of weight gain ($\beta = 0.046$, $P < .001$). Restricting the analysis to participants who reported the same level of frequency of dieting during the follow-up period resulted in a slight increase in the point estimate associated with frequent dieting for the girls and infrequent dieting for the boys, but it did not materially alter the other results (data not shown).

DISCUSSION

In a large cohort of preadolescents and adolescents living throughout the United States, dieting to control weight was fairly common. Although dieting was more common among the girls than the boys, dietary patterns of self-reported dieters were similar in both sexes: they reported lower intake of energy, percentage of energy from fat, and servings per day of snack foods than nondieters. Despite the seemingly healthy dietary intake, dieting frequency was predictive of larger relative weight change during 3 years of follow-up.

There are at least 3 mechanisms through which dieting could lead to the development of overweight. Dieting may result in an increase in metabolic efficiency; thus, dieters over time may require fewer calories to maintain weight. Moreover, an increase in metabolic efficiency would result in dieters' gaining weight when they consumed a diet that previously had been effective for maintaining their weight. Alternatively, the weight gain associated with dieting may be because restrictive diets are rarely maintained for an extended period of time.[22,23] It has been

TABLE 2. Dieting, Dietary Intake, and Binge Eating as Predictors of Weight Change* Among the Girls in GUTS

	Simple model†	Also Adjusted for Activity, Inactivity, and Energy Intake	Also Adjusted for Activity, Inactivity, and Dietary Intake, Model 1	Also Adjusted for Activity, Inactivity, and Dietary Intake, Model 2	Also Adjusted for Activity, Inactivity, Energy Intake, and Binge Eating
Infrequent dieting	0.043 (0.040–0.046)	0.042 (0.039–0.045)	0.042 (0.039–0.045)	0.042 (0.039–0.045)	0.042 (0.039–0.045)
Frequent dieting	0.054 (0.048–0.059)	0.058 (0.052–0.063)	0.056 (0.050–0.062)	0.057 (0.051–0.063)	0.057 (0.052–0.063)
Snack foods			−0.013 (−0.015 to −0.010)		
% of energy from carbohydrate				0.000 (−0.000–0.000)	
% of energy from fat				−0.000 (−0.000–0.000)	
Binge eating					0.005 (−0.005–0.015)

* Weight change was modeled as change in age- and sex specific z score of BMI. Girls with a z score change of 0 gained a mean of 9.4 lbs; girls with a z score change of 1 gained a mean of 19.7 1bs.
† Adjusted for age, age^2, height, height change over the past year, and Tanner stage of physical development.

TABLE 3. Dieting, Dietary Intake, and Binge Eating as Predictors of Weight Change* Among the Boys in GUTS

	Simple model‡	Also Adjusted for Activity, Inactivity, and Energy Intake	Also Adjusted for Activity, Inactivity, and Dietary Intake, Model 1	Also Adjusted for Activity, Inactivity, and Dietary Intake, Model 2	Also Adjusted for Activity, Inactivity, Energy Intake, and Binge Eating
Infrequent dieting	0.075 (0.070–0.080)	0.073 (0.068–0.078)	0.072 (0.067–0.078)	0.072 (0.067–0.077)	0.072 (0.067–0.078)
Frequent dieting	0.071 (0.061–0.081)	0.073 (0.062–0.084)	0.071 (0.060–0.082)	0.071 (0.060–0.082)	0.071 (0.060–0.082)
Snack foods			−0.007 (−0.011 to −0.004)		
% of energy from carbohydrate				−0.002 (−0.003 to −0.001)	
% of energy from fat				−0.002 (−0.003 to −0.001)	
Binge eating					0.046 (0.013–0.078)

* Weight change was modeled as change in age- and sex specific z score of BMI. Boys with a z score change of 0 gained a mean of 13.4 1bs; boys with a z score change of 1 gained a mean of 21.6 1bs.
† Adjusted for age, age^2, height, height change, and Tanner stage of physical development.

postulated that dieting may lead to a cycle of restrictive dieting, followed by bouts of overeating or binge eating.[24,25] In that scenario, it would be the repeated cycles of overeating, between the restrictive diets, that would be responsible for weight gain. Our finding that dieters were more likely than nondieters to binge eat offers support for the latter mechanism. A third mechanism through which dieting could lead to greater weight gain is through a response to diet with a high percentage of energy from carbohydrate, which is common among dieters. The physiologic responses to oral glucose suggest a possible mechanism linking glycemic index to weight gain. Our results did not offer much support for this third possible mechanism.

Numerous cross-sectional studies have observed that binge eating is more common among overweight adolescents and adults than their leaner peers.[2,26,27] Because weight gain results from an imbalance between energy intake and energy output, it seems likely that binge eating should result in weight gain. Nevertheless, we are unaware of other prospective studies on binge eating and weight change. Among the boys, binge eating was a significant predictor of weight gain. The lack of an effect of binge eating on weight gain among the girls may reflect that some girls consider an eating episode of modest caloric value to be an eating binge. Boys, conversely, are more likely than girls to eat very large amounts of food but not consider it to be binge because they did not feel distressed by the amount eaten or feel that they could not stop themselves from eating. Therefore, it is possible that the eating binges reported by the boys were higher in caloric value than those reported by the girls and thus stronger predictors of weight changes.

More research is needed to understand better the periods of time between restrictive diets, as well as the characteristics of overeating episodes. People who oscillate between restrictive eating and periods of overeating may have difficulty accurately completing the food frequency questionnaire because it would require them to average the 2 diet patterns in which they engage. The error in reported dietary intake by dieters may have resulted in an underestimation of the effect of dietary intake on weight change. Moreover, there is wide variability in what is perceived by preadolescents and adolescents to constitute dieting.[4,28,29] Thus, some of the self-described dieters may have been consuming diets that were very different from those that would be recommended by clinicians who treat pediatric obesity. Although there is some research to suggest that overweight children are more likely than their leaner peers to underreport their energy intake,[30] the data are not consistent.[31] Therefore, it is unclear how that might have affected our results.

One limitation of our study is that it does not represent a random sample of all US adolescents. The participants are children of nurses, and the sample is >90% white; thus, we are unlikely to have children of low socioeconomic status in the sample, so the results of the sample may not be readily generalizable to economically disadvantaged populations. Moreover, the results may not be generalizable to nonwhite ethnic groups. Nevertheless, because the rapid increase in the prevalence of obesity has been observed across the socioeconomic status and race/ethnicity spectrum, the results from this study may apply to many who are at risk of excessive weight gain. It is unclear how the relatively short follow-up period (3 years) and 89% response rates may have affected our results.

Research on young and middle-aged women in the Nurses' Health Study II, the cohort study in which the mothers of our participants are members, observed that BMI at age 18, weight gain from age 18 to 1989, and history of weight cycling between the ages of 18 and 30 (mean age: 36 years) all were independently predictive of adult weight gain. Thus, it seemed that the behaviors or lifestyle factors associated with weight control—or lack thereof—were established by late adolescence.[32] Our results suggest that precursors to weight cycling, dieting and periods of overeating, are predictive of weight gain during adolescence among both boys and girls. These results highlight the need to intervene early to break weight control habits that are rarely successful and potentially counterproductive.

Our findings are consistent with those of Stice et al,[11] who followed 692 adolescent girls for 4 years. Approximately 11% of the girls whom they studied became overweight during the follow-up, and dieters gained more weight than nondieters. We studied both boys and girls and observed that the association was present in both sexes. We are unaware of any other prospective studies that have assessed the relationship between weight control practices and weight change among young boys. Given that the prevalence of obesity is approximately equal among preadolescent and adolescent boys and girls, it is important to evaluate potential weight gain mechanisms in both sexes.

Drastic changes in dietary intake are rarely sustainable; thus, it is not surprising that few people maintain their weight losses. For children and adolescents who are overweight, diets carefully supervised by a clinician may be beneficial and appropriate; however, young people and adults who are not severely overweight need to be encouraged to adopt a modest and therefore sustainable weight control strategy that includes physical activity and does not require severe restriction of total calories or components of the diet, such as percentage of calories from fat. Although in the short-term a restrictive diet may be beneficial for weight loss, in the long-term, data suggest that dieting to control weight is not only ineffective, it may actually promote weight gain.

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