Trends in Physical Activity, Sedentary Behavior, Diet, and BMI Among US Adolescents, 2001–2009

WHAT'S KNOWN ON THIS SUBJECT: The prevalence of overweight and obesity in US adolescents has increased over the last century. However, recent evidence indicates a potential change in this trend. Parallel trends in adolescent behaviors that drive this epidemic have not been well studied.

WHAT THIS STUDY ADDS: Analyses of recent data indicate the prevalence of overweight and obesity may be stabilizing. Over the same period, adolescent physical activity, breakfast eating, and fruit and vegetable consumption increased and television viewing and consumption of sweets and sweetened beverages decreased.

abstract

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OBJECTIVE: The high prevalence of adolescent obesity in the United States has been attributed to population changes in physical activity (PA), sedentary behaviors, and dietary behaviors. This study examines 8-year trends in these behaviors in US adolescents ages 11 to 16.

METHODS: Nationally representative samples of US students in grades 6 to 10 were recruited during the 2001–2002 (N = 14 607), 2005–2006 (N = 9150), and 2009–2010 (N = 10 848) school years by using multistage stratified designs, with census regions and grades as strata, and school districts as the primary sampling units. African-American and Hispanic students were oversampled to obtain better estimates for those groups. Using the Health Behavior in School-aged Children quadrennial surveys, identical questions assessed BMI, PA, and sedentary and dietary behaviors at each school year. Logistic and linear regression analyses were conducted taking into account the sampling design and controlling for age, gender, race/ethnicity, and family affluence.

RESULTS: Across the quadrennial surveys, significant increases were identified in number of days with at least 60 minutes of PA, daily consumption of fruits and vegetables, eating breakfast on weekdays and weekends, and BMI. Television viewing and consumption of sweets and sweetened beverages decreased across this same period. These same patterns were seen in all racial/ethnic groups.

CONCLUSIONS: These patterns suggest that public health efforts to improve the obesity-related behaviors of US adolescents may be having some success. However, alternative explanations for the increase in BMI over the same period need to be considered. *Pediatrics* 2013;132:606–614

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KEY WORDS

trends, obesity, physical activity, diet, adolescent, gender

ABBREVIATIONS

95% CI—95% confidence interval
CU—computer use
DB—dietary behavior
HBSC—Health Behavior in School-aged Children Study
OR—odds ratio
PA—physical activity
SB—sedentary behavior
TV—television viewing
VG—video game playing

Dr Iannotti conceptualized and designed the study, coordinated and supervised data collection, contributed to the analysis, and drafted the initial manuscript; Dr Wang contributed to the conceptualization of the manuscript, carried out the initial analyses, and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

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Obesity, a risk factor for many of the leading causes of mortality, has increased dramatically over the last century.[1] However, recent studies of nationally representative samples suggest that the prevalence of obesity is stabalizing.[2–4] Further investigation of potential causes of this change in the obesity trajectory is warranted.

Among the preventable causes of adolescent obesity are physical activity (PA), sedentary behavior (SB), and diet.[5] Although PA decreased during the same historical period that obesity increased, there is some disagreement as to whether PA and SB, particularly television viewing (TV) and computer use (CU), have increased or decreased since 1999.[6–10] Secular trends in adolescents' dietary behaviors (DBs) over the last 2 decades suggest a decrease in the proportion of children eating breakfast, and an increase in caloric intake, mainly from increased consumption of snacks, soft drinks, and fruit drinks.[11,12]

The purpose of the current study was to examine secular trends in adolescent obesity, PA, SB, and DB from 2001 to 2009 in nationally representative samples of US adolescents. Gender, age, and racial/ethnic differences in these trends were also examined.

METHODS

Sample and Procedure

Nationally representative samples of US students in grades 6 to 10 were recruited during the 2001–2002 (N = 14 818), 2005–2006 (N = 9227), and 2009–2010 (N = 10 993) school years by using multistage stratified designs, with census regions and grades as strata, and school district as the primary sampling units. African-American and Hispanic students were oversampled to obtain better estimates for those groups. Participants completed the Health Behavior in School-aged Children (HBSC) survey anonymously with response rates of 83% in 2001–2002, 87% in 2005–2006, and 89% in 2009–2010. Youth assent and, depending on the requirements of the participating school districts, active or passive parental consent were obtained. The study was approved by the Institutional Review Board of the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development.

Measures

During the middle of each school year, trained assistants administered paper copies of the HBSC quadrennial surveys, which contained identical questions assessing BMI, PA, SB, and DB.[13]

Socio-demographic Variables

Socio-demographic variables included gender, age, race/ethnicity (white, African-American, Hispanic, and other) and family affluence. An estimate of family socioeconomic status was provided by the Family Affluence Scale: the adolescent having his/her own bedroom, scored 0 = no, 1 = yes; frequency of family traveling vacations in the past 12 months, scored 0 = none to 3 = more than twice; number of family computers, scored 0 = none to 3 = more than 2; and number of motor vehicles, scored 0 = none to 2 = 2 or more.[14] The scale was used as a continuous covariate in analyses with possible scores ranging from 0 to 9.

Physical Activity

A definition of PA was provided, "any activity that usually increases your heart rate and makes you get out of breath some of the time," with examples of qualifying activities and followed by an item that asked "How often over the past 7 days have you been physically active for a total of at least 60 minutes per day." The measure has been shown to have acceptable validity (r = 0.37 to 0.49 with accelerometer data).[15–17]

SB: TV, Playing Video Games, and CU

Amount of time viewing television was measured by the question "About how many hours a day do you usually watch television (including videos and DVDs) in your free time." Video game playing (VG) time and CU (chatting on-line, Internet, e-mailing, homework, etc) were identified in the 2005–2006 and 2009–2010 samples. Response categories ranged from "none at all" to "about 7 or more hours a day." These HBSC items have been shown to have acceptable test-retest reliability (intraclass correlations [ICCs] ranged from 0.76 to 0.81) and validity (rs ranged from 0.36 to 0.54).[18] Separate questions were asked for weekdays and weekends, and a weighted average of weekdays and weekend days was computed.

Dietary Intake

As part of a validated brief food frequency questionnaire, participants were asked how many times a week they usually ate fruits, vegetables, sweets (chocolates and candy), and sweetened soft drinks.[19] The response options for the items were scored as 1 = "never," 2 = "less than once a week," 3 = "once a week," 4 = "2 to 4 days a week," 5 = "5 to 6 days a week," 6 = "once a day, every day," and 7 = "every day, more than once."

Breakfast

Participants were asked "How often do you usually have breakfast (more than a glass of milk or fruit juice)" separately for weekdays and weekends with choices indicating the number of days.

Weight Status

Adolescents reported their heights and weights. Using BMI percentiles derived from the gender-specific BMI-for-age growth charts of the Centers for Disease Control and Prevention, weight status was categorized as follows: underweight or at risk for underweight (≤15th percentile); normal weight

(16th–84th percentile); overweight or at risk for obesity (85th–94th percentile); and obese (≥95th percentile).[20] Trends in both BMI percentile and weight status were examined.

Statistical Analyses

Regression analyses were conducted for continuous outcome variables with each outcome regressed on year, gender, age, and race/ethnicity. Family affluence was included as a covariate. Multinomial logistic regression analysis was used for examining the trends for BMI groups, with normal weight as the reference. When significant effects were detected, interactions of year with gender, age, and/or race/ethnicity were added to the model. All analyses took into account the sampling design with weights (derived with the same methods at each wave) to adjust for oversampling. Significance level was set at $P < .01$.

RESULTS

Sample sizes and weighted demographic characteristics for all 3 cohorts are presented in Table 1. Across samples, there was an increasing percentage of boys over time ($P < .001$), and the racial/ethnic composition varied ($P = .002$). The 2005–2006 sample was older than the samples in 2001–2002 and 2009–2010 ($P < .001$). All subsequent analyses controlled for sample demographics. Descriptive statistics for continuous outcomes are reported in Table 2.

Physical Activity

The average number of days of ≥60 minutes of PA was <5 days per week in all 3 samples (Table 2). PA was greater in boys than girls at each point in time ($P < .001$) (Table 3) and lower in Hispanic adolescents relative to White adolescents ($P < .001$) (data not shown). PA was lower in older adolescents in 2001 and in 2005 ($P < .001$) (data not shown). However, PA increased over time with adolescents reporting significantly more PA in 2009–2010 than in 2001–2002 ($P = .004$) (Table 2 and Fig 1).

Television Viewing

Adolescents averaged more than 2 hours per day of TV overall and during both weekdays and weekend days (Table 2), with higher rates on weekend days than weekdays ($P < .001$). TV decreased over the period being studied, and this pattern was true for total viewing ($P < .001$) as well as viewing on weekdays ($P < .001$) and weekends ($P < .001$) (Table 2 and Fig 1). In 2 of the 3 samples, boys reported significantly more TV than girls ($P < .001$). African-American, Hispanic, and "other" adolescents reported more TV than white adolescents ($P < .001$) (data not shown).

VG and CU

VG and CU were only assessed in 2005–2006 and 2009–2010. VG was higher in boys ($P < .001$) (Table 3), younger adolescents ($P < .001$), and nonwhite adolescents ($P < .001$) (data not shown). VG averaged <2 hours per day in all groups and did not change significantly from 2005 to 2009 in the overall sample but did increase significantly in girls ($P < .001$) (Tables 2 and 3).

CU also averaged <2 hours per day and did not change significantly from 2005–2006 to 2009–2010 (Table 2). CU was higher in girls ($P < .001$) (Table 3), older adolescents ($P < .001$), and nonwhite adolescents ($P < .001$) (data not shown).

Dietary Intake

The averages for consumption of fruits, vegetables, sweets, and soft drinks were below 6, the code for at least once a day (Table 2). Consumption of fruits

TABLE 1 Sample Characteristics of the US HBSC Samples in 2001–2002, 2005–2006, and 2009–2010 (Total $N = 34\,605$)

Categories	HBSC 2001–2002 ($N = 14\,607$)				HBSC 2005–2006 ($N = 9150$)				HBSC 2009–2010 ($N = 10\,848$)			
	N	%	SE	95% CI	*N*	%	SE	95% CI	*N*	%	SE	95% CI
Gender[a]												
Boy	6977	48.1	0.56	47.0–49.2	4431	49.2	0.83	47.6–50.8	5587	52.0	0.70	50.6–53.4
Girl	7630	51.9	0.56	50.8–53.0	4719	50.8	0.83	49.2–52.4	5261	48.0	0.70	46.6–49.4
Race/ethnicity[a,b]												
White	7399	62.9	2.18	58.6–67.2	3969	48.9	3.23	42.5–55.1	4662	50.7	3.34	44.2–57.3
African-American	3027	16.5	1.78	13.0–20.0	1822	17.9	2.53	12.9–22.9	2036	16.9	2.01	12.9–20.8
Hispanic	2883	12.8	1.27	10.3–15.3	2338	19.1	2.06	24.1–23.2	2946	19.8	2.49	14.9–24.7
Other	1298	7.9	0.66	6.6–10.3	1021	14.1	1.73	10.7–17.5	1204	12.7	1.24	10.2–15.1
Continuous variable		Mean	SE	95% CI		Mean	SE	95% CI		Mean	SE	95% CI
Age[a]		13.9	0.05	13.8–14.0		14.1	0.07	14.0–14.3		13.9	0.07	13.8–14.1

N = sample size; % = weighted percentage adjusting for complex survey design, including stratification, clustering, and over sampling. A total of 433 participants were excluded due to missing data on demographic information.

[a] Sample compositions differed significantly by gender, race/ethnicity, and age.

[b] The "other" group includes Asian, Hawaiian/Pacific Islander, and American Indian/Alaskan Native.

TABLE 2 Sample Sizes, Means, and SEs for Obesogenic Behaviors and BMI in US HBSC Samples in 2001–2002, 2005–2006, and 2009–2010

	2001–2002			2005–2006			2009–2010		
	N	Mean	SE	*N*	Mean	SE	*N*	Mean	SE
PA (days/week of 60 min)	14 243	4.33[a]	0.04	9049	4.35[a,b]	0.07	10 673	4.53[b]	0.05
TV (hours/day)	14 041	3.06[a]	0.04	9054	2.65[b]	0.06	10 741	2.38[c]	0.05
TV (hours/weekday)	14 041	2.78[a]	0.05	9058	2.39[b]	0.07	10 744	2.13[c]	0.06
TV (hours/weekend day)	14 074	3.76[a]	0.04	9077	3.31[b]	0.07	10 779	3.01[c]	0.05
VG (hours/day)[d]	—	—	—	9085	1.19[a]	0.03	10 724	1.29[a]	0.04
VG (hours/weekday)[d]	—	—	—	9087	0.95[a]	0.03	10 726	1.04[a]	0.03
VG (hours/weekend day)[d]	—	—	—	9129	1.79[a]	0.04	10 798	1.94[a]	0.05
CU (hours/day)[d]	—	—	—	9104	1.41[a]	0.05	10 762	1.51[a]	0.05
CU (hours/weekday)[d]	—	—	—	9108	1.30[a]	0.05	10 762	1.39[a]	0.05
CU (hours/weekend day)[d]	—	—	—	9134	1.69[a]	0.05	10 816	1.83[a]	0.06
Fruits (1 = never to 7 = >1/day)	14 048	4.29[a]	0.03	9036	4.72[b]	0.05	10 387	4.91[c]	0.04
Vegetables (1 = never to 7 = >1/day)	13 777	4.31[a]	0.03	9002	4.50[b]	0.04	10 255	4.61[b]	0.04
Sweets (1 = never to 7 = >1/day)	13 640	4.70[a]	0.02	8972	4.48[b]	0.05	10 231	4.10[c]	0.04
Sweetened soft drinks (1 = never to 7 = >1/day)	13 812	4.85[a]	0.03	8997	4.36[b]	0.06	10 342	4.18[c]	0.06
Breakfast (days/weekday)	14 409	2.98[a]	0.04	9051	3.12[b]	0.05	10 736	3.25[b]	0.05
Breakfast (days/weekend)	14 129	1.59[a]	0.01	8927	1.59[a]	0.01	10 440	1.62[a]	0.01
BMI Pct[e]	12 616	58.54[a]	0.42	8286	62.33[b]	0.67	9362	62.07[b]	0.59

[a] Means with the same superscript do not differ significantly across years.
[b] Means with the same superscript do not differ significantly across years.
[c] Means with the same superscript do not differ significantly across years.
[d] 2001 data are not provided for VG and CU because they were not assessed that year.
[e] BMI percentile adjusted for age and gender.

TABLE 3 Sample Sizes, Means, and SEs by Gender (for Significant Gender Effects Only)

	2001–2002			2005–2006			2009–2010		
	N	Mean	SE	*N*	Mean	SE	*N*	Mean	SE
Boy									
PA (days/week of 60 min)	6772	4.70[a]	0.04	4366	4.81[b]	0.06	5487	4.89[b]	0.05
TV (hours/day)	6695	3.16[a]	0.05	4373	2.61[b]	0.06	5516	2.43[c]	0.05
VG (hours/day)[d]	—	—	—	4395	1.62[a]	0.04	5506	1.66[a]	0.05
CU (hours/day)[d]	—	—	—	4406	1.25[a]	0.06	5531	1.36[a]	0.05
Fruits (1 = never to 7 = >1/day)	6616	4.30[a]	0.03	4365	4.68[b]	0.05	5311	4.87[c]	0.04
Vegetables (1 = never to 7 = >1/day)	6465	4.20[a]	0.03	4346	4.46[b]	0.06	5223	4.52[b]	0.04
Sweets (1 = never to 7 = >1/day)	6408	4.67[a]	0.03	4312	4.31[b]	0.05	5224	3.95[c]	0.04
Sweetened soft drinks (1 = never to 7 = >1/day)	6530	4.98[a]	0.04	4349	4.53[b]	0.06	5275	4.29[c]	0.06
Breakfast (days/weekday)	6847	3.27[a]	0.04	4377	3.36[a,b]	0.05	5512	3.44[b]	0.05
BMI Pct[d]	6019	61.79[a]	0.58	4008	63.44[b]	0.83	4887	63.50[b]	0.65
Girl									
PA (days/week of 60 min)	7471	3.99[a]	0.04	4683	3.89[a]	0.08	5186	4.14[b]	0.07
TV (hours/day)	7346	2.96[a]	0.05	4681	2.69[b]	0.08	5225	2.34[c]	0.06
VG (hours/day)[d]	—	—	—	4690	0.77[a]	0.03	5218	0.90[b]	0.03
CU (hours/day)[d]	—	—	—	4698	1.57[a]	0.05	5231	1.68[a]	0.06
Fruits (1 = never to 7 = >1/day)	7432	4.29[a]	0.03	4671	4.74[b]	0.06	5076	4.96[c]	0.05
Vegetables (1 = never to 7 = >1/day)	7312	4.40[a]	0.04	4656	4.55[b]	0.05	5032	4.70[c]	0.06
Sweets (1 = never to 7 = >1/day)	7232	4.72[a]	0.03	4660	4.64[a]	0.06	5007	4.26[b]	0.05
Sweetened soft drinks (1 = never to 7 = >1/day)	7282	4.74[a]	0.04	4648	4.20[b]	0.07	5067	4.07[b]	0.06
Breakfast (days/weekday)	7562	2.70[a]	0.04	4674	2.89[b]	0.06	5224	3.05[c]	0.05
BMI Pct[e]	6597	55.51[a]	0.54	4278	61.24[b]	0.78	4475	60.50[b]	0.83

[a] Means with the same superscript do not differ significantly across years.
[b] Means with the same superscript do not differ significantly across years.
[c] Means with the same superscript do not differ significantly across years.
[d] 2001 data are not provided for VG and CU because they were not assessed that year.
[e] BMI percentile adjusted for age and gender.

was greater in girls ($P = .015$) (Table 3), in younger adolescents ($P < .001$), and in white and other youth ($P < .001$) (data not shown). Fruit consumption increased at each time of assessment (Table 2 and Fig 2) ($P < .001$). A similar pattern was found for vegetable consumption: it was higher in girls ($P < .001$) (see Table 3), younger ($P < .001$),

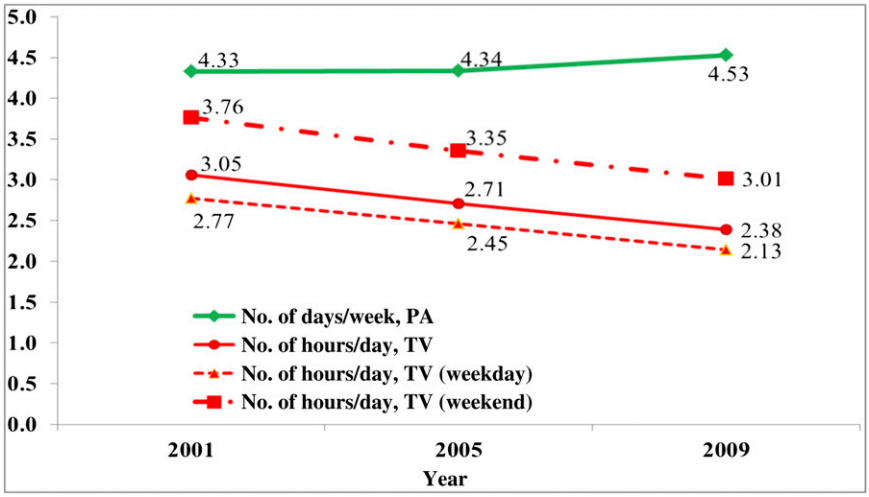

FIGURE 1
Trends in PA and TV.

and white and other adolescents ($P <$ .001) (data not shown). Consumption of vegetables increased, but the increase was from 2001–2002 to 2005–2006 in boys ($P <$ .001) and from 2005–2006 to 2009–2010 in girls (Table 2 and Fig 2).

Consumption of both sweets ($P <$ .001) and sweetened soft drinks ($P <$ .001) decreased over time, but the decrease in soft drinks was primarily from 2001–2002 to 2005–2006 ($P <$ .001) (Table 2 and Fig 2). Girls were more likely to eat sweets than boys ($P <$ .001), whereas boys were more likely to drink soft drinks than girls ($P <$ .001) (Table 3). Older adolescents consumed more sweets ($P <$ .001) and soft drinks ($P <$ .001), and African-American youth consumed the most sweets ($P <$ .001) and soft drinks ($P <$ .001) (data not shown).

Breakfast

Overall, adolescents reported missing breakfast approximately twice during the week and were more likely to eat breakfast on weekends (Table 2). During the week, girls reported eating breakfast less frequently than boys ($P <$ .001) (Table 3), older adolescents reported eating breakfast less frequently than younger adolescents ($P <$ .001), and African-American and Hispanic adolescents reported eating breakfast less frequently than white and other adolescents ($P <$ .001) (data not shown). Overall, eating breakfast on weekdays increased from 2001–2002 to 2005–2006 ($P <$ .001): in boys, breakfast eating on weekdays increased from 2001 to 2009 ($P <$ .001); in girls, breakfasts on weekdays increased across all 3 times ($P <$ .001). Breakfast eating on weekends did not change significantly over time.

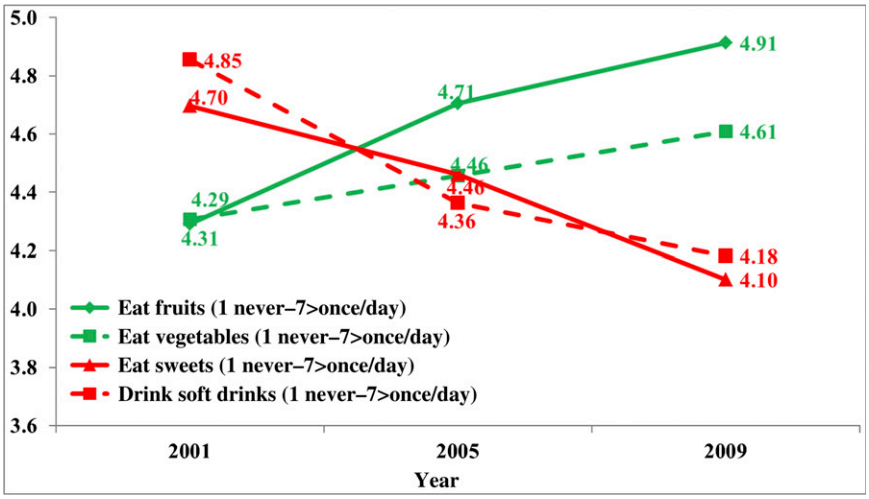

FIGURE 2
Trends in consumption of fruits, vegetables, sweets, and sweetened soft drinks.

Weight Status

The average BMI percentiles adjusted for age and gender at each assessment are presented in Table 2. Adjusted BMI was higher in boys than girls ($P = .001$) (Table 3), in older adolescents ($P < .001$), and in African-American and Hispanic youth relative to white and other youth ($P < .001$) (data not shown). The average BMI percentile increased over time ($P < .001$), but the significant change was from 2001–2002 to 2005–2006 ($P < .001$), and there was no significant change from 2005–2006 to 2009–2010. The significant change in BMI from 2001–2002 to 2005–2006 was seen in both boys and girls (Tables 3 and 4; Fig 3).

Multinomial logistic regressions of BMI group (underweight, normal weight, overweight, and obese) on year, age, gender, and race/ethnicity indicated that relative to younger adolescents, older boys and girls were less likely to be underweight over time (odds ratio [OR] = 0.44 [95% confidence interval (CI) = 0.34–0.56 and OR = 0.36 [95% CI = 0.28–0.46], respectively), and older boys were less likely to be overweight over time (OR = 0.85 [95% CI = 0.75–0.96]). Compared with white adolescents, African-American boys and girls were less likely to be underweight over time (OR = 0.58 [95% CI = 0.41–0.84] and OR = 0.60 [95% CI = 0.40–0.92], respectively) and more likely to be

TABLE 4 Descriptive Statistics on BMI Group by Gender of US HBSC Samples in 2001–2002, 2005–2006, and 2009-2010 (N = 30 264)

	2001–2002 (N = 12 616)			2005–2006 (N = 8286)			2009–2010 (N = 9362)		
	N	%	SE	*N*	%	SE	*N*	%	SE
All (N = 30 264)									
Underweight	626	4.7	0.26	327	3.7	0.31	404	4.2	0.31
Normal weight	8646	70.1	0.63	5426	66.6	0.91	6105	66.5	0.86
Overweight	1945	14.9	0.44	1383	17.0	0.61	1606	16.6	0.53
Obese	1399	10.3	0.40	1150	12.7	0.67	1247	12.7	0.58
	2001–2002 (N = 6019)			2005–2006 (N = 4008)			2009–2010 (N = 4887)		
Boy (N = 14 914)	*N*	%	SE	*N*	%	SE	*N*	%	SE
Underweight (671)	285	4.4	0.32	162	4.2	0.44	224	4.6	0.42
Normal weight (9413)	3874	65.5	0.83	2499	62.9	1.22	3040	63.6	1.05
Overweight (2577)	1006	16.5	0.67	707	18.4	1.00	864	17.4	0.62
Obese (2253)	854	13.6	0.60	640	14.5	0.85	759	14.4	0.74
	2001–2002 (N = 6597)			2005–2006 (N = 4278)			2009–2010 (N = 4475)		
Girl (N = 15 350)	*N*	%	SE	*N*	%	SE	*N*	%	SE
Underweight	341	5.0	0.34	165	3.3	0.32	180	3.7	0.42
Normal weight	4772	74.3	0.76	2927	70.2	1.11	3065	69.7	1.31
Overweight	939	13.4	0.48	676	15.7	0.67	742	15.7	0.90
Obese	545	7.3	0.41	510	10.9	0.73	488	10.9	0.71

N = sample size; % = weighted percentage adjusting for complex survey design, including stratification, clustering, and over sampling. Respondents with reported weight outside of the range 20 to 191 kg and with reported height outside of range 119.38 to 198.12 cm were excluded.

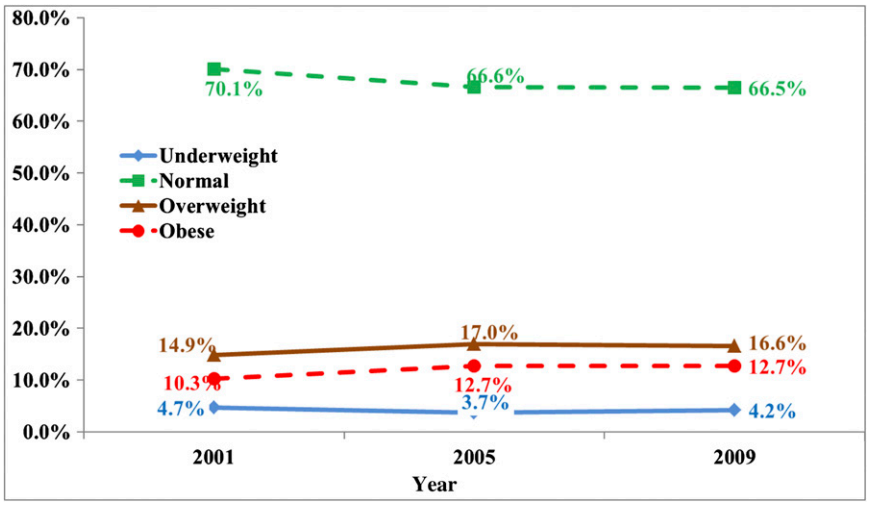

FIGURE 3
Trends in weight status.

obese (OR = 1.36 [95% CI = 1.15–1.61] and OR = 2.19 [95% CI = 1.81–2.66], respectively). Compared with white girls, African-American girls were also more likely to be overweight over time (OR = 1.71 [95% CI = 1.44–2.03]). Relative to white adolescents, Hispanic boys and girls were more likely to be overweight (OR = 1.49 [95% CI = 1.29–1.72] and OR = 1.50 [95% CI = 1.29–1.76], respectively) or obese (OR = 1.79 [95% CI = 1.51–2.12] and OR = 1.60 [95% CI = 1.30–1.95], respectively) over time.

DISCUSSION

The pattern of obesogenic behaviors in these representative national samples of US adolescents surveyed over the period of 2001 to 2009 indicates there is considerable need for improvement. Most adolescents did not engage in the recommended 60+ minutes per day of PA or consume 5+ servings of fruits and vegetables per day.[5,21] In contrast, most adolescents exceeded recommendations for <2hours per day of screen-based SB and minimizing consumption of energy dense snacks and sweetened beverages.[21,22] The average adolescent ate breakfast <5 times per week. This pattern of obesogenic behaviors is not surprising given the high prevalence of cardiovascular disease risk factors among US adolescents.[2] Establishment of obesogenic behaviors during adolescence is important because PA and diet track from adolescence to adulthood.[23] Furthermore, there is evidence that most US youth engage in multiple obesogenic behaviors, putting them at greater risk for physical and psychological health problems and indicating they could benefit from interventions targeting PA, SB, and diet.[24]

It may be that current public health efforts are succeeding; the trends from 2001 to 2009 are encouraging. In contrast with earlier studies, PA increased and TV, the most prevalent SB, decreased from 2001 to 2009.[7] During the same period consumption of fruits and vegetables and frequency of eating breakfast increased, whereas consumption of sweetened beverages and sweets decreased. Yet it appears that the magnitude of these changes in health behaviors were not sufficient to reverse the trends in weight status; BMI increased from 2001 to 2005. Still, there was no significant increase in BMI from 2005 to 2009, perhaps suggesting that the increase in adolescent obesity observed over previous decades may be beginning to stabilize.[1] This leveling of the obesity trend may be somewhat unique to the United States, and continued improvements in PA, SB, and DB may be necessary before the trend begins to turn downward.[4]

Although the overall trends in obesogenic behaviors were generally the same for adolescents of different gender, age, and race/ethnicity over the period being studied, there were significant differences in the level of these behaviors across gender, age, and race/ethnicity. Consistent with previous studies, boys report more PA than girls at all 3 times but also more screen-based SB (TV and VG), with the exception of CU, where girls exceeded boys.[7,8] It should be noted that most studies of obesogenic SB have focused on TV and associations between TV and diet, whereas negative effects of VG or CU have not been well established.[25] Previous studies have revealed mixed results with respect to gender differences in diet; however, in our national samples, girls exceeded boys in consumption of fruits and vegetables but also reported eating sweets more frequently than boys.[26,27] With respect to risks for overweight and obesity, BMI percentiles, adjusted for age and gender, were higher in boys than girls. Thus, the overall pattern of obesogenic behaviors was not uniformly better in one gender over another: boys reported more PA but also more SB; girls reported more frequent consumption of fruits and vegetables but also higher frequency of consumption of sweets and lower frequency of eating breakfasts. Based on these findings, pediatricians might provide different advice for boys and girls, and interventions could be tailored to the adolescent's gender (eg, reducing SB in boys and increasing PA in girls, or increasing fruit and vegetable consumption in boys and decreasing consumption of sweets in girls).

Age differences in these behaviors suggest a disturbing trend consistent with previous studies.[27–29] Compared with younger adolescents, older adolescents reported less PA, more CU, less frequent consumption of fruits and vegetables, more frequent consumption of sweets and sweetened soft drinks, and less frequent consumption of breakfast on week days. However, younger adolescents reported more frequent VG, a SB. Even though BMI percentiles controlled for age and gender, based on age differences in obesogenic behaviors, it should be no surprise that the adjusted BMI percentiles were higher in older adolescents. Thus, it appears that obesogenic behaviors increase with age, and this increase corresponds with an increase in obesity. Further study is needed to determine whether it is more efficient for clinics and public health efforts to focus on unhealthy patterns in older adolescents or if early intervention with younger adolescents would prevent the increases seen in older adolescents.

Although cardiovascular risk factors in US adolescents are prevalent across different race/ethnicity groups, African-American and Hispanic youth in the current study reported higher BMI than white and other adolescents.[2] Even with family affluence statistically controlled, PA was lower in Hispanic adolescents compared with white adolescents; TV, VG, and CU were lowest in white

adolescents; fruit, vegetable, and breakfast consumption was highest in white and other adolescents; and consumption of sweets and sweetened soft drinks were highest in African-American adolescents. These findings are consistent with previous studies of obesogenic behaviors in US youth.[8,30,31] Differences in neighborhood access to recreational facilities and produce markets, school food services and policies affecting PA, and availability of healthful versus unhealthful foods and support for PA at home are potential socioenvironmental contributors to racial/ethnic differences.[32–36] The higher prevalence of overweight and obesity and the pattern of obesogenic behaviors in nonwhite groups confirm the need to identify the social and environmental conditions that influence these behaviors in adolescents and the need for interventions targeting the full range of obesogenic behaviors in US minority children and adolescents.

The primary limitation of these data is that they are based on self-report. However, the measures have been validated, and other studies have revealed good correlations between self-reported and measured BMI, making it suitable for population studies.[37,38] Another limitation is that nationally representative samples were maintained at each wave, whereas matched samples could have reduced the risk of sampling bias. Finally, these cross-sectional data do not provide information regarding the causal relations between the behaviors and weight status. Further research is needed to examine the differential effects of single and multiple obesogenic behaviors on the development of overweight and obesity in US adolescents.[24]

CONCLUSIONS

Efforts to increase adolescent PA and reduce time spent watching television may be working. The potential role of pediatricians in improving these adolescent obesogenic behaviors needs further study. More research is needed to support the efficacy of brief physician interventions as a means of improving obesogenic behaviors in adolescents; however, incorporating behavior change principals into ongoing pediatric care may have promise.[39–41] Maintaining a focus on PA and diet while broadening efforts to decrease SBs may be necessary.

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Noted by Leah H. Carr, BS, MS-IV

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