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ARTICLE

Steroid Use Among Adolescents: Longitudinal Findings From Project EAT

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ABSTRACT

OBJECTIVE. We examined the prevalence, persistence, secular and longitudinal trends, and predictors of steroid use in a diverse sample of adolescents.

PARTICIPANTS AND METHODS. Data are from Project EAT-II (Eating Among Teens), a 5-year longitudinal study of eating, activity, weight, and related variables in 2516 middle and high school students. Data were collected in 1999 (time 1) and 2004 (time 2).

RESULTS. Approximately 1.5% of adolescents reported steroid use at time 2. Use differed by ethnicity but not socioeconomic status. Steroid use was not stable across time, although the risk of use at time 2 was higher for girls and (marginally) for boys who used steroids at time 1. No secular trends were noted in middle adolescents' steroid use between 1999 and 2004. Developmentally, steroid use decreased as adolescents grew older. Predictors of use for male adolescents included wanting to weigh more and reporting higher use of healthy weight-control behaviors. Female time 2 steroid users had higher BMIs and were less satisfied with their weight, had poorer nutrition knowledge and concern for health, and were marginally more likely to have participated in weight-related sports at time 1.

CONCLUSIONS. The prevalence of steroid use in adolescents was low but of concern. Although use was not persistent over 5 years, time 1 use was a risk factor for time 2 use in female adolescents. There was no change in the prevalence of steroid use by middle adolescents between 1999 and 2004 despite a great deal of public interest in steroids during this time period. Steroid use decreased as adolescents grew older. Weight-related variables predicted adolescents' steroid use 5 years later, and health and nutrition knowledge and concern and (marginally) participation in weight-related sports further predicted use in female adolescents. These findings suggest that early preventive efforts may be most useful.

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Key Words
steroids, anabolic agents, adolescent, body image, body composition, sports

Abbreviations
YRBS—Youth Risk Behavior Survey
Project EAT—Project Eating Among Teens
SES—socioeconomic status
OR—odds ratio

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ANABOLIC-ANDROGENIC STEROIDS ARE synthetic derivatives of testosterone that act to increase protein synthesis and the development of male secondary sex characteristics.[1] They are typically taken to increase muscle mass and strength, for either improved sports performance or to enhance appearance.[2] In studies of adults, anabolic steroids have been found to have significant adverse effects on the musculoskeletal, cardiovascular, endocrine/reproductive, and hepatic systems, as well as variability in mood and other possible psychological effects.[3] Given these serious consequences, it is important to understand the prevalence, persistence, secular changes, longitudinal trends, and predictors of steroid use in adolescents.

PREVALENCE

The prevalence of steroid use has been estimated in several large survey studies of adolescents. Overall, a nontrivial percentage of adolescents admit having used steroids, with boys generally having higher rates. The 2004 Monitoring the Future Study[4] reported that annual prevalences were 1.3% and 3.3% for 8th- and 12th-grade boys, respectively, whereas the prevalences in girls were 1.0% and 1.7% in 8th- and 12th-graders. These prevalences were based on samples of ~17 000 8th-graders and 14 600 12th-graders. Other surveys have shown comparable prevalences.[5] For instance, in a previous cross-sectional analysis of the time 1 data we used in this study ($N = 4476$),[6] we found annual prevalences of 4.4% among older adolescent boys and 1.4% among older adolescent girls, and slightly higher prevalences of 7.6% (boys) and 5.7% (girls) among younger adolescents. The 2005 Youth Risk Behavior Surveillance (YRBS) study reported lifetime prevalences of 4.8% in boys and 3.2% in girls in their sample of 13 953 adolescents in grades 9 through 12.[7]

SECULAR TRENDS

The prevalence of steroid use among adolescents rose throughout the 1990s,[7] causing concern among health professionals. However, research has not consistently shown that this increase continued into the next century. For instance, the Monitoring the Future study[4] found sharp increases in steroid use in 1999–2000, especially among boys. However, prevalences for the most part leveled off thereafter. In the YRBS, there was an upward trend in lifetime prevalence of steroid use between 1991 and 2003, but between 2003 and 2005 prevalences decreased somewhat.[7] Given recent publicity surrounding the use of anabolic-androgenic steroids and other performance-enhancing substances by professional and elite athletes,[8] it is important to determine whether use is still increasing or has leveled off or even decreased over the last 5 to 10 years.

LONGITUDINAL TRENDS

The research to date on developmental changes in steroid use is contradictory and primarily uses data from cross-sectional studies, which are not ideal for investigating longitudinal trends. In Monitoring the Future,[4] a cross-sectional study, prevalence of steroid use seemed to rise across increasing grade level. However, other samples have shown decreasing rates with increasing age or grade. For instance, a survey of Connecticut youth found decreases in use across 7th to 11th grades in male adolescents.[5] Regarding longitudinal studies, most research has involved constructs related to steroid use, but not steroid use itself. For instance, a recent longitudinal study of preadolescents used a composite measure of different strategies to increase muscularity, including exercising, eating, and the use of food supplements, but not the use of steroids. Findings indicated that strategies to gain muscles decreased over 16 months of follow-up in 8- to 11-year-olds.[9] In a similar study of adolescent boys 11 to 16 years old, researchers found a correlation of only 0.37 over 8 months on scores on a composite measure of strategies to increase muscles.[10] The only longitudinal study of steroid use itself that we could locate was conducted recently by Dodge and Jaccard,[11] who used data on 15 000 adolescents in the National Longitudinal Study of Adolescent Health. These researchers examined longitudinal predictors of steroid use but did not investigate longitudinal trends in the prevalence of steroid use. Although the studies conducted to date are suggestive, research that specifically examines longitudinal trends in steroid use is necessary to understand developmental changes in steroid use in adolescents.

PREDICTORS OF STEROID USE

Previous studies have identified several possible predictors of anabolic steroid use. One cross-sectional study of middle school boys found that self-reported media and parent and peer pressures regarding weight or muscles, as well as depression, negative body image, and tendency to compare one's appearance to that of others all distinguished boys who used steroids from those who did not.[12] Other researchers have found that perceived pressure to increase muscularity from the media, parents, and peers, as well as increased negative or decreased positive affect, predicted the use of muscle-building strategies 16 months later in both boys and girls[9]; however, the authors did not study steroid use specifically. In previous cross-sectional studies of body image and steroid use, a complex relationship has been found, suggesting perhaps that wanting to be larger may be associated with onset of use, but that users may have increased satisfaction.[13] However, longitudinal studies of body image and steroid use have not been conducted to date.[2] Participation in various types of sports, especially power sports such as football, wrestling, and track and

field, have been found in cross-sectional studies to be associated with increased steroid use, especially in boys.[2,14,15] In addition, the study by Dodge and Jaccard described above examined the longitudinal association between high school sports participation and later steroid use. They found a nonsignificant association between sports participation and steroid use, but a significant interaction between gender and sports participation, such that boys were at higher risk for steroid use overall compared with girls, and even more so if they had participated in sports in high school. The cross-sectional findings regarding higher or lower BMI as a possible risk factor have been inconsistent across age group and study, with some studies finding that lower BMI was associated with steroid use, and others finding no relationship, or a relationship with higher BMI.[2,5] Steroid use in boys has also been associated in several cross-sectional studies with the use of other illicit substances and other high risk behaviors, such as having unprotected sex, driving while under the influence of alcohol, and possessing a gun.[14,16] In sum, cross-sectional studies have generated a number of suggestive associations, and 1 longitudinal study has suggested that sports participation predicts steroid use longitudinally, at least in boys. However, we are unaware of any longitudinal studies that have tested associations with other variables over time.

Our group previously examined correlates of steroid use in a cross-sectional analysis of the time 1 data from Project EAT (Eating Among Teens[6]), which is the project on which the current longitudinal study is based. We found that for boys, factors associated with higher steroid use included dissatisfaction with one's shoulders, parental concern and family teasing about weight, self-report of binging and unhealthy weight-control behaviors and self-report of having received an eating disorder diagnosis, low self-esteem, depressed mood and a history of suicide attempts, poorer health and nutrition knowledge and attitudes, participation in weight-related sports, and use of alcohol, cigarettes, marijuana, and other drugs. The significant correlates of steroid use were similar for girls, including weight and shape concerns, low self-esteem and a history of suicide attempts, poorer nutrition and health knowledge and attitudes, involvement in weight-related sports, parental concern about weight, unhealthy weight-control behaviors, binging and eating disorder diagnosis, and use of marijuana and other drugs. However, because this was a cross-sectional study, the temporal order of these associations could not be established.

In summary, nearly all of the literature on steroid use in adolescence is based on cross-sectional studies and, therefore, cannot inform our understanding of developmental changes in steroid use and cannot distinguish between predictors and correlates of steroid use. Our study is a 5-year longitudinal study intended to address the gaps in the literature on steroid use in adolescence and to extend the findings of our previous work with this population. The aims of this study were to examine the prevalence of steroid use in our sample in 2004–2005 (time 2), the persistence of steroid use between time 1 and time 2, the secular and longitudinal changes in steroid use across the 5 years of follow-up, and the personal, socioenvironmental, and behavioral variables that predicted steroid use 5 years later.

METHODS

Study Sample and Design

Project EAT is a 5-year longitudinal study examining eating behaviors, weight concerns, and related variables in a large, ethnically diverse population of adolescents.[17,18] The first wave of data collection, time 1, took place in the 1998–1999 academic year, and the second wave, time 2, took place in the 2003–2004 academic year. Participants were recruited from 31 urban and suburban public middle and high schools in the Minneapolis/St Paul, Minnesota, metro area. The study sample at time 1 consisted of 4746 adolescents in 7th through 12th grades, with approximately equal numbers of boys and girls. Participants completed in-class surveys, and trained research staff measured their height and weight in a private area of the school. At time 2, surveys were mailed to the address given by the participant at time 1. In those cases where mail was returned because of an incorrect address, Internet tracking services were used to identify correct addresses. Initial nonresponders were sent 2 reminder postcards and 3 additional survey packets to encourage participation. Of the original sample at time 1, 1074 (22.6%) were unable to be followed, primarily because of missing or obsolete contact information. Of the remaining 3672 participants to whom surveys were mailed, 2516 responded, comprising 53.0% of the original cohort and 68.4% of participants with valid contact information at time 2. Of the 186 steroid users at time 1, 38 boys (32% of the time 1 male users) and 33 girls (49% of the time 1 female users) were included in our study.

The final study population consisted of 1130 boys (45%) and 1386 girls (55%) who completed surveys at both time 1 and time 2. The one third of the participants (32%) who were originally in middle school comprised the younger cohort; at time 1 their mean age was 12.8 years (SD: 0.8) and at time 2 their mean age was 17.2 years (SD: 0.6). The two thirds of the participants (68%) who were originally recruited from high schools constituted the older cohort; at time 1 their mean age was 15.8 years (SD: 0.8) and at time 2 their mean age was 20.4 years (SD: 0.8). Of this older cohort, 66% reported attending school full- or part-time during the previous year, 48% reported that they lived in their parents' home during the previous year, and 54% reported that they worked <30 hours per week during the previous

year. The University of Minnesota's Institutional Review Board Human Subjects Committee approved all study protocols.

Measures

The time 1 Project EAT survey contained 221 questions chosen from the literature or developed for the study by the research team in consultation with other experts in the area and with input from focus groups of adolescents.[19] Pilot testing was conducted with 7th- and 10th-graders, and revisions were undertaken in compiling the final survey packet. Some of the time 1 survey items were revised for time 2, but none of those items were used in this study; therefore, the items used were identical at time 1 and time 2 for both the older and younger cohorts.

Anabolic Steroid Use

Steroid use was assessed with the question "How often have you used steroids to gain muscle, during the past year (12 months): (1) Never, (2) A few times, (3) Monthly, (4) Weekly, (5) Daily?" This question was previously used in the Voice of Connecticut Youth survey.[20] Responses were dichotomized into "never" versus "ever."

Personal Factors

Weight and Shape Concerns

Weight concern was assessed with 4 items regarding thinking about being thinner, being worried about gaining weight, weighing oneself often, and skipping meals because of concern about weight.[21] Cronbach's α was .76 at time 1. Weight importance was assessed with an item adapted from the Questionnaire on Eating and Weight Patterns-Revised[22]: "During the past six months, how important has your weight or shape been in how you feel about yourself?" Three items from the Body Shape Satisfaction scale[23] were used to assess satisfaction with appearance. Participants rated on a 5-point scale their level of satisfaction with their body build, shoulders, and weight. Cronbach's α for the entire 10-item scale in this study was .92. Weight discrepancy was calculated by dividing self-reported "ideal weight" (ie, "At what weight do you think you would look best?") by self-reported current weight and multiplying this ratio by 100.[24] BMI was computed from measured height and weight at time 1 by using the formula: weight in kilograms divided by height in meters squared.

Psychological Measures

A 6-item shortened version of the Rosenberg Self-esteem scale[25] assessed general self-esteem. Cronbach's α for the scale was .79. Depressive symptoms were assessed using a 6-item scale developed by Kandel and Davies.[26] Chronbach's α in the current sample was .82 at time 1. Suicidal ideation and previous attempts were each assessed with 1 question: "Have you ever thought about killing yourself?" and "Have you ever tried to kill yourself?" These questions have been used in previous population-based surveys of adolescents.[27]

Health/Nutrition Knowledge and Attitudes

To assess knowledge of healthy eating, participants were instructed to indicate which food was healthier for each of 7 pairs of food items (for example, "frozen yogurt" and "ice cream"). The participant's score was the number of correct responses. Cronbach's α for this scale was .63. To assess self-efficacy for making healthy food choices, participants indicated their level of certainty that they could eat healthy foods when feeling certain emotions (for example, "stressed out") or when in certain situations (for example, "hungry after school"). The scale consisted of 9 items, and Cronbach's α was .85. Concern about health was assessed by responses to 5 questions regarding the importance of health and healthy eating. For this measure, Cronbach's α was .70 at time 1.

Socioenvironmental Factors

Sports Involvement

Weight related sports participation was assessed with the question "Are you in a sport or activity where it's important to stay a certain weight (wrestling, gymnastics, ballet, etc)?"

Weight-Related Norms/Teasing

Parental concern with weight consisted of 4 items asking about the participant's mother's and father's tendency to diet and to encourage the participant to diet to control weight. Cronbach's α at baseline was .76. Peer dieting behavior was assessed by the question, "Many of my friends diet to lose weight or keep from gaining weight." Weight teasing by family and by peers were each assessed with 1 question adapted from the Perception of Teasing scale, which has shown good reliability and validity in previous studies.[28]

Behavioral Factors

Physical Activity Level

A modified version of the Leisure Time Exercise Questionnaire[29] was used to assess hours of weekly activity. Participants reported the number of hours per week spent engaging in strenuous, moderate, and mild exercise. The test-retest correlation for this measure was .69 in previous research.[30]

Unhealthy Eating/Weight Control

To assess weight-control behaviors, participants were instructed to endorse the methods they had used during the past year to lose or maintain weight. Four items were healthy weight-control behaviors (for example, "ate more fruits and vegetables"), and 5 were unhealthy

behaviors (for example, "skipped meals").[17] To assess current weight gain/loss attempts, participants indicated whether they were currently trying to lose, maintain, or gain weight, or not doing anything about their weight.[31] Self-report of eating disorder diagnosis was assessed with the question "Has a doctor ever told you that you have an eating disorder such as anorexia nervosa, bulimia nervosa, or binge eating disorder?"[17] Binge eating was assessed with a combination of 2 items regarding binging and loss of control, from the Questionnaire on Eating and Weight Patterns-Revised.[22] Participants who answered "yes" to both questions were classified as having binged.

Substance Use

Participants were asked about past year use of cigarettes, alcohol, marijuana, and other drugs ("drugs other than marijuana [acid, crack, cocaine, etc]").[6] Response options ranged from "never" to "daily," and each item was dichotomized for analysis ("never" or "any").

Sociodemographic Characteristics

Gender, age (in years), ethnicity/race, and socioeconomic status (SES) were based on self-report at time 1. SES was calculated using on an algorithm that weighted parental education level most heavily but also took into account family eligibility for public assistance, eligibility for free or reduced-cost school meals, and employment status of the mother and father (see ref 18 for more information).

Statistical Analysis

Attrition at time 2 differed across sociodemographic characteristics. Thus, in all analyses participants' responses were weighted to adjust for this differential response rate. The response propensity method[32] was used to generate the weights, such that an individual's weight was the inverse of the estimated probability that the individual responded at time 2. Response propensities (ie, the probability of responding to the time 2 survey) were estimated using a logistic regression, with a large number of predictor variables from the time 1 survey predicting response at time 2 (yes/no). The selected response propensity model included main effects for time 1 gender, native-born status, ethnicity/race, SES, overweight status, parental marital status, individual's concern about health, and most common grade received in school. In addition, weights were calibrated so that the weighted total sample sizes we used in analyses for each gender cohort accurately reflected the actual observed sample sizes in those groups. The weighting method resulted in estimates representative of the demographic make-up of the original time 1 sample. The weighted ethnic/racial and SES proportions are as follows: 48.3% white, 18.9% black, 5.8% Hispanic, 19.6% Asian, 3.6% Native American, and 3.8% mixed or other race, and SES was low (17.8%), middle-low (18.9%), middle (26.7%), middle-high (23.3%), and high (13.3%).

All analyses were stratified by gender. Initial analyses included examination of the frequency of steroid use in male and female adolescents and demographic characteristics of adolescents who did and did not use steroids. Persistence of steroid use was investigated by examining the percentages of participants who used steroids at time 1 and time 2, as well as the incidence of new users of steroids and time 1 users who did not report use at time 2. Secular and longitudinal trends in prevalence of steroid use were examined using mixed model regressions,[33] with main effects for both year (1999 or 2004) and cohort (younger or older), a year by cohort interaction, and a random effect for individuals to account for longitudinal correlation. These mixed models were stratified by cohort and gender and adjusted for race/ethnicity and SES. Adjustment for race/ethnicity and SES was conducted to assure that the comparisons between 1999 and 2004 prevalences were not confounded by differences between the older and younger cohorts on race/ethnicity and SES.

Logistic regression was used to estimate the association between time 1 variables and the outcome of steroid use. Unadjusted means and prevalences for steroid users and nonusers are reported for continuous and dichotomous independent variables, respectively. Odds ratios (ORs) and the corresponding *P* values are adjusted for time 1 steroid use and sampling weights (although not for demographics because of the small number of steroid users). Standardized odds ratios are presented to allow comparison across differently scaled variables. *P* values were set at .05 without adjustment for multiple tests because of the exploratory nature of these analyses and the low base rate of steroid use. SAS 9.1 was used for all analyses.[34]

RESULTS

Descriptive Characteristics

Overall, 1.4% of female and 1.7% of male adolescents reported having used anabolic steroids in the last year; the difference in prevalence between genders was not statistically significant ($P = .57$) (Table 1). Among the male steroid users, 54% reported having used steroids a few times in the past year, 18% reported monthly use, 18% reported weekly use, and 10% reported daily use. The percentages for female users were 83%, 5%, 12%, and 0%, respectively. Regarding differences by age cohort, the younger group showed a higher prevalence of steroid use, which in male adolescents reached significance. Boys in the younger cohort, which had been in middle school at time 1, were nearly 3 times more likely to report steroid use than male adolescents in the older cohort.

The prevalence of steroid use differed across race/

TABLE 1 Time 2 Anabolic Steroid Use to Gain Muscle in the Past 12 Months According to Gender, Cohort, Race, and SES

	Male Adolescents ($n = 1130$)		Female Adolescents ($n = 1386$)	
	%	*n*	%	*n*
Gender	1.7	19	1.4	19
Cohort				
Older	1.1	8	1.2	11
Younger	3.1	11	1.9	8
P[a]	.02		.35	
Race				
White	1.3	8	0.1	1
Black	0.5	1	3.8	10
Hispanic	0.0	0	2.6	2
Other Asian	1.4	1	0.0	0
Native American	9.8	4	0.0	0
Mixed	0.0	0	0.0	0
Hmong	4.2	6	2.8	5
P	<.001		<.001	
SES				
Low	2.2	3	.8	2
Low-middle	1.4	3	2.3	6
Middle	2.5	7	1.1	3
High-middle	0.6	2	2.3	6
High	1.6	2	0	0
P	.51		.16	

Frequencies were weighted for nonresponse at time 2.
[a] *P* values are from χ^2 tests of independence.

TABLE 2 Temporal Stability of Steroid Use According to Gender

Time 1 Steroid Use	Time 2 Steroid Use			
	Boys		Girls	
	Nonusers ($n = 991$)	Users ($n = 15$)[a]	Nonusers ($n = 1224$)	Users ($n = 19$)
Nonusers				
%	98.7	1.3	98.8	1.2
n	952	13	1184	14
Users				
%	96.0	4.0	88.9	11.1
n	39	2	40	5
P[a]		.15		<.01

[a] Four male time 2 users were excluded because of missing data on time 1 use.
[b] *P* values are from χ^2 tests of independence conducted separately according to gender. Because of small cell sizes, Fisher's exact χ^2 was also computed, and results did not differ substantively from those indicated above.

ethnicity; however, the small number of steroid users limits our ability to draw conclusions regarding individual racial/ethnic categories. Simple examination of the data suggests that among male adolescents, Native American and Hmong participants had higher prevalences than did other groups, whereas among female adolescents, black participants had a higher prevalence of steroid use. Significant differences were not found across SES categories.

Temporal Stability of Self-reported Steroid Use

The temporal stability of steroid use was low overall. Of the 41 boys who reported steroid use at time 1, only 2 (4%) also reported use at time 2 (Table 2). Of 45 girls who indicated they had used steroids at time 1, only 5 (11%) again indicated that they used steroids at time 2. The incidence of new users was 1.3% for boys and 1.2% for girls. The odds of using steroids at time 2 were not significantly higher for boys who used steroids at time 1 compared with nonusers at time 1 ($P = .15$; OR: 3.15; 95% confidence limit: 0.60, 16.51). However, for girls the odds of time 2 use were ~10 times higher among those who had used at time 1, compared with those who were nonusers at time 1 (OR: 10.37; 95% confidence limit: 3.57, 30.17).

Secular and Longitudinal Trends in Steroid Use

Figure 1 depicts the secular trends in steroid use for middle adolescent boys and middle adolescent girls between 1999 and 2004, as well as the developmental changes in steroid use between early and middle adolescence, and between middle and late adolescence. Secular changes can be identified by comparing the prevalence in the younger cohort (solid lines) to that in the older cohort (broken lines) at the middle of the graph, which is middle adolescence. In neither male (difference in prevalence: 1.7%, $P = .14$) nor female adolescents (difference in prevalence: 0.1%, $P = .91$) was there a significant secular trend in steroid use between 1999 and 2004 among middle adolescents.

However, both the younger and older cohorts of male adolescents showed significant longitudinal decreases in steroid use across the 5 years of follow-up. Among female adolescents, only the younger cohort had a significant longitudinal decrease in steroid use between time 1 and time 2. The older female cohort had a very low prevalence at time 1, creating a floor effect with very little decrease possible over follow-up.

Predictors of Steroid Use

For male adolescents, 2 variables were significant predictors of time 2 steroid use. Having an ideal body size that is larger than one's current body size and self-report of healthy weight-control behaviors at time 1 predicted steroid use 5 years later (Table 3).

For female adolescents, lower satisfaction with weight and higher BMI at time 1 were significant predictors of time 2 steroid use (Table 4). Time 2 steroid users also showed a higher mean level of satisfaction with their shoulders at time 1. In addition, lower levels of knowledge of healthy eating and concern with health at time 1 characterized time 2 users. Those who used steroids at time 2 were over twice as likely as nonusers to have participated in weight-related sports at time 1, although this trend was only marginally significant.

DISCUSSION

The aims of this study were to examine the prevalence of steroid use, the persistence of steroid use across time,

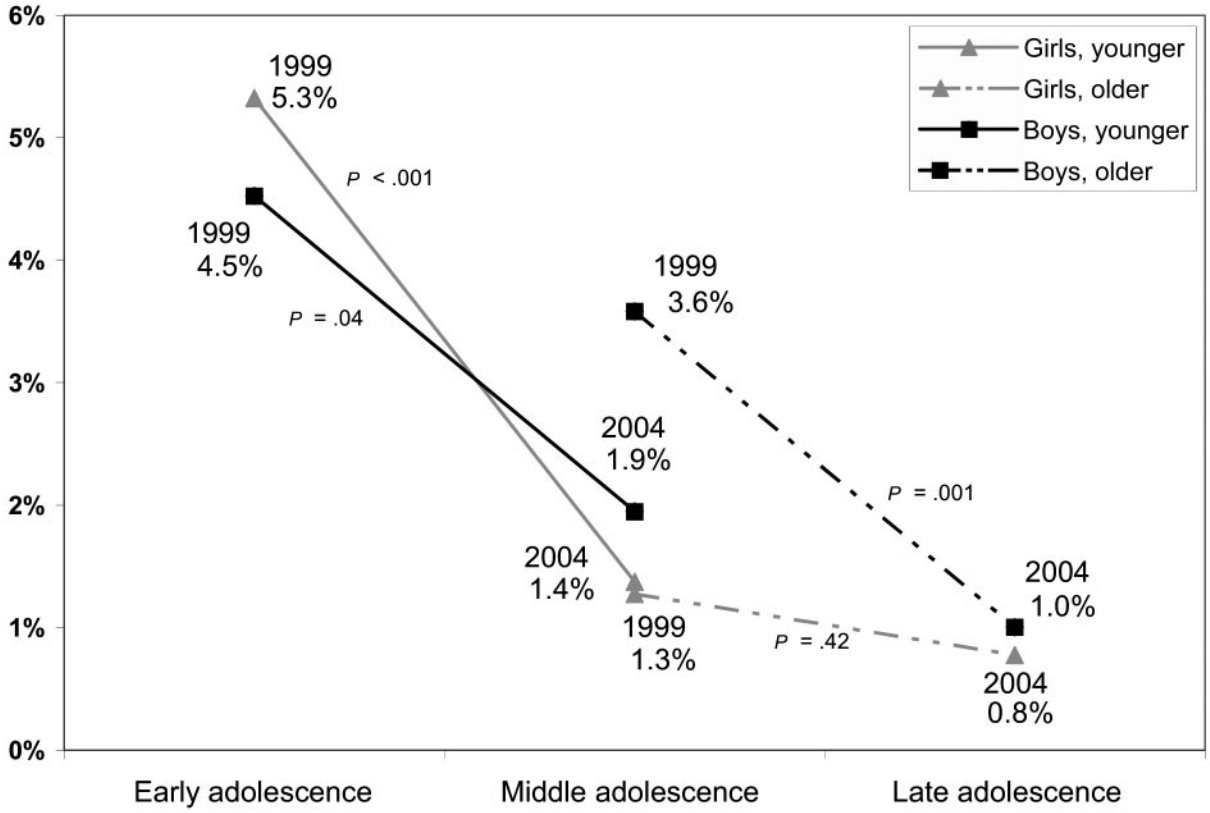

FIGURE 1
Secular and longitudinal trends in anabolic-androgenic steroid use. Adjusted for race and SES. Prevalences differ slightly from those shown in Tables 1 and 2 because of adjustment and missing data. Secular trends are illustrated by comparing the percentages of participants in middle adolescence who reported steroid use in 1999 with those who reported steroid use in 2004 (male steroid users [3.6% in 1999 vs 1.9% in 2004; $P = .14$]; female steroid users [1.3% in 1999 vs 1.4% in 2004; $P = .91$]). *P* values for longitudinal trends are shown.

secular and longitudinal changes in steroid use over 5 years, and the personal, environmental, and behavioral predictors of steroid use 5 years later. This study comprises one of the first longitudinal investigations of steroid use in adolescents.

In this second wave of Project EAT, ~1.5% of male and female adolescents reported having used steroids for muscle gain, with no significant difference in prevalence between genders. With regard to the persistence of steroid use across the 5 years of follow-up, the vast majority of participants who were using at time 1 were not still using at time 2, although the odds of time 2 use were 10 times higher for girls who had used at time 1 compared with nonusers at time 1. Likewise, although not statistically significant, the odds of using at time 2 were 3 times higher for boys who had reported use at time 1. There were no significant secular changes found for steroid use between 1999 and 2004. However, in our examination of longitudinal trends we found that the prevalence of steroid use decreased significantly as adolescents grew older for all but the older female cohort. Regarding the longitudinal predictors of steroid use, few variables held up over 5 years and after adjusting for baseline steroid use. For boys, wanting to have a larger body size predicted steroid use 5 years later, as did the use of healthy weight-control behaviors. For girls, lower satisfaction with body weight and higher BMI predicted later steroid use, as did lower levels of knowledge of healthy eating and concern with health. There was also a marginally significant relationship between time 2 steroid use and time 1 participation in weight-related sports. Higher satisfaction with their shoulders also predicted time 2 use among girls.

The prevalences of steroid use in this study are similar to, or lower than, those reported in other studies. For instance, as previously discussed, the 2004 Monitoring the Future Study[4] reported annual prevalences of 1.3% and 3.3% of middle and high school boys, and 1.0% and 1.7% of middle and high school girls, in line with our findings. It is possible that the prevalences found in this study are lower than some others due to underreporting, because complete anonymity cannot be maintained in a longitudinal study. However, if this were biasing the prevalences, we would have expected to see lower time 1 prevalences as well, which we did not. The lack of a gender difference in this study, however, is decidedly different from other studies, most of which consistently found that more male than female adolescents use steroids.[2,4,14] Some studies have reported increases in steroid use among female subjects during the 1990s.[14] Fur-

TABLE 3 **Predictors of Time 2 Steroid Use in Boys**

Time 1 Variable	Time 2 Nonusers ($n = 1074$)[b]	Time 2 Users ($n = 19$)[b]	OR	*P*
Personal factors				
Weight and shape concerns				
Weight concerns, mean (SD)	5.9 (2.2)	6.1 (3.0)	1.04	.89
Weight importance, mean (SD)	1.9 (0.9)	2.2 (0.9)	1.37	.19
Satisfaction, body build, mean (SD)	3.6 (1.1)	3.4 (1.3)	0.79	.39
Satisfaction, shoulders, mean (SD)	3.9 (1.0)	3.7 (1.1)	0.86	.53
Satisfaction, weight, mean (SD)	3.5 (1.1)	3.2 (1.2)	0.80	.38
Ideal/estimated weight, mean (SD)	99.9 (15.6)	106.1 (18.2)	1.39	.04
BMI, mean (SD)	22.4 (4.5)	22.0 (5.2)	0.93	.78
Psychological variables				
Self-esteem, mean (SD)	18.7 (3.5)	17.9 (2.9)	0.84	.50
Depressed mood, mean (SD)	9.7 (2.7)	8.7 (2.1)	0.55	.07
Suicide, thoughts, % (*n*)	18.7 (188)	7.8 (1)	0.38	.34
Suicide, attempt, % (*n*)	5.0 (50)	7.8 (1)	1.46	.72
Health/nutrition attitudes				
Knowledge, healthy eating, mean (SD)	3.7 (2.8)	2.3 (3.0)	0.71	.15
Efficacy, healthy food choices, mean (SD)	31.8 (9.7)	29.9 (5.2)	0.81	.44
Concern about health, mean (SD)	15.8 (2.4)	16.1 (1.9)	1.30	.35
Socio-environmental factors				
Sports involvement				
Weight-related sports, % (*n*)	15.9 (163)	30.2 (5)	2.23	.18
Weight-related norms/teasing				
Parental concern with weight, mean (SD)	7.2 (3.0)	8.0 (3.9)	1.19	.48
Peer dieting, mean (SD)	2.3 (1.5)	2.3 (1.2)	0.97	.92
Teased about weight (family), % (*n*)	14.9 (150)	30.9 (5)	1.96	.27
Teased about weight (peers), % (*n*)	24.5 (248)	31.4 (5)	1.48	.49
Behavioral factors				
Physical activity level				
Hours of weekly activity, mean (SD)	10.5 (6.4)	10.0 (7.2)	0.96	.86
Eating/weight control behaviors				
Healthy weight control, mean (SD)	1.8 (1.6)	2.4 (1.5)	1.85	.03
Unhealthy weight control, mean (SD)	0.6 (1.1)	1.7 (1.7)	1.31	.18
Trying to gain weight, % (*n*)	26.6 (232)[c]	35.4 (5)[c]	1.77	.34
Trying to lose weight, % (*n*)	23.2 (192)[c]	42.1 (6)[c]	1.02	.98
Eating disorder diagnosis, % (*n*)	2.1 (22)	8.7 (2)	4.87	.08
Binge eating, % (*n*)	2.8 (29)	6.6 (1)	3.57	.19
Substance use				
Cigarettes, % (*n*)	28.3 (284)	11.3 (2)	0.16	.09
Alcohol, % (*n*)	41.5 (416)	29.7 (5)	0.48	.23
Marijuana, % (*n*)	24.0 (239)	16.5 (3)	0.42	.29
Other, % (*n*)	6.3 (63)	5.4 (1)	—	—

ORs and *P* values were derived from analyses adjusted for time 1 steroid use and propensity weights. ORs were standardized to allow comparison across scales. — indicates statistics were unable to be computed because of insufficient sample size.

[a] Percentage (*n*) values at time 1 of time 2 users and nonusers are reported for the dichotomous predictors; values for the continuous variables are means and SDs.

[b] Individuals tests may have different *n* values because of missing data on specific scales.

[c] The denominator of the proportion contains only the number of individuals answering "yes" to the question plus the number of individuals who answered that they have not tried to either gain or lose weight.

thermore, the 2005 YRBS showed no difference between genders in lifetime prevalence of steroid use for individuals in 9th grade, although in 10th through 12th grade, boys did have higher prevalences.[7] The prevalences in our study and these other studies may reflect a shrinking gender gap in adolescent steroid use, although there is some controversy surrounding the validity of recent self-reports of steroid use by girls.[35]

The fact that steroid use was not very persistent across the 5 years is consistent with other studies that found steroid use to be less persistent than the use of other substances.[4] This seems to point more toward experimental use or to a pattern of alternating initiation and cessation of use rather than a pattern in which initiation leads to continued use, as seems to be the case with alcohol, for instance.[4] Even so, the risk of future steroid use is greatly increased in female users at time 1.

Secularly, steroid use was stable in adolescents in high school between 1999 and 2004. This corroborates the findings of other studies, which have found preva-

TABLE 4 **Predictors of Time 2 Steroid Use in Girls**

Time 1 Variable	Time 2 Nonusers ($n = 1320$)[b]	Time 2 Users ($n = 19$)[b]	OR	P
Personal factors				
Weight and shape concerns				
Weight Concerns, mean (SD)	7.7 (2.6)	8.0 (2.7)	1.14	.59
Weight Importance, mean (SD)	2.3 (0.9)	2.8 (1.4)	1.37	.16
Satisfaction, body build, mean (SD)	3.2 (1.2)	3.4 (1.8)	1.22	.42
Satisfaction, shoulders, mean (SD)	3.6 (1.2)	4.3 (1.3)	2.10	.01
Satisfaction, weight, mean (SD)	2.9 (1.3)	2.2 (1.4)	0.54	.02
Ideal/estimated weight, mean (SD)	92.6 (13.9)	92.4 (18.7)	0.96	.86
BMI, mean (SD)	22.3 (4.5)	24.1 (6.4)	1.45	.04
Psychological variables				
Self-esteem, mean (SD)	17.3 (3.5)	16.5 (3.2)	0.87	.56
Depressed mood, mean (SD)	11.1 (2.7)	10.5 (1.7)	0.78	.29
Suicide, thoughts, % (*n*)	32.5 (403)	41.9 (8)	1.41	.47
Suicide, attempt, % (*n*)	12.6 (157)	21.4 (4)	1.58	.43
Health/nutrition attitudes				
Knowledge, healthy eating, mean (SD)	4.2 (2.5)	0.23 (3.9)	0.35	<.0001
Efficacy, healthy food choices, mean (SD)	31.2 (9.3)	28.2 (11.7)	0.68	.15
Concern about health, mean (SD)	16.6 (2.3)	14.8 (3.1)	0.53	.006
Socio-environmental factors				
Sports involvement				
Weight-related sports, % (*n*)	16.1 (201)	41.8 (8)	2.62	.05
Weight-related norms/teasing				
Parental concern with weight, mean (SD)	6.9 (2.9)	9.0 (4.5)	1.52	.09
Peer dieting, mean (SD)	2.7 (1.3)	2.6 (1.8)	0.81	.39
Teased about weight (family), % (*n*)	27.9 (346)	39.4 (8)	1.63	.31
Teased about weight (peers), % (*n*)	30.1 (375)	43.0 (8)	1.68	.27
Behavioral factors				
Physical activity level				
Hours of weekly activity, mean (SD)	8.6 (6.2)	6.9 (7.7)	0.79	.33
Eating/weight control behaviors				
Healthy weight control, mean (SD)	2.6 (1.5)	2.1 (1.8)	0.69	.11
Unhealthy weight control, mean (SD)	1.5 (1.6)	1.8 (2.0)	1.10	.69
Trying to gain weight, % (*n*)	11.4 (81)[c]	33.3 (3)[c]	2.96	.16
Trying to lose weight, % (*n*)	48.5 (590)[c]	62.3 (9)[c]	1.72	.32
Eating disorder diagnosis, % (*n*)	3.9 (50)	6.8 (1)	1.13	.91
Binge eating, % (*n*)	11.7 (148)	4.5 (1)	0.35	.39
Substance use				
Cigarettes, % (*n*)	32.8 (405)	26.6 (5)	0.77	.62
Alcohol, % (*n*)	38.8 (475)	23.3 (4)	0.54	.27
Marijuana, % (*n*)	18.9 (232)	17.7 (3)	0.91	.88
Other, % (*n*)	4.0 (49)	6.2 (1)	0.80	.83

ORs and *P* values were derived from analyses adjusted for time 1 steroid use and propensity weights. ORs were standardized to allow comparison across scales.

[a] Percentage (*n*) values at time 1 of time 2 users and nonusers are reported for the dichotomous predictors; values for the continuous variables are means and SDs.

[b] Individuals tests may have different *n* values because of missing data on specific scales.

[c] The denominator of the proportion contains only the number of individuals answering "yes" to the question plus the number of individuals who answered that they have not tried to either gain or lose weight.

lences to be fairly stable or show only slight increases or declines after the turn of the century. In any case, our findings and those of others suggest that the press coverage in recent years surrounding steroid use by famous athletes and the congressional hearings into steroid use in baseball[36] have not led to ever increasing levels of steroid use among adolescents.

The longitudinal nature of this investigation allowed us to properly examine developmental changes in steroid use as youth transition from middle school to high school, and from high school to young adulthood. Across the 5 years of follow-up, there were significant longitudinal reductions in use for older and younger boys and younger girls. There has been some cross-sectional support from other studies for decreased use across time. For instance, the YRBS in 2005 found that prevalences were higher for 9th-graders than for 12th-graders.[7] The Monitoring the Future study reported lower prevalences for young adults compared with high school students, although they also found that older high school students had higher prevalences compared with younger adolescents. Our study, however, has the benefit of document-

ing decreased use across time in the same group of participants, confirming that use does in fact seem to decrease as youth progress through adolescence.

Because of the study design, we were also able to examine longitudinal predictors of steroid use over 5 years. Those boys who desired to weigh more and who used healthier weight-control behaviors were more likely to be steroid users after 5 years. The findings regarding healthy weight-control behaviors may reflect a general tendency to attend to eating and weight control, perhaps not yet developed to the point of being unhealthy, which may place boys at risk for engaging in steroid use later on. The lack of association between weight-related sports participation and steroid use in boys differs from the findings of other studies, including the longitudinal study by Dodge and Jaccard.[11] We suspect it may be attributable to low power, because participation in weight-related sports at time 1 was nearly twice as high among time 2 steroid users as among nonusers. Another possible explanation is that sports participation is a risk factor for steroid use, but one that operates over a shorter period of time than the 5 years in our study. A better test of the influence of weight-related sports participation on steroid use might require a shorter time lag between participation and steroid use.

Steroid use in girls showed a marginally significant relationship with weight-related sports participation, with well over twice as many time 2 female steroid users as nonusers involved in weight-related sports at baseline. This finding begs additional exploration to determine whether and how strong a risk factor weight-related sports participation is for girls. Although the prevalence of steroid use is still low even among girls involved in weight-related sports, the identification of additional risk factors may allow us to define a high-risk group that could be targeted for prevention efforts.

Female adolescents who reported time 2 steroid use additionally had higher BMIs and were less satisfied with their weight at time 1. Thus, for girls, steroids may be a strategy to become leaner and more "toned," whereas boys' use is more often associated with wanting to increase their muscle mass and size. Interestingly, female time 2 steroid users were also more satisfied with their shoulders than time 2 nonusers. Female steroid users also had much lower levels of healthy nutrition knowledge and were less concerned about their health at time 1. This finding may be useful for identifying female adolescents at higher risk of steroid use in the future. One possible interpretation of these results is that female steroid users are typical of female adolescents in their desire to be smaller, but may have less concern for the health effects of the strategies they use to obtain their desired size.

The null findings regarding the use of other substances were unexpected. A number of studies have reported significant cross-sectional associations between the use of steroids and the use of other substances.[14] However, in our study there were no significant associations, and in fact, for all of the substances studied, the prevalence of time 1 use of other substances was lower among time 2 steroid users than among nonusers. While keeping in mind the possibility of low power, this finding might be interpreted as indicating that drug use does not independently predict future steroid use above and beyond baseline levels.

Strengths of our study include its longitudinal design, its large, ethnically and socioeconomically diverse sample, and the many constructs assessed. However, there are limitations to our study that are important to consider. Despite the large sample size of our study, the relatively low, albeit disturbing, prevalence of steroid use indicates a need for interpreting our findings cautiously. Future research on steroid use should incorporate a larger sample size and more strategies to reduce attrition to capture greater numbers of steroid users. In addition, because steroid use was assessed with a single item regarding past year use, we were unable to determine the pattern of use during the 5-year study period. It would be of interest in future studies to be able to track steroid use over multiple, shorter intervals. Also, steroid use has been reported to frequently occur in monthly cycles, and questions regarding use should be designed to capture this cyclical pattern. Furthermore, given the proliferation of performance- and physique-enhancing substances available currently, there is always a concern that questions regarding the use of "steroids" may be misinterpreted by adolescents. Although it was not within the scope of our current study, future researchers might ask specifically about these substances (for instance, androstenedione or creatine) as well. In addition, it must be noted that attrition among time 1 steroid users was greater than among the other participants, so that associations may be biased if those steroid users who did not respond to EAT 2 were different from the ones who did respond, above and beyond what the propensity weighting could control.

Our study provides important information about steroid use in adolescence. These results are both encouraging, in that steroid use by participants declined as they became older, and concerning, in that over 1 in 100 adolescents (and in some groups much higher numbers) reported having used steroids at least once in the previous year. The narrowing gap between boys and girls observed in our investigation warrants additional study. Also, the fact that peak use occurred at younger ages and declined thereafter points to the usefulness of early prevention efforts, perhaps beginning in or even before the middle school years. Overall, the results of this study confirm the findings of others that steroid use is still a public health problem among adolescents, provide additional understanding of the natural course of steroid use

over time, and offer insight into possible risk factors for future steroid use.

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