ARTICLE

Diet, Physical Activity, and Sedentary Behaviors as Risk Factors for Overweight in Adolescence

Kevin Patrick, MD, MS; Gregory J. Norman, PhD; Karen J. Calfas, PhD; James F. Sallis, PhD; Marion F. Zabinski, PhD, MPH; Joan Rupp, MS; John Cella, MD

Background: The proportion of overweight adolescents has increased, but the behavioral risk factors for overweight youth are not well understood.

Objective: To examine how diet, physical activity, and sedentary behaviors relate to overweight status in adolescents.

Design and Setting: Baseline data from the Patient-Centered Assessment and Counseling for Exercise Plus Nutrition Project, a randomized controlled trial of adolescents to determine the effects of a clinic-based intervention on physical activity and dietary behaviors.

Participants: A total of 878 adolescents aged 11 to 15 years, 42% of whom were from minority backgrounds.

Main Outcome Measure: Centers for Disease Control and Prevention body mass index–for-age percentiles divided into 2 categories: normal weight (<85th percentile) and at risk for overweight plus overweight (AR+O) (≥85th percentile).

Results: Overall, 45.7% of the sample was classified as AR+O with a body mass index for age at the 85th percentile or higher. More girls from minority backgrounds (54.8%) were AR+O compared with non-Hispanic white girls (42%) (χ^2_1=7.6; P=.006). Bivariate analyses indicated that girls and boys in the AR+O group did fewer minutes per day of vigorous physical activity, consumed fewer total kilojoules per day, and had fewer total grams of fiber per day than those in the normal-weight group. Boys in the AR+O group also did fewer minutes per day of moderate physical activity and watched more minutes per day of television on nonschool days than normal-weight boys. Final multivariate models indicated that independent of socioeconomic status (as assessed by household education level), girls had a greater risk of being AR+O if they were Hispanic or from another minority background (odds ratio [OR]=1.65; 95% confidence interval [CI], 1.09-2.49) and a reduced risk of being AR+O as minutes per day of vigorous physical activity increased (OR=0.93; 95% CI, 0.89-0.97). A low level of vigorous physical activity was the only significant risk factor for boys being AR+O (OR=0.92; 95% CI, 0.89-0.95). Analyses based on meeting behavioral guidelines supported these findings and showed that failing to meet the 60 min/d moderate to vigorous physical activity guideline was associated with overweight status for both girls and boys. In addition, boys who failed to meet sedentary behavior and dietary fiber guidelines were more likely to be overweight.

Conclusions: Of the 7 dietary and physical activity variables examined in this cross-sectional study, insufficient vigorous physical activity was the only risk factor for higher body mass index for adolescent boys and girls. Prospective studies are needed to clarify the relative importance of dietary and physical activity behaviors on overweight in adolescence.

Arch Pediatr Adolesc Med. 2004;158:385-390

From the University of California, San Diego (Drs Patrick, Norman, and Zabinski), San Diego State University (Drs Calfas and Sallis and Ms Rupp), and Kaiser Permanente Medical Group, San Diego (Dr Cella).

THE PROPORTION OF CHILDREN and adolescents who are overweight has increased dramatically in the past decade.[1,2] Adolescent obesity increases the long-term (approximately 50-year) risk of adult morbidity and mortality independent of adult obesity status,[3] and 70% of obese 10- to 13-year-old children become obese adults.[4] It is hypothesized that an industrialized, or "Westernized," lifestyle of excessive energy intake and sedentary behavior partially explains the recent emergence of type 2 diabetes mellitus and obesity in youth.[5,6]

However, the evidence linking eating and physical activity patterns with overweight in youth is contradictory and inconclusive. Energy intake is not reliably associated with weight status in epidemiologic studies, in part because overweight people tend to underreport food intake.[7] There is evidence for a link between fat intake and obesity,[8,9] but fruit, vegetable, and fiber intake have been insufficiently studied. Only 16 of 31 stud-

ies in children and 6 of 21 studies in adolescents have shown a significant association between physical activity and weight status.[10] By contrast, sedentary behaviors, particularly hours of television viewing, have been consistently related to overweight in youth.[11]

A major limitation of this literature is that most studies examined either nutrition or physical activity, whereas few examined both. A second limitation is that few nutrition and physical activity patterns have been examined despite the complexity of these behaviors. A third limitation is that studies of the association of overweight in youth with nutrition and physical activity seldom report detailed findings by sex, ethnic background, or age. A fourth limitation is that dietary and physical activity behaviors are usually assessed through self-report.

Recommendations for optimal physical activity and dietary behaviors have been advanced by several groups, but little is known about how meeting these guidelines relates to overweight status in youth. Recent guidelines from an international panel recommend 60 min/d of physical activity for youth.[12] Although US national survey data indicate that 72% of adolescent boys and 57% of adolescent girls meet the recommendation for 60 min/wk of vigorous physical activity,[13] objective measures suggest that as few as 30% of teenagers are meeting the 60-minute guideline.[14] Girls, older adolescents, minorities, and disadvantaged youth are less likely to be meeting this recommendation. The Healthy People 2010[15] objective for the proportion of adolescents who view television less than 2 h/d is 75%, yet baseline data in 1999 found that only 57% of adolescents did so.

The Centers for Disease Control and Prevention (CDC), Atlanta, Ga, estimates that only 15% of adolescents aged 12 to 19 years meet the recommendation that less than 30% of total daily energy intake come from fat and that only 7% of adolescents meet the recommendation that less than 10% of total daily energy intake come from saturated fat.[13,15] Data from the CDC's 2001 Youth Risk Behavior Surveillance[16] survey indicate that less than 22% of high school students consumed 5 or more servings per day of fruits and vegetables during the week before the survey. In addition to the number of servings per day, another measure of adequate consumption of fruits and vegetables is dietary fiber intake. The recommendation of the Institute for Cancer Prevention (Valhalla, NY) for minimal intake of fiber for children is the age of the child plus 5 g of dietary fiber per day.[17] The age plus 5 g guideline is similar to the American Academy of Pediatrics recommendation of 0.5 g/kg of body weight for children up to age 10 years but less for teenagers, among whom the risk of low iron, calcium, and zinc intakes is a concern.

For purposes of intervention development, especially those that target specific subgroups of adolescents or those capable of being tailored to the unique needs of an individual, there is a need to more clearly understand the relationships between and among these risk behaviors. What is the relative importance of dietary vs physical activity–related risk factors for overweight status in youth? Among dietary behaviors, which are the most critical to address? Among activity-related behaviors, is moderate or vigorous physical activity most important? How is this affected by sedentary behavior? How do these relationships vary by age, sex, or ethnicity? Also, what can we learn by examining body mass index (BMI) status and its association with attainment of the guidelines noted previously? This study reports an exploratory analysis of these questions among a group of 878 adolescents aged 11 to 15 years.

METHODS

The Patient-Centered Assessment and Counseling for Exercise Plus Nutrition Project (PACE+) for adolescents is a randomized controlled trial to determine the effects of a 1-year intervention on adolescents' physical activity and dietary behaviors. The intervention program is channeled through participants' primary care provider and includes physician interaction, a tailored interactive computer program for assessment and goal setting, and monthly telephone counseling sessions with a trained health counselor.[18] The study was reviewed and approved by the institutional review boards of both San Diego State University and the University of California, San Diego. This article presents data from the baseline assessment of PACE+ study participants.

PARTICIPANTS

Adolescents between the ages of 11 and 15 years were recruited through their primary care providers. A total of 45 primary care providers from 6 clinic sites in San Diego County agreed to participate in the study. Recruitment methods included the following: (1) recruiting participants when parents called the PACE+ office in response to either an initial mailing to eligible participants or flyers posted in the clinics; (2) calling patients of participating physicians who had an upcoming scheduled visit; and (3) "cold calling" patients of participating physicians at random who did not return an opt-out postcard from the initial mailing. A representative group of adolescents seeing primary care providers was sought, with no emphasis on being overweight to participate. Participants and parents knew that the study involved randomization to either a physical activity and dietary intervention or the comparison sun protection intervention.

Recruitment occurred from May 2001 through June 2002. Trained study recruiters attempted to contact 3366 households, from which 1032 contacts (31%) gave both parental consent and child assent verbally by telephone. A total of 878 adolescents were randomized into the study after signing consent forms and completing baseline measurements at the PACE+ office. **Table 1** displays the demographic and anthropometric characteristics of the sample. Although not fully representative of the San Diego community, in which those aged 10 to 17 years are 35% Hispanic, 7% African American, 12% Asian or other, and 45% non-Hispanic white,[19] the sample was diverse with approximately 42% of participants from minority backgrounds.

MEASURES

Height and Weight

A wall stadiometer measured standing height. Weight was measured with a calibrated digital scale. Each measure was obtained twice, and the mean of the 2 readings was calculated. The BMI was calculated as the weight in kilograms divided by the height in meters squared. The BMI for age was determined from CDC national norms using age to the nearest month, sex-specific median, standard deviation, and power of the Box-Cox transformation.[20]

Physical Activity

Physical activity was measured with the Computer Science and Applications Accelerometer (WAM 7164; Actigraph, Ft Wal-

ton Beach, Fla; now available through www.mtiactigraph.com). This uniaxial accelerometer is small (5.1×3.8×1.5 cm), lightweight (45 g), and worn on a belt snugly around the waist. Accelerometers stored data as 1-minute means for a 7-day period. In laboratory and field settings, these accelerometers have been shown to be a valid measure for quantifying children's activity levels.[21] The equations for estimating physical activity variables were derived by Freedson and Miller.[22] All physical activity variables were calculated by processing accelerometer data with a program written by Trost et al.[21] Physical activity variables were averaged across valid days of monitoring for each participant and included total energy expenditure (kilojoules per kilogram per day) and minutes of moderate physical activity (3.0-5.9 metabolic equivalents [METs]) and vigorous physical activity (>6 METs). Metabolic equivalents are the ratio of the work metabolic rate to the resting metabolic rate. One MET is defined as 4.18 kJ/kg per hour and is roughly equivalent to the energy cost of sitting quietly.[23] Complete data from the activity monitors were available for 770 participants (88%).

Sedentary Behavior

Participants completed a self-report measure of recent nonschool day time spent watching television, modified from a validated survey developed by Robinson.[24] Time spent watching television was used as a proxy for sedentary behavior given the positive relationship with BMI.[25] Nonschool day television time was selected to give an accurate representation of self-selected behavior during unstructured time (eg, no school). Participants' responses were measured on an 8-point scale and ranged from "none" to "6 hours or more."

Dietary Intake

Three 24-hour food recalls assessed dietary intake. Trained data collectors conducted dietary recalls for 2 weekdays and 1 weekend day using University of Minnesota Nutrition Data System for Research software version 4.04.[26] Participants were taught how to measure food portions with 3-dimensional food models. The first interview was conducted in person, and the second and third were conducted by telephone (participants were given 2-dimensional food models to use for the second and third assessments). Nutrient variables (total kilojoules per day, percentage of calories from total fat, and total grams of fiber) were calculated by averaging values from the 3 intake records. Grams of dietary fiber were adjusted for total energy intake in multivariate analyses, as recommended by Willett.[27]

Highest Household Education Level

The parent of the adolescent participant completed a short demographic survey that asked him or her to indicate the highest level of education completed for "myself," "other adult female," and "other adult male" in the household. Nine education levels were included that ranged from "high school or less" to "doctorate degree." Household education level was calculated as the maximum value from the adult education levels and was divided into 3 categories: "less than high school through associate's degree," "bachelor's degree," and "greater than or equal to graduate or professional school."

Behavioral Guidelines

Physical activity and dietary intake data were used for direct comparison with national guidelines. Separate variables were created for minutes of physical activity per day, hours of television per day, percentage of calories from total fat, percentage of calories from saturated fat, and amount of fiber (grams per day).

Table 1. Demographic and Anthropometric Sample Characteristics*

Characteristic	Girls (n = 471)	Boys (n = 407)	Total (N = 878)
Age, mean ± SD, y	12.8 ± 1.3	12.7 ± 1.4	12.7 ± 1.3
11	97 (20.6)	91 (22.4)	188 (22.4)
12	121 (25.7)	96 (23.6)	217 (24.7)
13	108 (22.9)	93 (22.9)	201 (22.9)
14	91 (19.3)	77 (18.9)	168 (19.1)
15	54 (11.5)	50 (12.3)	104 (11.8)
Ethnicity			
Asian/Pacific Islander	12 (2.5)	18 (4.4)	30 (3.4)
African American	27 (5.7)	31 (7.6)	58 (66.)
Native American Indian	4 (0.8)	2 (0.5)	6 (0.7)
Hispanic	65 (13.8)	50 (12.3)	115 (13.1)
Non-Hispanic white	274 (58.2)	234 (57.5)	508 (57.9)
Multiethnic/other	89 (18.9)	72 (17.7)	161 (18.3)
Highest household education level			
<High school to associate's degree	176 (37.4)	113 (27.8)	289 (32.9)
Bachelor's degree	123 (26.1)	128 (31.4)	251 (28.6)
≥Graduate or professional school	164 (34.8)	154 (37.8)	318 (36.2)
Did not report	8 (1.7)	12 (2.9)	20 (2.3)
Height, mean ± SD, cm	156.3 ± 8.0	158.6 ± 11.6	157.4 ± 9.9
Weight, mean ± SD, kg	59.1 ± 17.8	58.7 ± 19.4	59.0 ± 18.5
BMI, mean ± SD	24.0 ± 6.5	23.5 ± 6.4	23.6 ± 6.3
BMI-for-age percentile, mean ± SD	74 ± 26.1	69 ± 28.8	72 ± 27.4
BMI category			
<85th percentile	248 (52.7)	228 (56.2)	476 (54.3)
≥85th to <95th percentile	95 (20.2)	64 (15.8)	159 (18.1)
≥95th percentile	128 (27.2)	114 (28.1)	242 (27.6)

Abbreviation: BMI, body mass index (calculated as the weight in kilograms divided by the height in meters squared).
*Data are presented as number (percentage) unless otherwise indicated.

STATISTICAL ANALYSIS

All analyses were stratified by sex. A BMI status variable was created using accepted cutoff values for evaluating adolescent obesity.[28] We performed several exploratory analyses of these data and found that the most informative way to analyze them was by combining the at risk for overweight (BMI for age ≥85th percentile and <95th percentile) and overweight (≥95th percentile) categories into 1 group (labeled at risk for overweight plus overweight [AR+O]) and comparing it with the normal-weight category (BMI for age <85th percentile). The CDC considers children lower than the 5th percentile to be underweight. Ten adolescents in the sample met this definition for underweight and were included in the normal-weight group.

We used χ^2 tests of independence to examine the relationships between demographic variables and BMI status. Analysis of variance tests assessed group differences in BMI status for the 4 activity and 3 dietary variables. Multivariate logistic regression models were specified to examine combined effects of the physical activity and dietary predictors on BMI status. Age, ethnicity, highest household education level, and total energy intake were entered into the model as control variables in the first step. For the second step, forward entry determined which physical activity and dietary predictors entered the model. All 2-way interaction terms for variables remaining in steps 1 and 2 were forward entered in step 3. A significance criterion for forward entry was set at $P<.05$. The Hosmer-Lemeshow test[29] assessed goodness of

Table 2. Physical Activity and Diet Variables by BMI Status for Girls and Boys*

Variable	Girls			Boys		
	<85th Percentile	≥85th Percentile	Mean Difference (95% CI)	<85th Percentile	≥85th Percentile	Mean Difference (95% CI)
Moderate physical activity, min/d	48.0 ± 21.9	44.4 ± 21.6	3.5 (–0.7 to 7.8)	62.5 ± 26.6†	55.9 ± 25.9†	6.6 (1.1 to 12.1)†
Vigorous physical activity, min/d	6.3 ± 6.3†	4.2 ± 4.5†	2.1 (1.0 to 3.1)†	12.4 ± 9.5†	8.0 ± 6.3†	4.4 (2.7 to 6.1)†
Television time on nonschool days, min/d	121.7 ± 97.8	135.6 ± 88.0	–13.8 (–30.8 to 3.1)	108.4 ± 81.3†	141.5 ± 101.4†	–33.1 (–50.9 to –15.2)†
Total energy expenditure, kJ/kg per day	178.9 ± 17.9	176.6 ± 16.2	2.3 (–1.0 to 5.6)	184.0 ± 18.7	181.7 ± 18.5	2.3 (–1.6 to 6.2)
Total kJ/d	7196.2 ± 2463.5†	6623.2 ± 2393.7†	573.0 (132.2 to 1013.8)†	8808.4 ± 2810.7†	7525.1 ± 2780.0†	1283.3 (722.1 to 1844.5)†
Kilojoules from fat per day, %	32.4 ± 6.4	33.1 ± 5.7	–0.66 (–1.8 to 0.4)	32.5 ± 5.7	32.6 ± 6.3	–0.14 (–1.3 to 1.0)
Total grams of fiber per day	12.0 ± 5.1†	10.9 ± 4.7†	1.1 (0.2 to 2.0)†	14.4 ± 6.7†	12.2 ± 6.6†	2.2 (0.88 to 3.5)†

Abbreviations: BMI, body mass index; CI, confidence interval.
*Data are presented as mean ± SD unless otherwise indicated. BMI status indicates BMI-for-age percentile.
†Indicates statistically significant differences at $P<.05$.

Table 3. Final Logistic Regression Models of Predictors of at Risk Plus Overweight in Girls and Boys

Predictor	Girls		Boys	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Age	0.97 (0.82-1.14)	.70	0.92 (0.76-1.11)	.38
Ethnicity (Hispanic or other minority background)	1.65 (1.09-2.49)	.02	1.38 (0.85-2.22)	.19
Highest household education level	1.11 (0.87-1.41)	.39	0.90 (0.68-1.20)	.47
Total kJ/d	0.99 (0.98-1.00)	.03	0.98 (0.97-0.99)	<.001
Vigorous physical activity, min/d	0.93 (0.89-0.97)	.002	0.92 (0.89-0.95)	<.001

Abbreviations: CI, confidence interval; OR, odds ratio.

fit at each step. Additionally, we determined the proportion of normal-weight and AR+O boys and girls who met accepted guidelines for physical activity and nutrient intake.

RESULTS

DEMOGRAPHIC CHARACTERISTICS BY BMI STATUS

Overall, 45.7% of the sample was classified as AR+O. There was no difference between the proportion of girls (47.3%) and boys (43.8%) in this group ($\chi^2_1=1.1$; $P=.30$). There were also no differences found in the proportion of AR+O by age (girls: $\chi^2_4=3.4$; $P=.50$; boys: $\chi^2_4=5.3$; $P=.26$) or highest household education level (girls: $\chi^2_2=0.12$; $P=.94$; boys: $\chi^2_2=3.0$; $P=.22$).

Ethnicity was divided into 2 groups: non-Hispanic white and Hispanic individuals plus other minorities. In total, 42.2% were in this latter group, with 50% of these individuals identifying themselves as Hispanic or part Hispanic. Significantly more girls from Hispanic or other minority backgrounds (54.8%) were AR+O compared with non-Hispanic white girls (42%) ($\chi^2_1=7.6$; $P=.006$). However, no difference was found for BMI status between boys from Hispanic or other minority backgrounds (45.7%) and non-Hispanic white boys (42.5%) ($\chi^2_1=0.41$; $P=.52$).

PHYSICAL ACTIVITY AND DIETARY VARIABLES BY BMI STATUS

Table 2 presents the means, standard deviations, and group difference tests for physical activity and dietary variables for girls and boys. Both girls and boys in the normal-weight group were doing significantly more minutes per day of vigorous physical activity than those in the AR+O group ($P<.001$). However, only boys showed a statistical difference between groups for minutes per day of moderate physical activity ($P=.02$). Boys in the AR+O group reported significantly more mean minutes per day of television watching on nonschool days than the normal-weight group ($P<.001$), whereas no group difference was found for girls.

Reported total energy consumption differed by BMI status for both girls and boys, with the AR+O group consuming fewer total calories than the normal-weight group ($P=.01$ for girls; $P<.001$ for boys). Percentage of calories from fat did not differ by BMI status. However, AR+O girls and boys reported consuming fewer total grams of fiber per day than the normal-weight group ($P=.01$ for girls; $P<.001$ for boys).

MULTIVARIATE MODELS

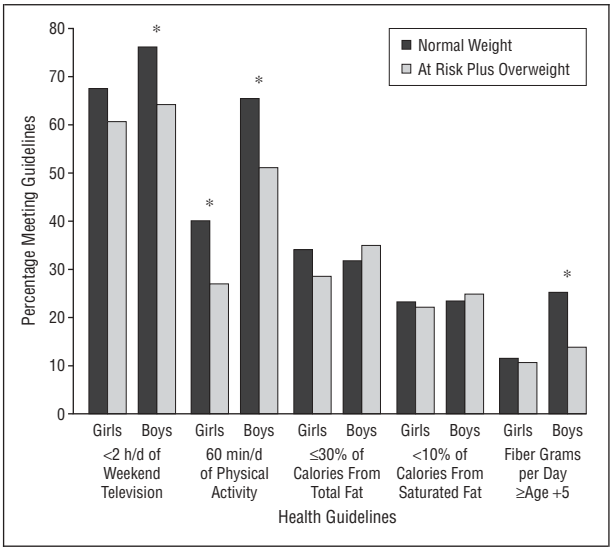
Final multiple regression models are presented in **Table 3**. Because some studies have demonstrated that ethnic minority status is independent of socioeconomic status as a predictor of selected risk factors such as BMI[30] and because, as a practical matter, interventions aimed at these factors are often developed and deployed in ways that use each of them, we included both in the model, with highest household education level as a proxy for socioeconomic status. For girls, being Hispanic or from another minority background was associated with a greater likelihood of being AR+O (odds ratio [OR] = 1.65; $P=.02$). Higher reported total kilojoules per day was associated with a decreased likelihood of being AR+O (OR = 0.99;

$P=.03$). The only predictor entering the model at step 2 was vigorous physical activity, with more minutes of vigorous physical activity associated with a decreased likelihood of being AR+O ($P<.001$). No 2-way interaction terms entered the model at step 3. The overall model was statistically significant ($\chi^2_5=24.7$; $P<.001$; $R^2=0.08$).

For boys, higher reported total kilojoules per day was again associated with a decreased likelihood of being AR+O (OR=0.98; $P<.001$). Only vigorous physical activity entered the model, indicating that more minutes of vigorous physical activity were associated with a decreased likelihood of being AR+O ($P<.001$). No 2-way interaction terms entered the model at step 3. The overall model was statistically significant ($\chi^2_5=50.7$; $P<.001$; $R^2=0.18$).

MEETING HEALTH RECOMMENDATIONS BY BMI STATUS

To further understand the differences among BMI status groups, we examined the proportion of each group meeting recommended health guidelines for adolescents. The **Figure** shows 5 health objectives that corresponded with our measured variables. More boys (71%) than girls (64%) met the television–viewing time guideline, and significantly more normal-weight boys (76%) than AR+O boys (64%) met this guideline ($\chi^2_1=6.8$; $P=.009$). More boys (59%) than girls (34%) met the physical activity guideline of 60 min/d. For both boys and girls, a higher proportion of the normal-weight group attained the physical activity objective compared with the AR+O group (boys: $\chi^2_1=7.5$; $P=.006$; girls: $\chi^2_1=7.9$; $P=.005$). Only small proportions of girls and boys met dietary fat and fiber guidelines. These proportions did not differ between BMI status groups except that more normal-weight boys (25%) met the fiber intake guideline than AR+O boys (14%) ($\chi^2_1=8.3$; $P=.004$).



Percentage of weight status groups meeting recommended health guidelines. Normal weight indicates a body mass index lower than the 85th percentile; at risk plus overweight, a body mass index at the 85th percentile or higher. Asterisk indicates differences of $P<.01$. Sources of health guidelines: Healthy People 2010,[15] Williams et al,[17] and Biddle et al.[31]

COMMENT

Most previous studies examined overall energy intake and expenditure as risk factors for youth overweight, but our results indicate that it is more fruitful to investigate a range of eating and physical activity behavior patterns. For example, fiber intake was related to overweight status, whereas the more frequently studied variable of percentage of calories from fat was unrelated. Although physical activity has been inconsistently related to youth overweight status in past studies,[10] in this study, objectively monitored vigorous physical activity was related to overweight in both girls and boys. Consistent with past studies,[32] boys' overweight status was related to time spent watching television.

Interestingly, in this group of adolescents, increased energy intake (higher kilojoules) was related to decreased overweight status. At first, this finding appears contradictory. However, given the increased levels of vigorous activity among this group, it is likely that they expend greater amounts of energy, creating a favorable energy balance. Research has indicated that consistent exercise participation is crucial for weight maintenance across time in adults,[33,34] and it is probable that this relationship also holds in youth. An alternate explanation for these findings, however, might be the underreporting of food intake by overweight and obese adolescents. This is a recognized problem with adults[35,36] and likely occurs with adolescents as well.

These results suggest that overweight status in adolescence is associated with a complex pattern of energy intake and energy expenditure behaviors including types of nutrient intake and time in physical and sedentary activities. There was no evidence that the interaction of diet and activity variables was associated with weight status. This is one of the first studies to specifically test diet-activity interactive effects on overweight, so additional studies are needed to clarify these issues. The finding that only vigorous physical activity appeared to have an independent association with weight status for girls and boys is, to our knowledge, a novel one and has interesting implications for both researchers and intervention developers. If this finding is confirmed in subsequent prospective studies, physical activity interventions may have the most generalized effects on reducing overweight in adolescence. Our finding of a higher likelihood of girls from Hispanic and other minority backgrounds vs non-Hispanic white girls being AR+O is consistent with the findings of others.[2,37] That this finding appears to be independent of socioeconomic status as measured by household education level suggests that ethnic and/or cultural factors may have to be addressed if interventions in this area are to succeed.

The findings related to meeting behavioral guidelines are consistent with our bivariate analyses, especially the differences between normal-weight and AR+O boys for physical activity and television viewing. That 75% and 65%, respectively, of normal-weight boys meet these guidelines suggests that attaining them may be genuinely helpful. Consistent with national data,[16,38] we found that few adolescent girls or boys were meeting any of the 3 dietary recommendations. The difference in fiber intake between normal-weight and AR+O boys suggests that this indicator of dietary quality may become more important in the future as a behavior to target for inter-

What This Study Adds

Although the prevalence of overweight and obesity during adolescence has increased substantially in the past few years, the evidence linking specific eating and physical activity behaviors with overweight is inconclusive. Most previous studies have examined nutrition or physical activity factors, but few have examined both.

This study examined a variety of dietary and physical activity variables in relation to weight status and found that only vigorous physical activity was associated with weight for adolescent boys and girls. We also found that few adolescents, regardless of weight status, were meeting recommended dietary guidelines.

vention. However, the overall low prevalence of meeting fiber recommendations is a disturbing finding given that plant foods high in fiber are also rich in potentially anticarcinogenic compounds,[39] and effective cancer prevention may well need to begin in this stage of human development. These findings provide an additional rationale for the need for concerted efforts to improve adolescents' diets.[15] Although most girls and boys reported meeting the television-viewing recommendations, only a modest majority of boys and a clear minority of girls met the physical activity guideline of 60 min/d. Thus, there is also a need for concerted efforts to develop interventions to improve physical activity for girls.

Limitations of our study include restriction to 1 geographic region, use of self-report for dietary and sedentary behaviors, and a relatively narrow age range. These results need to be replicated, ideally with improved objective measures of physical activity and more precise measures of the expanding range of sedentary behaviors including computer and electronic game use. Nonetheless, the findings from this study contribute to the body of evidence suggesting that adolescents continue to require interventions that target multiple aspects of physical activity and nutrition. This should help increase the proportion of adolescents who meet recommended health guidelines.

Accepted for publication December 8, 2003.

This project was supported by grant R01 CA81495 from the National Cancer Institute, Bethesda, Md.

We thank the primary study providers at Kaiser Permanente, San Diego, Calif (Charles Freedman, MD, and Louis Luevanos, MD), Scripps Clinic, La Jolla, Calif (Richard Buchta, MD), and the University of California, San Diego, Medical Center (Lawrence Friedman, MD).

Corresponding author and reprints: Kevin Patrick, MD, MS, Department of Family and Preventive Medicine, University of California, San Diego, 9500 Gilman Dr, Dept 0811, La Jolla, CA 92093-0811 (e-mail: kpatrick@ucsd.edu).

REFERENCES

1. Troiano RP, Flegal KM, Kuczmarski RJ, Campbell SM, Johnson CL. Overweight prevalence and trends for children and adolescents. *Arch Pediatr Adolesc Med.* 1995;149:1085-1091.
2. Ogden CL, Flegal KM, Carroll MD, Johnson CL. Prevalence and trends in overweight among US children and adolescents, 1999-2000. *JAMA.* 2002;288:1728-1732.
3. Must A, Jacques PF, Dallal GE, Bajema CJ, Dietz WH. Long-term morbidity and mortality of overweight adolescents. *N Engl J Med.* 1992;327:1350-1355.
4. Whitaker RC, Wright JA, Pepe MS, Seidel KD, Dietz WH. Predicting obesity in young adulthood from childhood and parental obesity. *N Engl J Med.* 1997;337:869-873.
5. Hill JO, Peters JC. Environmental contributions to the obesity epidemic. *Science.* 1998;280:1371-1374.
6. Koplan JP, Dietz WH. Caloric imbalance and public health policy. *JAMA.* 1999;282:1579-1581.
7. Jebb SA. Energy intake and body weight. In: Fairburn CG, Brownell KD, eds. *Eating Disorders and Obesity: A Comprehensive Handbook.* 2nd ed. New York, NY: Guilford; 2002:37-42.
8. Lissner L, Heitmann BL. Dietary fat and obesity. *Eur J Clin Nutr.* 1995;49:79-90.
9. Levitsky DA. Macronutrient intake and the control of body weight. In: Coulston AM, Rock CL, Monsen ER, eds. *Nutrition in the Prevention and Treatment of Disease.* New York, NY: Academic Press; 2001:499-516.
10. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. *Med Sci Sports Exerc.* 2000;32:963-975.
11. Sherwood NE, Story M, Neumark-Sztainer D. Behavioral risk factors for obesity: diet and physical activity. In: Coulston AM, Rock CL, Monsen ER, eds. *Nutrition in the Prevention and Treatment of Disease.* New York, NY: Academic Press; 2001:517-537.
12. Cavill N, Biddle S, Sallis JF. Health enhancing physical activity for young people. *Pediatr Exerc Sci.* 2001;13:12-25.
13. Kann L, Kinchen SA, Williams BI, et al, and State and Local YRBSS Coordinators. Youth risk behavior surveillance—United States, 1999. *MMWR CDC Surveill Summ.* 2000;49:1-32.
14. Pate RR, Freedson PS, Sallis JF, et al. Compliance with physical activity guidelines. *Ann Epidemiol.* 2002;12:303-308.
15. US Department of Health and Human Services. *Healthy People 2010: Understanding and Improving Health.* 2nd ed. Washington, DC: US Government Printing Office; 2000.
16. Grunbaum JA, Kann L, Kinchen SA, et al. Youth risk behavior surveillance—United States, 2001. *MMWR Surveill Summ.* 2002;51:1-62.
17. Williams CL, Bollella M, Wynder EL. A new recommendation for dietary fiber in childhood. *Pediatrics.* 1995;96:985-988.
18. Patrick K, Sallis J, Lydston D, et al. A multicomponent program for nutrition and physical activity change in primary care: PACE+ for adolescents. *Arch Pediatr Adolesc Med.* 2001;155:940-946.
19. San Diego Association of Governments. Demographics and other data. Available at: www.sandag.org. Accessed March 7, 2003.
20. Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, et al. *CDC Growth Charts.* Hyattsville, Md: National Center for Health Statistics; 2000. Advance Data From Vital and Health Statistics, No. 314.
21. Trost SG, Ward DS, Moorehead SM, Watson PD, Riner W, Burke JR. Validity of the computer science and applications (CSA) activity monitor in children. *Med Sci Sports Exerc.* 1998;30:629-633.
22. Freedson PS, Miller K. Objective monitoring of physical activity using motion sensors and heart rate. *Res Q Exerc Sport.* 2000;71:S21-S29.
23. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of physical activities. *Med Sci Sports Exerc.* 2000;32(suppl):S498-S516.
24. Robinson TN. Reducing children's television viewing to prevent obesity: a randomized controlled trial. *JAMA.* 1999;282:1561-1567.
25. Andersen RE, Crespo CJ, Bartlett SJ, Cheskin LJ, Pratt M. Relationship of physical activity and television watching with body weight and level of fatness among children. *JAMA.* 1998;279:938-942.
26. Schakel SF, Sievert YA, Buzzard IM. Sources of data for developing and maintaining a nutrient database. *J Am Diet Assoc.* 1988;88:1268-1271.
27. Willett WC. *Nutritional Epidemiology.* New York, NY: Oxford University Press; 1990.
28. Barlow SE, Dietz WH. Obesity evaluation and treatment: Expert Committee recommendations. *Pediatrics.* 1998;102:E29.
29. Hosmer DW, Lemeshow S. *Applied Logistic Regression.* New York, NY: Wiley; 1989.
30. Winkleby MA, Kraerner HC, Ahn DK, Varady AN. Ethnic and socioeconomic differences in cardiovascular disease risk factors. *JAMA.* 1998;280:356-362.
31. Biddle S, Cavill N, Sallis J. Policy framework for young people and health—enhancing physical activity. In: Biddle S, Sallis J, Cavill N, eds. *Young and Active? Young People and Health-Enhancing Physical Activity: Evidence and Implications.* London, England: Health Education Authority; 1998:3-16.
32. Eisenmann JC, Bartee RT, Wang MQ. Physical activity, TV viewing, and weight in US youth: 1999 Youth Risk Behavior Survey. *Obes Res.* 2002;10:379-385.
33. Wadden TA. What characterizes successful weight maintainers? In: Allison DB, Pi-Sunyer, Z, eds. *Obesity Treatment.* New York, NY: Plenum Press; 1995:103-111.
34. Ewbank PP, Darga LL, Lucas CP. Physical activity as a predictor of weight maintenance in previously obese subjects. *Obes Res.* 1995;3:257-263.
35. Thompson FE, Subar AF. Dietary assessment methodology. In: Coulson AM, Rock CL, Monsen ER, eds. *Nutrition in the Prevention and Treatment of Disease.* San Diego, Calif: Academic Press; 2001:3-30.
36. Lichtman SW, Pisarska K, Berman ER, et al. Discrepancy between self-reported and actual caloric intake and exercise in obese subjects. *N Engl J Med.* 1992;327:1893-1898.
37. Strauss RS, Pollack HA. Epidemic increase in childhood overweight, 1986-1998. *JAMA.* 2001;286:2845-2848.
38. Cavadini C, Siega-Riz AM, Popkin BM. US adolescent food intake trends from 1965 to 1996. *Arch Dis Child.* 2000;83:18-24.
39. Steinmetz KA, Potter JD. Vegetables, fruit, and cancer prevention: a review. *J Am Diet Assoc.* 1996;96:1027-1039.