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DECLINE IN PHYSICAL ACTIVITY IN BLACK GIRLS AND WHITE GIRLS DURING ADOLESCENCE

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ABSTRACT

Background Physical activity declines during adolescence, but the underlying reasons remain unknown.

Methods We prospectively followed 1213 black girls and 1166 white girls enrolled in the National Heart, Lung, and Blood Institute Growth and Health Study from the ages of 9 or 10 to the ages of 18 or 19 years. We used a validated questionnaire to measure leisure-time physical activity on the basis of metabolic equivalents (MET) for reported activities and their frequency in MET-times per week; a higher score indicated greater activity.

Results The respective median activity scores for black girls and white girls were 27.3 and 30.8 MET-times per week at base line and declined to 0 and 11.0 by year 10 of the study (a 100 percent decline for black girls and a 64 percent decline for white girls, $P<0.001$). By the age of 16 or 17 years, 56 percent of the black girls and 31 percent of the white girls reported no habitual leisure-time activity. Lower levels of parental education were associated with greater decline in activity for white girls at both younger ages ($P<0.001$) and older ages ($P=0.005$); for black girls, this association was seen only at the older ages ($P=0.04$). Pregnancy was associated with decline in activity among black girls ($P<0.001$) but not among white girls, whereas cigarette smoking was associated with decline in activity among white girls ($P<0.001$). A higher body-mass index was associated with greater decline in activity among girls of both races ($P\leq0.05$).

Conclusions Substantial declines in physical activity occur during adolescence in girls and are greater in black girls than in white girls. Some determinants of this decline, such as higher body-mass index, pregnancy, and smoking, may be modifiable. (N Engl J Med 2002;347:709-15.)

SINCE the early 1960s, the prevalence of obesity in female children and adolescents in the United States has more than doubled, with the greatest increase among black girls.[1] Periodic surveys show no concomitant increase in food intake.[2,3] Analogous information on trends in activity level in this population is not available. It has been conjectured that adolescents have become less active in recent years, and that this trend may be responsible for the increased prevalence of obesity.[4-8]

In cross-sectional studies, activity levels have been reported to drop by as much as 50 percent during adolescence.[7,8] Although white girls tend to be more active than black girls,[7-14] both groups become increasingly sedentary with age, beginning as early as the age of 10 years.[6,11-13,15] However, the factors associated with the decline in activity during adolescence remain largely unknown.[15,16]

We examined longitudinal changes in physical activity in a large, biracial cohort of adolescent girls and examined racial differences and other factors associated with these changes.

METHODS

Study Population

The National Heart, Lung, and Blood Institute Growth and Health Study is a multicenter prospective study of 1213 black girls and 1166 white girls followed annually from the ages of 9 or 10 years (year 1 of the study) to 18 or 19 years (year 10). The partic-

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ipants were recruited from schools near San Francisco and in Cincinnati and from a health maintenance organization (HMO) in the Washington, D.C., area. The schools were selected with the use of census data that showed about equal percentages of black and white children and minimal disparity in income and education between black and white residents of the areas served by the schools. The subjects from the HMO were randomly selected from a list of eligible families. Race was defined by self-declaration as either white or black in a racially concordant household. The study design and base-line characteristics of the Growth and Health Study have been reported previously.[17,18] The overall follow-up rate was 89 percent (91 percent for blacks and 88 percent for whites) at the end of the study (year 10). Written informed consent was obtained from all participants and their parents or guardians. The study protocols were approved by institutional review boards at each site.

Information Collected

Assessment of Physical Activity

The Habitual Activity Questionnaire (HAQ) is a longitudinally validated instrument used to assess activities of adolescent girls over the previous year, other than those performed in physical-education classes during school.[19] They included sports or recreational activities (such as bicycling, basketball, and walking for exercise) and lessons (such as swimming, dance, and gymnastics) — that is, leisure-time activities that require energy expenditure above that required for activities of daily living.[20] There were no differences in the types of activities most frequently cited by black and white girls. The HAQ was administered in years 1, 3, 5, 7, 8, 9, and 10 of the study.[19] A central unit standardized the collection and coding of the HAQ data. All HAQs reporting "zero" activities were verified in person by centrally trained interviewers.

The HAQ score was computed by multiplying an estimate of the metabolic equivalents (MET) for each recorded activity by the weekly frequency and the fraction of the year during which it was performed.[19] Weekly tallies for all HAQ items were summed, and an overall average weekly score was calculated as MET-times per week.[19] Typical activities performed during adolescence and their corresponding values in MET-times per week are as follows: bicycling one or two times per week for 52 weeks per year, 8.0 MET-times per week; playing basketball one or two times per week for 39 weeks per year, 9.0 MET-times per week; swimming three or more times per week for 13 weeks per year, 4.5 MET-times per week; and walking for exercise three or more times per week for 39 weeks per year, 9.0 MET-times per week.

Measures of Socioeconomic Status

Information on socioeconomic status, collected at base line (1987 to 1988), included the maximal educational level achieved by either parent and total annual household income. Data on education were collapsed into the categories of high school or less, some college, and four or more years of college. Data on annual income were collapsed into the categories of less than $20,000, $20,000 to $39,999, and $40,000 or more.

Anthropometric Measurements

The body-mass index (the weight in kilograms divided by the square of the height in meters) was derived from annual measurements of height and weight by centrally trained examiners.

Pregnancy and Smoking

Information on pregnancy and smoking was collected from year 6 (age 14 or 15) onward. The girls were asked if they had ever been pregnant. Smoking status was categorized as positive if a girl answered yes when asked whether she smoked daily, almost daily, or weekly.

School Dropout Rates

School dropout rates were tracked annually from year 7 (age 15 or 16) onward.

Statistical Analysis

Two-sample t-tests, χ^2 tests, or Wilcoxon two-sample tests were used to examine racial differences in descriptive characteristics.[21] Because of the skewed distribution of HAQ scores, median rather than mean scores were used. Because a higher rate of pregnancy could confound the steeper decline in activity among black girls, the changes in HAQ scores were examined with girls who became pregnant excluded. In years 1 through 8, HAQ scores did not change significantly even when those who became pregnant were excluded; therefore, the final analysis included all girls, regardless of pregnancy history. Because school enrollment could also affect activity, HAQ scores for year 8 were compared including and excluding those who were out of school.

Only data from the first eight study years were analyzed, because the median HAQ score fell to zero for black girls by year 8. Race-specific longitudinal generalized estimating equations were used to determine whether changes in activity scores from year 1 to year 5 differed from those from year 5 to year 8.[21,22] Because the rate of decline in activity differed significantly between the two periods, and also because information on pregnancy and cigarette smoking was collected in the latter half of the study, final analyses were based on separate models for these two periods.

Initial analyses included race as an independent variable as well as interactions between race and all the predictor variables. These analyses showed the following to be significant: race ($P<0.001$) and interactions of race with parental education (for younger ages, $P=0.006$), living in a single-parent household (for older ages, $P=0.02$), and cigarette smoking (for older ages, $P=0.045$). Therefore, the final analyses were race-specific.

Race-specific generalized-estimating-equation models were constructed separately for years 1 to 5 (encompassing HAQ scores at years 1, 3, and 5) and years 5 to 8 (encompassing HAQ scores at years 5, 7, and 8).[21] The outcome measure was the change in HAQ scores between successive follow-up intervals (e.g., the year 3 score minus the year 1 score and the year 5 score minus the year 3 score). A similar approach was used for years 5 to 8, except that the change in the HAQ score from year 5 to year 7 was divided by 2 so that it represented an annualized change, to be consistent with the change from year 7 to year 8.

Predictor variables for each model included household income (reference category, $40,000 or more), parental level of education (reference category, four or more years of college), number of parents in the household (reference category, two parents), body-mass index, and the HAQ score at the outset of each successive follow-up interval. Pregnancy (reference category, never pregnant) and smoking (reference category, nonsmoker) were examined for years 5 to 8. The final model excluded income or education if the effect was not statistically significant.

RESULTS

Study Population

Throughout the study, black girls had significantly higher body-mass index values. By the age of 16 or 17 years (year 8), the frequency of pregnancy was higher among black girls and the frequency of cigarette smoking was higher among white girls (Table 1). A greater proportion of black girls came from single-parent households and had parents with lower levels of education and household income. Although school dropout rates in year 7 were similar in the two groups, 5.7

TABLE 1. COHORT CHARACTERISTICS ACCORDING TO RACE.*

VARIABLE	BLACK GIRLS (N=1213)	WHITE GIRLS (N=1166)
Body-mass index		
Year 1 (age, 9 or 10 yr)	19.2±4.1	17.9±3.3†
Year 3 (age, 11 or 12 yr)	21.5±5.1	19.9±4.0†
Year 5 (age, 13 or 14 yr)	23.7±5.8	21.6±4.3†
Year 7 (age, 15 or 16 yr)	25.1±6.4	22.7±4.6†
Year 8 (age, 16 or 17 yr)	25.9±7.0	23.1±4.8†
Maximal parental level of education (%)		
High school or less	31.6	20.3†
Some college	47.3	30.1
≥4 yr college	21.1	49.6
Annual household income (%)		
<$20,000	50.5	21.1†
$20,000–$39,999	27.6	30.8
≥$40,000	21.9	47.8
No. of parents in household (%)		
1	43.7	18.9†
2	56.3	81.1
Ever pregnant by year 8 (%)	22.3	7.5†
Cigarette smoking (%)	5.7	27.0†
School dropout rate (%)		
Year 7 (age, 15 or 16 yr)	1.8	1.5
Year 8 (age, 16 or 17 yr)	5.7	3.7‡

*Plus–minus values are means ±SD.

†P<0.001 for the comparison with black girls.

‡P=0.04 for the comparison with black girls.

percent of black girls had dropped out of school by year 8, as compared with 3.7 percent of white girls (P=0.04).

Decline in Activity

HAQ scores were skewed toward the lower end of the distribution at base line for both groups and shifted more to the left with time (Fig. 1). Racial differences became more notable at older ages, particularly at the lower end of the distributions.

The median activity score for the whole group decreased by 83 percent from year 1 (age, 9 or 10 years) to year 10 (age, 18 or 19 years) (Fig. 2). During the same period, the decrease in median HAQ scores for black girls was 100 percent, as compared with 64 percent for white girls (P<0.001). For both races, the mean annual decline in scores was greater at older ages (years 5 to 8: 4.1 MET-times per week for black girls and 3.5 MET-times per week for white girls) than at younger ages (years 1 to 5: 3.5 MET-times per week for black girls and 2.7 MET-times per week for white girls) (Fig. 2). Even at year 1, activity levels were lower for black girls than for white girls (P=0.008). By year 8 (age, 16 or 17 years), 56 percent of black girls and 31 percent of white girls reported no habitual leisure-time activity (HAQ scores of zero). School enrollment had no effect on HAQ scores at year 8 for either white or black girls.

Predictors of Decline from Year 1 to Year 5

Because in all the generalized-estimating-equation analyses household income was not significantly associated with changes in HAQ scores, the final analyses excluded income. For year 1 to year 5, parental education was associated with the extent of decline in activity among white girls, but not among black girls (Table 2). Among white girls, those for whom the maximal level of parental education was "some college" had a greater decline in physical activity than those who had at least one parent with four or more years of college. The decline was most marked in girls whose parents had attended high school only. Living in a single-parent household was not associated with decline in activity among either black girls or white girls.

The body-mass index at base line was directly associated with declines in activity scores for both races (P=0.006 for black girls and P=0.03 for white girls). For each additional 1 unit in body-mass index, the yearly decrease in activity scores was 0.17 MET-time per week for black girls and 0.21 MET-time per week for white girls. For each additional 1 MET-time per week in HAQ score at the outset, the yearly decline in activity scores was, on average, 0.79 MET-time per week for black girls and 0.82 MET-time per week for white girls (P<0.001).

Predictors of Decline from Year 5 to Year 8

Parental education continued to be inversely associated with the extent of decline in activity among white girls in years 5 to 8, although this association was less marked than during years 1 to 5 (Table 2). In this older age group, parental education was also inversely associated with decline in activity among black girls. As among white girls, the decline was greater for those whose parents had only a high-school education or less or some college education than for those with at least one college-educated parent.

In contrast to years 1 to 5, in years 5 to 8 living in a single-parent household was associated with a greater decline in activity than living in a two-parent household for white girls in this older age group; this association with household composition was not observed in older black girls. Higher body-mass index remained associated with a decline in activity among both black girls and white girls (Table 2). Higher HAQ scores were also associated with a decline in activity (P<0.001 for both groups).

Pregnancy was associated with a decrease in physical activity among black girls (P<0.001) but not among white girls, whereas cigarette smoking was as-

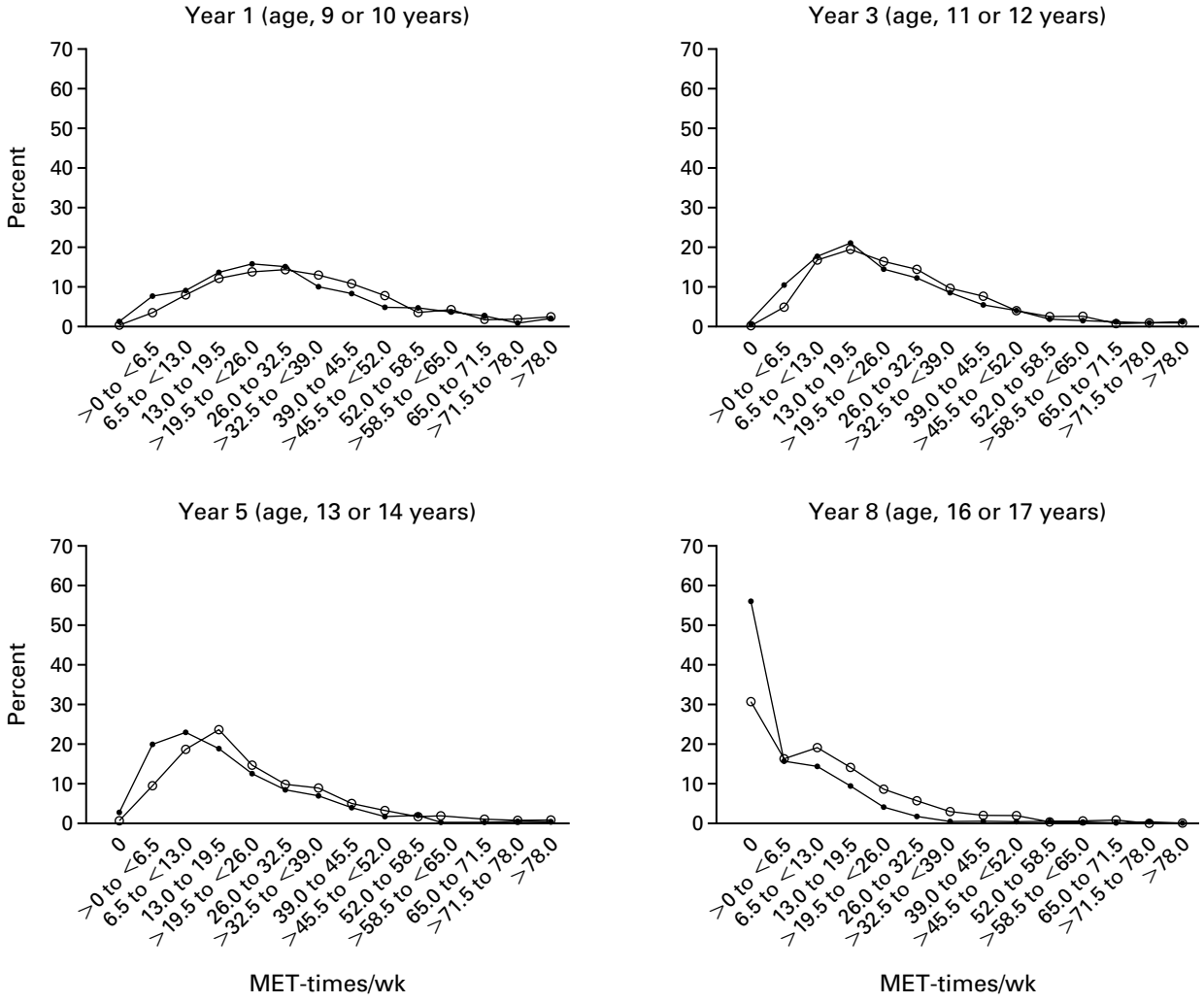

Figure 1. Frequency Distribution of Habitual Activity Questionnaire Scores According to Year of Study and Race. Scores are expressed in MET-times per week. Solid circles represent black girls, and open circles white girls.

sociated with a decrease in activity among white girls only ($P<0.001$) (Table 2).

DISCUSSION

Our findings suggest that levels of physical activity decline precipitously in girls in the United States during adolescence. Although the decline in our study began at the outset of adolescence, its rate accelerated so that by the ages of 18 and 19 years, the majority of the girls engaged in virtually no habitual physical activities other than those performed during school.

Because the study prospectively assessed physical activity in the same cohort of about 2400 girls, the natural history and determinants of this steep decline could be tracked through adolescence. Race was a factor, with black girls having a decline in activity twice that of white girls. Behavioral risk factors such as smoking (for white girls) and pregnancy (for black girls) also affected the decline in activity. Although information on the correlates of decline in activity among adults is limited, both childbirth (in Swedish women) and cigarette smoking (in U.S. men and women) have been found to be significant risk factors for inactivity and for a decline in leisure-time activities.[23,24] In our study, living in a single-parent household was a risk factor for a decline in activity among older white girls but not older black girls. A similar racial difference in the effect of household composition on obesity was reported previously.[25] Heavier girls of both races also had a greater decline in ac-

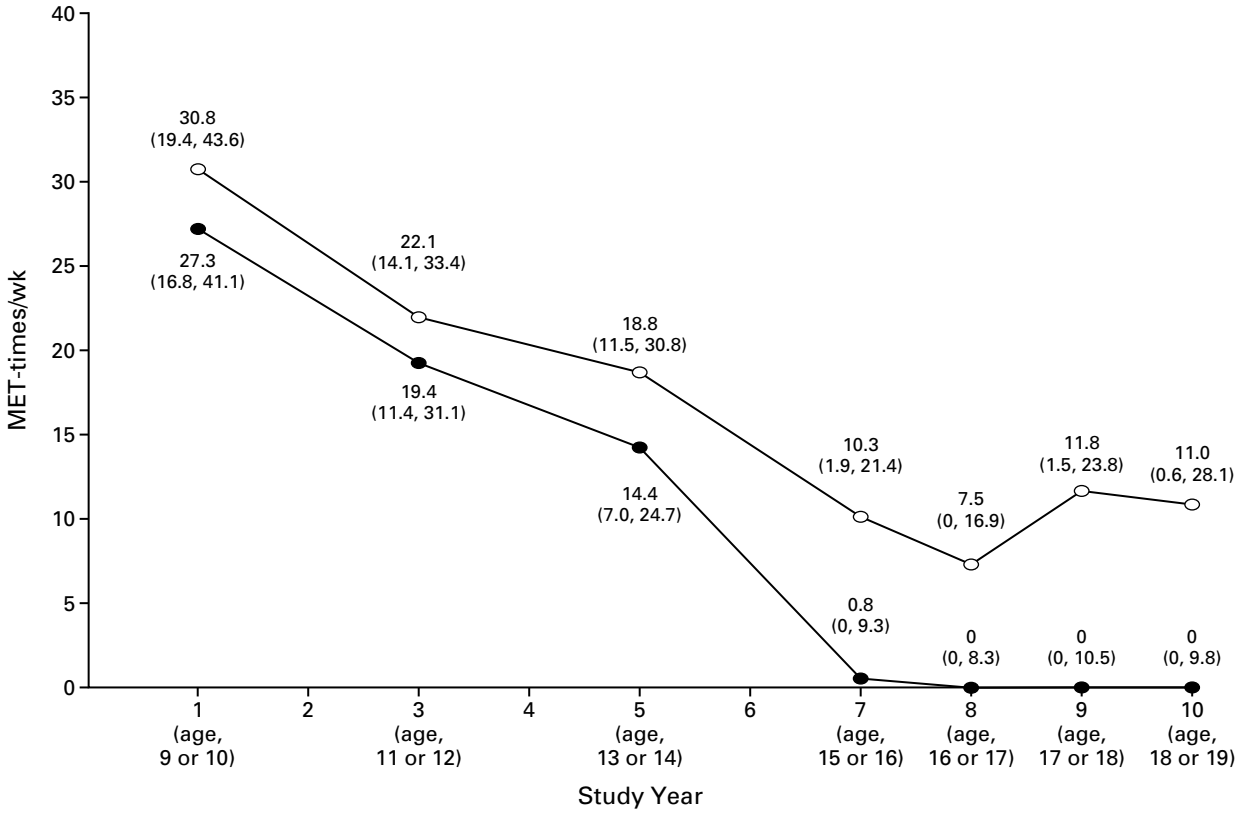

Figure 2. Median Habitual Activity Questionnaire Scores According to Year of Study and Race.
Scores are expressed in MET-times per week. Solid circles represent black girls, and open circles white girls. Values in parentheses are the 25th and 75th percentiles.

tivity than less heavy girls. Higher body-mass index has been observed as a barrier to activity in other studies.[26-28]

The relation between parental education and decline in physical activity differed according to race. For white girls, the level of parental education was inversely associated with the decline in activity throughout adolescence but became less pronounced at older ages. This observation suggests that as white girls get older, physical activity may become more self-motivated and less influenced by parents. In contrast, for black girls, an inverse association between parental education and decline in activity was manifested only at older ages.

It is uncertain why parental education was not related to the extent of decline in activity among black girls at younger ages. In a previous report from the National Heart, Lung, and Blood Institute Growth and Health Study, it was found that 9- and 10-year-old black girls felt socially accepted regardless of their degree of adiposity, and white girls with greater adiposity felt rejected.[29] Although there was less obesity among 9- and 10-year-old white girls from better-educated families, no such variation in obesity according to level of parental education was seen among black girls.[25] We speculate that as black girls become older, their ideal body image may evolve to be more consonant with that in the popular culture. Girls with better-educated parents may be better informed about or more encouraged to participate in physical activity to achieve this goal.

Annual household income, although generally correlated with educational level, was not associated with the decline in activity. The association of parental education, but not income, with health and behavior among white girls has been consistently found in other reports from the Growth and Health Study.[25,30,31] In addition, a previous report noted a lower prevalence of obesity among black mothers with higher levels of education, but not among those with higher income.[24] National data have also linked lower levels of education, but not of income, to physical inactivity and obesity in both white and black women.[12,13] The

TABLE 2. DETERMINANTS OF CHANGES IN HAQ SCORES ACCORDING TO PERIOD.*

PREDICTOR†	YEAR 1 TO YEAR 5				YEAR 5 TO YEAR 8			
	EFFECT SIZE IN BLACK GIRLS	P VALUE	EFFECT SIZE IN WHITE GIRLS	P VALUE	EFFECT SIZE IN BLACK GIRLS	P VALUE	EFFECT SIZE IN WHITE GIRLS	P VALUE
	MET-times/wk/yr		MET-times/wk/yr		MET-times/wk/yr		MET-times/wk/yr	
Parental level of education				<0.001		0.04		0.005
High school or less	−0.49		−4.34	<0.001	−1.28	0.01	−1.80	0.01
Some college	0.49		−2.53	0.003	−0.99	0.04	−1.57	0.003
Single-parent household	0.35		0.10		−0.02		−1.27	0.02
Ever pregnant	—		—		−1.91	<0.001	−0.25	
Cigarette smoking	—		—		−0.38		−1.89	<0.001
Body-mass index‡	−0.17	0.006	−0.21	0.03	−0.08	0.05	−0.08	0.05
HAQ score (MET-times/wk)‡	−0.79	<0.001	−0.82	<0.001	−0.43	<0.001	−0.35	<0.001

*HAQ denotes Habitual Activity Questionnaire, and MET metabolic equivalents. Effect size represents the change in HAQ scores (in MET-times per week per year) as compared with that in the reference category of the predictor variable of interest (for categorical variables) or per one-unit increase in the predictor variable of interest (for continuous variables), after adjustment for all other predictor variables listed. The effect size was determined with the use of generalized estimating equations. A decline of 4.34 MET-times per week per year, for example, is equivalent to one fewer time per week participating in bicycling or in walking for exercise. P values for tests of effect size different from 0 are given for statistically significant effects.

†The reference categories for categorical variables were as follows: parental level of education, four or more years of college; number of parents in household, two; pregnancy, never pregnant; and cigarette smoking, nonsmoker. Body-mass index and HAQ score were treated as continuous variables.

‡Data represent the values at the outset of each successive follow-up interval.

effect of education on activity among adolescent girls in this study and among U.S. women, regardless of race, suggests that educational underattainment has an important role in the development of sedentary lifestyles.

Some limitations of our measure of physical activity should be noted. The HAQ scores do not take into account the duration of the activities performed. This is because pilot testing indicated that girls 9 or 10 years of age were relatively unaware of the duration of activities, even when they were provided with wristwatches. Also, activities such as nonrecreational walking are not included in this measure. However, omission of these activities would not be expected to account for racial differences or observed declines in activity over time.

We documented a precipitous drop in levels of activity during adolescence among both black girls and white girls, and the drop was particularly marked among black girls. These findings should sound an alarm, given the current epidemic of obesity. Some of the identified risk factors for declining activity could be helpful in prioritizing resources to reach more vulnerable girls. Moreover, some determinants of declining activity levels, such as teenage pregnancy and cigarette smoking, are possible targets of structured interventions to increase physical activity among adolescents.

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REFERENCES

1. Troiano RP, Flegal KM, Kuczmarski RJ, Campbell SM, Johnson CL. Overweight prevalence and trends for children and adolescents: the National Health and Nutrition Examination Surveys, 1963 to 1991. Arch Pediatr Adolesc Med 1995;149:1085-91.

2. Carroll MD, Abraham S, Dresser CM. Dietary intake source data: United States, 1976-80. Advance data from vital and health statistics. No. 231. Hyattsville, Md.: National Center for Health Statistics, 1983. (DHHS publication no. [PHS] 83-1681.)

3. McDowell MA, Briefel RR, Alaimo K, et al. Energy and macronutrient intakes of persons ages 2 months and over in the United States: Third National Health and Nutrition Examination Survey, Phase 1, 1988-91. Advance data from vital and health statistics. No. 255. Hyattsville, Md.: National Center for Health Statistics, 1994:1-24. (DHHS publication no. [PHS] 94.)

4. Kann L, Kinchen SA, Williams BI, et al. Youth risk behavior surveillance — United States, 1997. MMWR Morb Mortal Wkly Rep CDC Surveill Summ 1998;47:SS-3:1-89.

5. Sallis JF, Simons-Morton BG, Stone EJ, et al. Determinants of physical activity and interventions in youth. Med Sci Sports Exerc 1992;24:Suppl 6:S248-S257.

6. Department of Health and Human Services. Physical activity and health: a report of the Surgeon General. Atlanta: Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, 1996.

7. Heath GW, Pratt M, Warren CW, Kann L. Physical activity patterns in American high school students: results from the 1990 Youth Risk Behavior Survey. Arch Pediatr Adolesc Med 1994;148:1131-6.

8. Aaron DJ, Kriska AM, Dearwater SR, et al. The epidemiology of leisure physical activity in an adolescent population. Med Sci Sports Exerc 1993; 25:847-53.

9. Sallis JF, Zakarian JM, Hovell MF, Hofstetter CR. Ethnic, socioeconomic, and sex differences in physical activity among adolescents. J Clin Epidemiol 1996;49:125-34.
10. Trost SG, Pate RR, Saunders R, Ward DS, Dowda M, Felton G. A prospective study of the determinants of physical activity in rural fifth-grade children. Prev Med 1997;26:257-63.
11. Washburn RA, Kline G, Lackland DT, Wheeler FC. Leisure time physical activity: are there black/white differences? Prev Med 1992;21:127-35.
12. Crespo CJ, Smit E, Andersen RE, Carter-Pokras O, Ainsworth BE. Race/ethnicity, social class and their relation to physical inactivity during leisure time: results from the Third National Health and Nutrition Examination Survey, 1988-1994. Am J Prev Med 2000;18:46-53.
13. Crespo CJ, Ainsworth BE, Keteyian SJ, Heath GW, Smit E. Prevalence of physical inactivity and its relation to social class in U.S. adults: results from the Third National Health and Nutrition Examination Survey, 1988-1994. Med Sci Sport Exerc 1999;31:1821-7.
14. Wolf AM, Gortmaker SL, Cheung L, Gray HM, Herzog DB, Colditz GA. Activity, inactivity, and obesity: racial, ethnic, and age differences among schoolgirls. Am J Public Health 1993;83:1625-7.
15. Sallis JF, Alcaraz JE, McKenzie TL, Hovell MF. Predictors of change in children's physical activity over 20 months: variations by gender and level of adiposity. Am J Prev Med 1999;16:222-9.
16. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. Med Sci Sports Exerc 2000;32:963-75.
17. Obesity and cardiovascular disease risk factors in black and white girls: the NHLBI Growth and Health Study. Am J Public Health 1992;82:1613-20.
18. Kimm SYS, Barton BA, Obarzanek E, et al. Racial divergence in adiposity during adolescence: the NHLBI Growth and Health Study. (Accessed July 1, 2002, at http://www.pediatrics.org/cgi/content/full/107/3/e34.)
19. Kimm SY, Glynn NW, Kriska AM, et al. Longitudinal changes in physical activity in a biracial cohort during adolescence. Med Sci Sports Exerc 2000;32:1445-54.
20. Kriska AM, Casperson CJ. Introduction to a collection of physical activity questionnaires. Med Sci Sports Exerc 1997;29:Suppl 6:S5-S9.
21. SAS/STAT user's guide, version 8. Cary, N.C.: SAS Institute, 1999.
22. Draper NR, Smith H. Applied regression analysis. New York: Wiley, 1966.
23. Barnekow-Bergkvist M, Hedberg G, Janlert U, Jansson E. Physical activity pattern in men and women at the ages of 16 and 34 and development of physical activity from adolescence to adulthood. Scand J Med Sci Sports 1996;6:359-70.
24. Lazarus NB, Kaplan GA, Cohen RD, Leu DJ. Smoking and body mass in the natural history of physical activity: prospective evidence from the Alameda County Study, 1965-1974. Am J Prev Med 1989;5:127-35.
25. Kimm SY, Obarzanek E, Barton BA, et al. Race, socioeconomic status, and obesity in 9- to 10-year-old girls: the NHLBI Growth and Health Study. Ann Epidemiol 1996;6:266-75.
26. Kimm SYS, Glynn NW, McMahon RP, Streigel-Moore R, Voorhees C. Barriers to physical activity in a biracial cohort of adolescent girls: perception or reality? Ann Behav Med 1999;21:Suppl:S206.
27. Ball K, Crawford D, Owen N. Too fat to exercise? Obesity as a barrier to physical activity. Aust N Z J Public Health 2000;24:331-3.
28. Trost SG, Kerr LM, Ward DS, Pate RR. Physical activity and determinants of physical activity in obese and non-obese children. Int J Obes Relat Metab Disord 2001;25:822-9.
29. Kimm SYS, Barton BA, Berhane K, Ross JW, Payne GH, Schreiber GB. Self-esteem and adiposity in black and white girls: the NHLBI Growth and Health Study. Ann Epidemiol 1997;7:550-60.
30. Crawford PB, Obarzanek E, Schreiber GB, et al. The effects of race, household income, and parental education on nutrient intake of 9- and 10-year-old girls: NHLBI Growth and Health Study. Ann Epidemiol 1995;5:360-8.
31. McNutt SW, Hu Y, Schreiber GB, Crawford PB, Obarzanek E, Mellin L. A longitudinal study of the dietary practices of black and white girls 9 and 10 years old at enrollment: the NHLBI Growth and Health Study. J Adolesc Health 1997;20:27-37.