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Risk factors for anabolic-androgenic steroid use among weightlifters: a case–control study

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Abstract

Anabolic-androgenic steroid (AAS) use represents a major public health problem in the United States, but the risk factors for this form of drug use are little studied. We evaluated 48 men who had used AAS for at least 2 months and 45 men who had never used AAS, using a verbal interview and a battery of questionnaires covering hypothesized demographic, familial, and psychosocial risk factors for AAS use. All subjects in both groups were experienced weightlifters; thus, differences between groups were likely to be associated specifically with AAS use, rather than with weightlifting in general. The AAS users and non-users generally described similar childhood and family experiences, but users reported significantly poorer relationships with their fathers and greater childhood conduct disorder than non-users. At the time that they first started lifting weights, AAS users and non-users were similar in their perceived physical, social, and sexual status, but users were significantly less confident about their body appearance. AAS users displayed much higher rates of other illicit substance use, abuse, or dependence than non-users, with use of other illicit substances almost always preceding first use of AAS. These findings suggest that AAS use may be most likely to occur in men with high levels of antisocial traits and low levels of body esteem.

Keywords: Anabolic steroids; Risk factors; Males; Weight lifting

1. Introduction

The illicit use of anabolic-androgenic steroids (AAS) represents a major public health problem in the United States (Pope and Brower, 2000; Kanayama et al., 2001). Probably at least 1 million Americans have used these drugs to gain muscle or lose body fat (Buckley et al., 1988; Durant et al., 1993; Pope and Brower, 2000), and the prevalence of AAS use among high-school students has increased over the last 10 years (Johnston et al., 2002). AAS use poses various medical dangers, including suppression of normal neuroendocrine function, adverse effects on lipoproteins, and hepatotoxicity (Pope and Brower, 2000; Brower, 2002; Kutscher et al., 2002). Adverse psychiatric effects of AAS include major mood syndromes (Malone et al., 1995; Pope and Katz, 2003), dependence syndromes (Brower, 2002), violent behavior (Pope and Katz, 2003), and possibly an increased risk of progressing to opioid abuse (McBride et al., 1996; Arvary and Pope, 2000; Kanayama et al., 2003). These issues have prompted major programs to prevent AAS use among American adolescents (Goldberg et al., 1996), and to educate the public about the dangers of AAS (National Institutes of Health, 2002).

Despite these concerns, little is known about risk factors for use of AAS. Prevalence studies have generally provided only basic demographic information on AAS users: they are typically male, often involved in athletics, and likely to have used other illicit substances (Buckley et al., 1988; Durant et al., 1993; Bahrke et al., 2000; Johnston et al., 2002). Some surveys of high school students have noted differences between AAS users and non-users on other indices such as antisocial behaviors (Middleman et al., 1995; Scott et al., 1996; Handelsman and Gupta, 1997; Kindlundh et al., 1999)

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or lack of adult supervision (Handelsman and Gupta, 1997; Kindlundh et al., 1999). A few other studies of AAS users from athletic (Brower et al., 1994; Blouin and Goldfield, 1995; Yates et al., 1990; Burnett and Kleiman, 1994; Porcerelli and Sandler, 1995) or college (Lovstakken et al., 1999) settings have suggested that they may display low self-esteem (Brower et al., 1994; Blouin and Goldfield, 1995) and narcissistic or antisocial personality traits (Yates et al., 1990; Burnett and Kleiman, 1994; Porcerelli and Sandler, 1995). However, interpretation of these results is compromised by several factors: (1) all of these studies were based exclusively on questionnaires (most of which were anonymous questionnaires); none interviewed subjects directly; (2) some studies were performed outside of North America (Handelsman and Gupta, 1997; Kindlundh et al., 1999) and might not generalize to American populations; and most importantly, (3) all of the surveys asked only about current or recent attributes of AAS users, or of individuals judged at high risk for AAS use (Brower et al., 1994; Lovstakken et al., 1999); no published study, to our knowledge, has compared AAS users and non-users for attributes present before they first used these drugs. Thus it is difficult to ascertain whether specific attributes, such as antisocial behaviors, might be risk factors for AAS use, or are merely consequences of it.

In the present study, we sought to identify risk factors for AAS use by comparing AAS users and matched non-users on attributes present before they first started using these drugs. Of course, not all risk factors are causal risk factors, but we hoped to provide data to help identify and target young men most likely to use AAS; identify potentially treatable psychiatric disorders that might predispose young men to AAS use; and provide a basis for subsequent prospective studies of the etiology of AAS use. We selected a list of candidate risk factors for AAS use on the basis of three sources. First, we examined prior studies of risk factors for other forms of substance use (Resnick et al., 1997; Petraitis et al., 1998; Kilpatrick et al., 2000; Brown, 2002), including our own review of risk factors for cannabis use (Gruber and Pope, 2002). Second, we considered current attributes of AAS users noted in recent studies (Pope and Katz, 1994; Handelsman and Gupta, 1997; Kindlundh et al., 1999)—since some of these might represent attributes that had been present prior to first AAS use. Third, we considered findings from a recent study in which we assessed childhood and adolescent features of 54 weightlifters, 13 (24%) of whom had used AAS (Olivardia et al., 2000). On the basis of these prior studies, we hypothesized that AAS users would report childhood and adolescent histories of (1) lower parental involvement, or so-called 'parental connectedness' (Resnick et al., 1997), as evidenced by poor or distant relationships with parents (Resnick et al., 1997; Handelsman and Gupta, 1997; Kindlundh et al., 1999; Olivardia et al., 2000); (2) higher rates of attention deficit hyperactivity disorder (ADHD) (Gittelman et al., 1985); (3) higher rates of conduct disorder and antisocial traits (Middleman et al., 1995; Scott et al., 1996; Handelsman and Gupta, 1997; Kindlundh et al., 1999); (4) lower self-esteem, especially with regard to body image (Adalf and Smart, 1992; Williamson, 1993; Brower et al., 1994; Blouin and Goldfield, 1995; Elliot and Goldberg, 1996; Olivardia et al., 2000); (5) more frequent use of other illicit drugs (Durant et al., 1993; Middleman et al., 1995; Scott et al., 1996), and (6) higher rates of mood and anxiety disorders (Olivardia et al., 2000).

2. Methods

2.1. Study population

We used a case–control design, comparing male weightlifters who had used AAS with a similar group of weightlifters who reported that they had never used these drugs. We restricted our sample to weightlifters because virtually all AAS users perform regular weight training (Pope et al., 1988; Bahrke and Yesalis, 1994); thus this restriction would seem unlikely to produce a limited or atypical sample of AAS users. Similarly, because AAS use is much more common in men than in women (Buckley et al., 1988; Durant et al., 1993; Pope and Brower, 2000), we restricted our sample to males. Men 18–65 years of age were recruited by posting advertisements in gymnasiums and sports supplement stores in the vicinity of Boston, Massachusetts and Fort Lauderdale, Florida. We chose these two geographical regions, rather than just one, to reduce possible effects that might be idiosyncratic to one region. The advertisements stated, 'Can you bench press 275 pounds for at least one repetition? Earn $100 for a 1-h research study.' The text of the advertisement explained that respondents would not actually be required to perform a bench press, but instead would receive measurements of their body fat and muscle mass, together with an evaluation of their 'athletic history, diet and use of supplements, use of drugs (if any), and history of psychological and medical symptoms.' The study's focus on AAS use was not disclosed. The requirement of a 275-pound bench press was simply a device to select a group of experienced weightlifters. We did not require proof of a 275-pound bench press since we could easily confirm by our measurements that subjects were reasonably muscular, and knowing the subject's actual maximum bench press was irrelevant to our purposes. All men responding to the advertisement were invited to participate, provided that they were within the 18–65 age range and claimed that they could bench press at least 275 pounds. All

subjects were evaluated jointly in person by the same two investigators (GK and HGP). Upon arriving for the evaluation, all subjects signed informed consent for the study after the full study procedures had been explained.

2.2. Study instruments and data collection

We measured each subject's height, weight, and body fat, and then calculated his fat-free mass index (FFMI), a measure of muscularity previously developed in our laboratory (Kouri et al., 1995). Subjects were then administered a verbal interview that covered demographic information; history of use of performance-enhancing dietary supplements and performance-enhancing drugs, including AAS; use of alcohol and tobacco; use of ordinary drugs of abuse (cannabis, stimulants, cocaine, inhalants, hallucinogens, opioids, phencyclidine, methylenedioxymethamphetamine ('ecstasy'), and sedative–hypnotics); and history of DSM-IV Axis I psychiatric disorders (American Psychiatric Association (APA), 1994), obtained through an abbreviated version of the Structured Clinical Interview for DSM-IV ((SCID); Williams et al., 1992; First et al., 1996). The interviewers were not blinded to the subject's AAS history because they were required to determine whether Axis I disorders or other types of substance use began before or after first AAS use.

Subjects were next asked to complete a group of questionnaires that included (1) a questionnaire evaluating family and childhood environment, together with demographic information, derived from Finkelhor's Life Events Questionnaire (Finkelhor, 1979); (2) the Wender Utah Rating Scale ((WURS); Ward et al., 1993); (3) a modified rating scale for ADHD (DuPaul, 1991; Findling et al., 1996); and (4) a questionnaire covering the DSM-IV criteria for childhood conduct disorder (American Psychiatric Association (APA), 1994) which closely resembled the questions used on the Structured Clinical Interview for DSM-IV Axis II Personality Disorders ((SCID-II); First et al., 1995, 1997). We have used these instruments in previous studies of individuals with eating disorders (Olivardia et al., 1995), body-image disorders (Olivardia et al., 2000) and substance use (Pope et al., 2001; Halpern et al., 2001).

Finally, we administered a fifth questionnaire of our own design, inquiring about attributes at the time that the subject first started lifting weights. The items on this 'gym questionnaire' were derived from published studies (Brower et al., 1994; Pope and Katz, 1994; Blouin and Goldfield, 1995; Elliot and Goldberg, 1996; Olivardia et al., 2000) as well as our anecdotal experience with personal interviews of several hundred AAS users in the past. In these interviews, AAS users have often mentioned that when they first began weightlifting, they were not as big as other boys of their age (users have generally used the generic term 'big,' rather than 'muscular,' 'heavy,' or 'tall'). Some users have also reported that they were picked on by other boys, lacked confidence in their appearance, or felt unsuccessful in interacting with girls. Accordingly, the gym questionnaire asked the age at which the subject first started lifting weights at least three times per week, and then asked him to rate himself at that age on 5 Likert scales inquiring: (1) How big were you? (2) To what extent were you humiliated or 'picked on'? (3) How confident did you feel about your body appearance? (4) How much were you preoccupied with your appearance? and (5) How successful were you with members of the opposite sex? The last item was restricted to heterosexual subjects. Each scale was numbered from 0 to 100, with 50 defined as 'about average' and with 0 and 100 representing the lowest and highest levels of each attribute. Unlike the first four questionnaires, the gym questionnaire represented an exploratory instrument with untested psychometric properties.

2.3. Data analysis

For descriptive physical measurements (age, height, weight, etc.), we calculated the adjusted mean differences between groups and their 95% confidence intervals (CI) using linear regression. For putative risk factor variables, we assessed the relationship between each variable and case status (AAS user vs. non-user) by logistic regression analyses adjusting for the geographic location where the subject was interviewed (Florida vs. Massachusetts). We present the results without adjustment for age since the groups were very closely matched in age distribution, and adjustment for age had no appreciable effect on the estimates of differences between groups. In our analyses, we collapsed all categorical variables into binary groupings (defined as shown in the tables) and computed the odds ratio (OR) and its 95% CI. To generate the OR for continuous scales, we used logistic regression to estimate the increase in log odds for an increase of 10% in the score on that scale (see examples below). Because many of the measures were correlated, it was difficult to calculate an appropriate correction for multiple comparisons. Accordingly, the results are presented without correction, with alpha set at 0.05, two-tailed; the reader should, therefore, recognize that some findings may represent chance associations.

3. Results

3.1. Demographic features of subjects

We evaluated 101 men, of whom 44 were seen in Massachusetts and 57 in Florida. Of these, one was

excluded from analysis because he had briefly tried illicit 'steroids' that were almost certainly counterfeit, in that neither he nor his friends noticed any effects despite using substantial doses. This subject never subsequently attempted to obtain AAS. Another subject was excluded because he had received AAS only by a doctor's prescription for treatment of HIV infection. We also excluded three very muscular subjects who denied AAS use because we suspected that they were not truthful. These men displayed FFMI measurements of 25.4, 25.5, and 30.2 kg/m^2 with body fat measurements of only 7.2, 7.4, and 8.6%, respectively. However, as we have demonstrated previously, it is very rare that an individual can maintain body fat in the 7–8% range, yet attain an FFMI of greater than 25 without drugs (Kouri et al., 1995; Pope and Brower, 2000). In addition, we noted that all three men displayed disproportionate hypertrophy in the shoulder and trapezius muscles, a feature characteristic of AAS-induced muscle growth (Pope and Brower, 2000; Brower, 2002). Finally, a close friend of one of the three subjects, who himself participated in the study, indicated in his remarks that his friend had used AAS.

Of the remaining 96 subjects, 51 reported at least some AAS use. Three of these reported lifetime AAS use of less than 2 months (i.e. less than one typical "cycle," or course, of AAS use (Pope and Brower, 2000; Yesalis, 2000; Brower, 2002)); we excluded these short-term users, leaving a sample of 48 men who had used AAS for a median [interquartile range] of 5.5 [3.2,17.5] months, and a comparison group of 45 men who had never used AAS. The users and non-users were closely matched on both physical and demographic measures (Table 1), except that users were significantly more muscular than non-users.

3.2. Parental connectedness

On the demographic questionnaire, AAS users were significantly more likely than non-users to report a 'fair,' 'poor,' or 'terrible' childhood relationship with their fathers (15 [33%] of users versus 4 [10%] of non-users; OR [95% CI] = 3.85 [1.13, 13.1]; $P = 0.03$), but not with their mothers (8 [17%] vs. 4 [19%]; OR = 1.10 [0.27, 4.56]; $P = 0.90$). Items on the demographic questionnaire regarding violence within the family, beatings, and childhood sexual abuse showed no significant differences between groups. Another possible indicator of lack of parental connectedness is one of the DSM-IV diagnostic criteria for conduct disorder, "staying out at night despite parental prohibitions, beginning before age 13." This was acknowledged by 9 (19%) AAS users and 3 (7%) non-users (OR = 3.6 [0.9, 14.8], $P = 0.08$).

3.3. Attention-deficit hyperactivity disorder and conduct disorder

Contrary to our second hypothesis, AAS users and non-users did not differ significantly in either total symptoms of ADHD or in prevalence of a diagnosis of ADHD, as assessed by either the modified ADHD rating scale (DuPaul, 1991; Findling et al., 1996) or the WURS (see Ward et al., 1993 for scoring details) (Table 2). However, the users were significantly more likely than non-users to qualify for a diagnosis of conduct disorder by DSM-IV criteria (Table 2). It should be noted that the DSM-IV diagnosis of conduct disorder is

Table 1
Demographic features of AAS users and non-users

Attribute	AAS users ($N = 48$)		Non-users ($N = 45$)		Mean difference	95% CI	P value
	Mean	S.D.	Mean	S.D.			
Age, years	29.3	6.5	30.3	10.2	−1.10	−4.72, 2.52	0.55
Height, meters	1.79	0.06	1.79	0.06	0.0	−0.30, 0.02	0.80
Weight, kilograms	96.2	12.1	90.7	15.3	4.15	−1.58, 9.87	0.15
Body fat%	18.5	6.9	17.0	7.8	1.00	−2.1, 4.1	0.53
Fat Free Mass Index (FFMI), kg/m^2	24.4	2.6	23.2	2.1	1.06	0.03, 2.08	0.04
	Number	%	Number	%	Odds ratio		
Ever married	14	29	15	33	0.86	0.35, 2.12	0.74
Ethnicity, non-white	9	19	8	18	1.40	0.46, 4.25	0.55
Education, at least some college	38	79	41	91	0.37	0.10, 1.32	0.13
Current household income < $30 000	18[a]	38	21[b]	49	1.00	0.41, 2.33	1.00
Mother's education, at least some college	23	48	23[c]	52	1.07	0.45, 2.55	0.88
Father's education, at least some college	28	58	26[b]	61	1.27	0.52, 3.10	0.60

[a] $N = 47$ due to missing data.
[b] $N = 43$ due to missing data.
[c] $N = 44$ due to missing data.

Table 2
ADHD and conduct disorder diagnoses in AAS users and non-users

Attribute	AAS users ($N = 48$)		Non-users ($N = 45$)		Odds ratio[a]	95% CI	P value
	Mean	S.D.	Mean	S.D.			
Distractibility[b]	6.3	5.7	5.0	3.7	1.14	0.89, 1.45	0.31
Hyperactivity[b]	7.0[c]	6.0	7.0[d]	6.1	0.98	0.81, 1.19	0.83
Total score[b]	13.4[d]	10.6	11.9[d]	9.1	1.05	0.83, 1.33	0.68
	Number	%	Number	%			
DSM-IV diagnosis of ADHD[e]	6[c]	12.8	4[d]	9.1	1.11	0.28, 4.49	0.88
Wender diagnosis of ADHD[f]	11	26.2	4	11.1	2.14	0.58, 7.87	0.25
DSM-IV diagnosis of conduct disorder[g]	23	48.9	9	22.0	3.29	1.26, 8.55	0.01

[a] For continuous scales (distractibility, hyperactivity, and total score), represents increase in log odds for an increase of 10% on that scale; see text for details.
[b] Based on modified ADHD rating scale; see DuPaul (1991) and Findling et al. (1996) for details.
[c] $N = 47$ due to missing data.
[d] $N = 44$ due to missing data.
[e] See DuPaul (1991) and Findling et al. (1996) for details; a DSM-IV diagnosis was assigned when subjects scored "pretty much" or "very much" on six or more of the distractibility items and/or six or more of the hyperactivity items.
[f] See Ward et al. (1993) for details. Based on a score of 46 or higher on 25 selected items from the WURS; only 42 users and 36 non-users due to missing data.
[g] Endorsed three or more of the DSM-IV criteria for conduct disorder; only 47 users and 41 non-users due to missing data.

based on characteristics before age 18; since 2 of the 23 AAS users with conduct disorder had already started AAS use before age 18, it cannot be stated with certainty that conduct disorder preceded AAS use in these two cases. However, when we restricted the analysis only to the 44 users who started AAS at age 18 or older, the association of AAS with conduct disorder was unchanged (adjusted OR [95%CI]: 3.3 [1.2, 8.6], $P = 0.017$). We also calculated a conduct disorder score for grade-school years only, using the method of a previous study (Pope et al., 2001), in which we added the scores on four items on the WURS: "ran away from home;" "get in fights;" "trouble with authorities, trouble with school, visits to the principal's office;" and "trouble with the police, booked, convicted." On this scale, the mean (S.D.) scores of AAS users were again significantly greater than non-users (4.0 [4.0] vs. 2.4 [2.5] points; OR = 1.34 [1.05, 1.71]; $P = 0.02$). Because the OR for the association between disorder and exposure in case–control studies is an unbiased estimate of the incidence rate ratio (Miettinen, 1976; Rothman and Greenland, 1998), we can interpret this effect as follows: for each 10% increase in childhood conduct disorder score, the estimated incidence of AAS use increases by 34%.

3.4. Self-ratings of physical, social, and sexual status

On the gym questionnaire, AAS users and non-users reported similar mean ages at which they first started regular weightlifting (17.5 [2.9] vs. 17.6 [5.7] years; OR = 0.98 [0.88, 1.08]; $P = 0.62$). No subject reported AAS use prior to the age at which he first began regular weightlifting—consistent with our impression, mentioned above, that virtually all AAS users perform regular weight training when they are using these drugs. Although we had hypothesized that AAS users would generate lower self-ratings than non-users on most or all of the five scales of this questionnaire, four of the five scales showed few differences (Table 3). However, one scale—confidence in body appearance—produced marked differences (see Table): for each 10% increase in confidence about body appearance on this scale, the estimated incidence of AAS use decreased by 23%.

3.5. Psychiatric and substance use disorders

AAS users reported various psychiatric and substance use disorders, some of which began before and others after the onset of AAS use. Since disorders beginning after first AAS use could not be considered risk factors, we compared users with non-users using a) the rates of various disorders beginning before AAS use among the users vs. b) the rates of these same disorders among the non-users before they reached age 23.5 years, which corresponded to the mean age at which the AAS users had first used AAS. Looking first at use of other illicit drugs, AAS users were somewhat more likely to have taken other illicit drugs prior to AAS than non-users prior to age 23.5—although this difference did not reach significance (Table 4). AAS users also did not differ significantly from non-users in rates of alcohol abuse or dependence. However, 13 (27%) of AAS users had already developed some form of illicit substance abuse

Table 3
Gym questionnaire responses in AAS users and non-users

Attribute	AAS users ($N = 48$)		Non-users ($N = 45$)		Odds ratio[b]	95% CI	P value
	Mean[a]	S.D.	Mean[a]	S.D.			
How big were you?	41.6	23.8	46.2[c,d]	28.9	0.96	0.81, 1.13	0.61
To what extent were you picked on?	69.9	30.0	65.9	27.5	1.11	0.95, 1.29	0.20
How confident about body appearance?	39.3	19.5	52.0	22.2	0.77	0.61, 0.96	0.02
How preoccupied with your appearance?	60.9	18.6	60.0	19.4	1.03	0.82, 1.28	0.82
How successful with the opposite sex?[e]	50.4	27.1	60.1	23.5	0.88	0.74, 1.0	0.14

[a] Mean score on a 100-point Likert scale, where 50 was defined as "about average" and 0 and 100 represented the lowest and highest levels of each attribute.
[b] Represents increase in log odds for an increase of 10% (10 points) on the scale; see text for details.
[c] $N = 44$ due to missing data.
[d] $N = 43$ due to missing data.
[e] $N = 40$ for non-users, because three identified themselves as homosexual, 1 as bisexual, and 1did not mark the scale.

or dependence prior to AAS use—a rate markedly greater than in the non-users (Table 4).

Contrary to our hypotheses, we did not find higher rates of premorbid Axis I disorders among the AAS users. Although 18 (38%) of the AAS users reported a lifetime history of major depressive disorder or bipolar disorder, only 3 (7%) experienced a major mood disorder prior to first using AAS—a rate not significantly different from the rate of 4 (9%) cases among the non-users prior to age 23.5. Rates of anxiety disorders were similarly low in both groups (4 [9%] cases among AAS users prior to first AAS use and 4 [9%] among non-users prior to age 23.5). Body dysmorphic disorder (BDD) occurred in 7 (15%) of AAS users prior to use versus 2 (4%) of non-users prior to age 23.5, but this OR of 2.80 failed to reach significance because of its wide CI (0.53, 14.9; $P = 0.23$). Interestingly, 8 (17%) AAS users reported a lifetime history of the muscle dysmorphic form of BDD (Pope et al., 1997; Olivardia et al., 2000), in which they became preoccupied that their bodies were not sufficiently lean and muscular, but five of these developed muscle dysmorphia only after starting use of AAS. Three of these five men, however, described prominent symptoms of muscle dysmorphia (including frequent preoccupation with their muscularity and reluctance to allow their bodies to be seen in public) even before AAS use, although they did not qualify for the full diagnosis of muscle dysmorphia until after starting AAS.

4. Discussion

AAS use is a recognized public health problem, but risk factors for AAS use are poorly understood. We conducted a case–control study of 48 men who had used AAS and 45 other men, of similar age, education, ethnicity, and socioeconomic status, who had never used AAS. Because all men in both groups were experienced weightlifters, differences between groups seemed likely to be specifically associated with AAS use, rather than with weightlifting in general. We assessed six hypothesized risk factors for AAS use, including low "parental connectedness"; attention-deficit hyperactivity disorder; conduct disorder and antisocial traits; lower self-esteem, especially with regard to body image; use of alcohol and of illicit drugs prior to AAS; and history of mood and anxiety disorders prior to AAS use.

Two of our hypotheses were not supported: among AAS users, rates of ADHD and rates of Axis I mood and anxiety disorders prior to AAS use were not significantly different from rates among non-AAS-using weightlifters. Our four other hypotheses, however, received some support: AAS users reported poorer relationships with their fathers (suggesting lower parental connectedness), higher levels of childhood conduct disorder, lower self-confidence about body appearance, and strikingly higher rates of other illicit substance abuse or dependence before they first used AAS.

Our findings are generally consistent with the limited available literature that has examined possible risk factors for AAS use. For example, previous studies have noted higher levels of antisocial behavior—such as school truancy (Handelsman and Gupta, 1997; Kindlundh et al., 1999), and physical fighting (Middleman et al., 1995), as well as use of other illicit drugs (Buckley et al., 1988; Durant et al., 1993; Yesalis et al., 1993; Scott et al., 1996; Kindlundh et al., 1999; Bahrke et al., 2000)—among AAS users, but these studies did not assess the temporal relationship between antisocial behaviors and AAS use. We found that AAS users displayed high levels of childhood conduct disorder and extensive use of other illicit drugs prior to first AAS use, even in comparison to otherwise similar weightlifters. Thus, our study strongly suggests that antisocial behavior and illicit drug abuse precedes AAS use, even

Table 4
Drug use history in AAS users and non-users

Drug	AAS Users ($N=48$)				Non-users ($N=45$)				Odds ratio[c]	95% CI	P value
	Total cases	%	Onset before First AAS use	%	Total cases	%	Onset before Age 23.5 years[b]	%			
Any illicit drug use[a]	42	88	41[d]	85	30	67	30	67	2.45	0.86, 6.97	0.09
Substance abuse or dependence											
Alcohol	4	8	3	6	5	11	5	11	0.36	0.07, 1.73	0.20
Cannabis	6	13	5	10	1	2	0	0	([e])	–	0.06
Cocaine	1	2	0	0	0	0	0	0	–	–	–
Opioids	2	4	0	0	0	0	0	0	–	–	–
Two or more substances	8	17	8	17	0	0	0	0	([e])	–	0.006
Any substance	21	44	16	33	6	13	5	11	3.24	1.03, 10.14	0.04
Any non-alcohol substance	17	35	13	27	1	2	0	0	([e])	–	< 0.001

[a] See text of Section 2 for list of illicit drug categories; the term "substance" includes both illicit drug categories and alcohol; "non-alcohol substance" includes illicit drug categories only.
[b] Age 23.5 years corresponds to the mean age at which the AAS users first used AAS; see text for details.
[c] Compares the prevalence of cases with onset prior to AAS among the AAS users vs. the prevalence of cases among controls before they reached age 23.5.

though AAS use may perhaps further potentiate such behavior later on.

Several studies have also indicated that low self-esteem, especially with regard to body image, is associated with AAS use (Adalf and Smart, 1992; Williamson, 1993; Brower et al., 1994; Blouin and Goldfield, 1995; Elliot and Goldberg, 1996; Pope et al., 1997; Bahrke et al., 2000; Olivardia et al., 2000). Interestingly, we found that several of the measures on our gym questionnaire (Table 3), which we had expected to be sensitive to self-esteem, were not compromised among AAS users prior to first use. Additionally, AAS users did not exhibit increased rates of premorbid mood or anxiety disorders on the SCID. However, in agreement with previous studies, we found that one specific aspect of self-esteem—confidence in body appearance—was reduced in AAS users, as evidenced by self-ratings on the relevant Likert scale. Also, the lifetime prevalence of BDD was somewhat higher among AAS users—but in agreement with previous studies (Pope et al., 1997; Olivardia et al., 2000), we found that BDD (especially the muscle dysmorphic type) frequently developed only after first using AAS. Thus body image disorders may be both a risk factor for AAS and a consequence of it.

An interesting finding of our study was that AAS users often reported poor relationships with their fathers. No previous study of AAS users, to our knowledge, has assessed this variable; however, in a previous study using the same questionnaire, our group noted that college men with eating disorders also reported poor relationships with their fathers (Olivardia et al., 1995). It is intriguing to speculate that a poor relationship with one's father may perhaps lead in some manner to deficits in male 'body esteem,' which the individual tries to rectify by gaining muscle (through AAS) or losing fat (through anorexic or bulimic behaviors). Extending speculation a bit further, the combination of low male body esteem plus antisocial traits may create the optimum conditions for AAS use; by contrast, low male body esteem alone may cause eating disorders or BDD, but not AAS use, whereas antisocial traits alone might lead to use of other illicit drugs, but not AAS.

Several limitations of this study should be considered. First, given the modest sample sizes, our power to detect differences between groups was limited. Also, the two geographical regions studied may have differed in various ways from other parts of the United States; a larger sample spanning additional regions might be more representative. Second, our interview evaluations were necessarily conducted non-blind to AAS use; we cannot exclude the possibility that this might have introduced bias in our SCID and substance abuse diagnoses. On the other hand, items scored on the basis of the subject's questionnaire responses, such as diagnoses of ADHD or conduct disorder, would presumably

not be influenced by investigator bias. Third, we lacked a comparison group of men who had used large amounts of other illicit drugs, but not AAS. Such a comparison group would improve our ability to assess which risk factors are specific to AAS use and which to illicit substance use in general. Notably, the principal measures found associated with AAS use in our study, such as relationship with one's father, a diagnosis of childhood conduct disorder, and confidence in body appearance on the "gym questionnaire," were not significantly associated with general illicit drug use among the AAS non-users ($P > 0.3$ for all comparisons). However, to better establish the specificity of these latter measures, we would require a larger comparison group of AAS non-users who had extensively used other illicit drugs.

Fourth, selection bias might have influenced which subjects presented for study. For example, an individual with antisocial traits and no regular employment might be more likely to respond to our offer of $100—leading to an overestimate of the prevalence of antisocial traits in the source population. However, for such bias to affect the comparisons between groups, one would have to assume a differential effect between the two groups of weightlifters—say, that AAS users with antisocial traits would be more likely to respond to our advertisements than non-using weightlifters with antisocial traits—a less likely possibility.

It might also be argued that our inclusion criteria themselves created selection bias, in that individuals meeting our bench-press criterion represented a narrowly selected group of weightlifters. However, as noted above, it appears that the great majority of AAS users are experienced weightlifters (Pope et al., 1988; Bahrke and Yesalis, 1994)—so that our sampling method would seem unlikely to have produced a limited or atypical sample of AAS users. Indeed, our sampling method was intentional and potentially advantageous, in that it allowed us to isolate risk factors that were specific to AAS use, rather than to weightlifting in general. Our narrow inclusion criteria, if anything, likely produced overly conservative estimates of the effects of these risk factors.

Fifth, a differential response bias, either unintentional or intentional, might affect some variables. In particular, there is a possibility that, even after excluding three probable "liars" from the non-user group, we still misclassified as non-users some individuals who did not disclose their AAS use. Our assurances of confidentiality and use of FFMI measurements likely minimized such misclassifications. Unfortunately, however, there exists no definitive laboratory test of past AAS use, since most AAS disappear from the urine within a few weeks to a few months. In any event, if such misclassifications did occur, they would likely tend to bias our findings towards the null hypothesis, rather than yield spurious associations.

Differential response bias might also have occurred if subjects in one group (say, AAS users) recalled certain childhood experiences (such as body image concerns) more than subjects in the other group. Although this possibility cannot be excluded in a cross-sectional study such as ours, the groups were closely matched in age, thus minimizing differences in the time elapsed since the events they were being asked to remember. Also, subjects were not aware that they were being compared on the basis of the presence or absence of AAS use. Furthermore, none of the AAS users exhibited any current AAS-associated hypomanic or depressive syndromes at the time of interview, so that subjects' mental status would seem unlikely to have contributed to a differential response bias. Therefore, differential response bias in this study seems less likely than in case–control studies where subjects who know that they are ill and subjects who know that they are not ill are asked to recall life events that they may consider potentially causal to their illness (Werler et al., 1989; Pope and Hudson, 1995).

Finally, our study cannot distinguish between causal and non-causal risk factors. Some factors identified in our study, such as lack of confidence in body appearance, seem likely to be causal—meaning that treating this problem in young men might reduce their risk of AAS use. Other factors, such as a poor relationship with one's father, are less clearly causal. Further studies, including more sophisticated case–control studies and prospective cohort studies, followed by judicious experimental intervention studies, will be required both to identify which young men are most likely to use AAS, and which interventions might most effectively prevent them from doing so.

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