Anabolic Androgenic Steroids: A Survey of 500 Users

ANDREW B. PARKINSON[1] and NICK A. EVANS[2]

[1]*Department of Orthopaedic Surgery, Harbor-UCLA Medical Center, Torrance, CA; and*
[2]*UCLA-Orthopaedic Hospital, Los Angeles, CA*

ABSTRACT

PARKINSON A. B., and N. A. EVANS. Anabolic Androgenic Steroids: A Survey of 500 Users. *Med. Sci. Sports Exerc.*,Vol. 38, No. 4, pp. 644–651, 2006. **Purpose:** The use of anabolic androgenic steroids (AAS) to increase muscle size and strength is widespread. Information regarding self-administered AAS used nonmedically to enhance athletic performance or improve physical appearance is sparse and poorly documented. The purpose of this study is to identify current trends in the drug-taking habits of AAS users. **Methods:** An anonymous self-administered questionnaire was posted on the message boards of Internet Web sites popular among AAS users. **Results:** Of the 500 AAS users who participated in the survey, 78.4% (392/500) were noncompetitive bodybuilders and nonathletes; 59.6% (298/500) of the respondents reported using at least 1000 mg of testosterone or its equivalent per week. The majority (99.2%) of AAS users (496/500) self-administer injectable AAS formulations, and up to 13% (65/500) report unsafe injection practices such as reusing needles, sharing needles, and sharing multidose vials. In addition to using AAS, 25% of users admitted to the adjuvant use of growth hormone and insulin for anabolic effect, and 99.2% (496/500) of users reported subjective side effects from AAS use. **Conclusions:** This survey reveals several trends in the nonmedical use of AAS. Nearly four out of five AAS users are nonathletes who take these drugs for cosmetic reasons. AAS users in this sample are taking larger doses than previously recorded, with more than half of the respondents using a weekly AAS dose in excess of 1000 mg. The majority of steroid users self-administer AAS by intramuscular injection, and approximately 1 in 10 users report hazardous injection techniques. Polypharmacy is practiced by more than 95% of AAS users, with one in four users taking growth hormone and insulin. Nearly 100% of AAS users reported subjective side effects. **Key Words:** ANABOLIC STEROIDS, TESTOSTERONE, BODYBUILDING, SIDE EFFECTS, GROWTH HORMONE, INSULIN

Anabolic androgenic steroids (AAS) are synthetic derivatives of testosterone. According to surveys and media reports, the illegal use of these drugs to increase muscle size and strength is widespread (8). In 1991, data from the National Household Survey on Drug Abuse indicated that there were more than one million AAS users in the United States and that the lifetime use was 0.9% for males and 0.1% for females (29). Despite the fact that AAS were added to the list of Schedule III Controlled Substances in 1990, recent data suggest that AAS use has increased. Current estimates indicate that there are as many as three million AAS users in the United States and that 2.7–2.9% of young American adults have taken AAS at least once in their lives (19). Surveys in the field indicate that AAS use among community weight trainers attending gyms and health clubs is 15–30% (5,16,22) and that the majority of AAS users are noncompetitive recreational bodybuilders or nonathletes, who use these drugs for cosmetic purposes rather than to enhance sports performance (9).

There is a growing body of evidence that AAS have positive anabolic actions on the musculoskeletal system, influencing lean body mass, muscle size, strength, protein metabolism, bone metabolism, and collagen synthesis (3,4,8,11,21,26,27). Skeletal muscle is a primary target tissue for the anabolic effects of AAS. Supraphysiological doses of testosterone administered to healthy young men over periods lasting 10–20 wk increase lean body mass, muscle size, and strength, with or without exercise (3,4,27). The anabolic effect of testosterone is dose dependent, and significant increases in muscle size and strength only occur with doses of 300 $mg \cdot wk^{-1}$ and higher (4,27). Such supraphysiological doses elevate mean serum testosterone concentrations above normal values to over 1000 $ng \cdot dL^{-1}$.

The testosterone-induced increase in muscle size and strength is due to a dose-dependent hypertrophy that results from an increase in cross-sectional area of muscle fibers and an increase in myonuclear number (27). Evidence suggests that these morphometric effects are the result of a testosterone-induced increase in muscle protein synthesis (11,26,28). AAS also enhance collagen synthesis (21) and increase bone mineral density (1). The

Address for correspondence: Nick A. Evans, M.D., Orthopaedic Hospital, 2400 S. Flower Street, Los Angeles, CA 90007; E-mail: DrNickE@yahoo.com.
Submitted for publication May 2005.
Accepted for publication October 2005.

0195-9131/06/3804-0644/0
MEDICINE & SCIENCE IN SPORTS & EXERCISE®

DOI: 10.1249/01.mss.0000210194.56834.5d

anabolic effect of AAS is mediated primarily by androgen receptors in skeletal muscle (14). The androgen receptor regulates the transcription of target genes that may control the accumulation of DNA required for muscle growth. It has also been suggested that AAS exert several complementary anabolic actions, including a psychoactive effect on the brain, glucocorticoid antagonism, and stimulation of the growth hormone (GH)–insulin-like growth factor-1 (IGF-1) axis (17).

In the United States, AAS are classed as Schedule III Controlled Substances, and possession of these drugs without a prescription is illegal. Many sporting organizations have banned the use of these performance-enhancing drugs. Fearing legal consequences or a sporting ban, AAS users rarely disclose their drug-taking habits. As a result, information on the self-administered AAS used nonmedically to enhance athletic performance or improve physical appearance is relatively sparse. Several observational studies have surveyed the unsupervised drug habits of AAS users in "natural" settings (5,9,23,24). This kind of study is subject to selection bias because AAS users are recruited on a voluntary basis, and information bias may arise when the participants recall their experience. Nevertheless, field studies of AAS users are a valid source of information regarding self-administered AAS regimens. Consistencies and similarities between several published surveys support and validate the results.

Recently, the Internet has become a valuable tool for researchers desiring to gain an in-depth understanding of particular individuals or groups (13). Previous studies have documented the validity of Web-based surveys by comparing them with identical studies in the real world, suggesting that the validity and reliability of data obtained online are comparable to those with classic methods (6,7). With these factors in mind, we developed a Web-based survey to gain in-depth insight into the dosing patterns, regimens, demographics, accessory drug use, and side effects common among AAS users. Inherent in this type of study is a selection bias due to the nonrepresentative nature of the Internet as well as through self-selection of participants (10). However, given the goals of our study, this was not a confounding variable.

The purpose of this study is to identify current trends in the drug-taking habits of AAS users and to improve our understanding of this widespread phenomenon. Our hypothesis was that despite the risk of side effects, drug doses are increasing and the use of adjuvant anabolic agents like GH or insulin is gaining popularity.

METHODS

Subjects were recruited from several popular AAS-related Internet discussion forums, identified by way of an Internet search using the phrase "anabolic steroids." Twelve Web site forums were chosen at random from the search results. These Web sites generally host many different discussion topics related to strength training and bodybuilding, including AAS, workout regimens/training, and nutrition/dietary supplementation. The AAS discussion areas provide an open forum for researching and discussing everything relating to the use of these substances including (but not limited to) drug profiles, health issues, dosing regimens, and side effect discussions, and also provide an open arena for exchange of ideas and advice among members. To gain access to AAS-related information and to participate in the posting/discussion forums, Web visitors are required to sign up as members; the most popular AAS-related sites boast several thousand members. The sites are open to anyone wishing to participate in discussions relating to AAS and to appeal to those individuals who are using drugs or who have a general curiosity on the topic and wish to learn more. Permission to survey the membership was granted by the Web masters. After initial pilot testing, the study was approved by the institutional review board of Orthopaedic Hospital.

During January through March of 2004, a Web link was posted on message boards of 12 AAS-related Internet discussion forums. The link directed subjects who were current or past AAS users to an HTML-based Web survey consisting of an anonymous, self-administered 30-item questionnaire. An accompanying cover letter provided additional information, explaining the purpose of the study and assuring anonymity. Participation in the survey implied informed consent. The questionnaire was designed to elicit single-answer responses with the option of providing additional information, such as dosage regimens, as indicated. It was proposed that the duration of time required to complete the 30-item questionnaire would deter nonserious or repeat responders. For inclusion in the study and to facilitate statistical analysis, respondents were required to complete all 30 questions.

Respondents were asked their age and sex and whether they participated in any form of competitive sport. They were asked at what age they began using AAS and the duration of their drug use. Inquiry was made into their self-administered AAS regimens including the weekly dose, duration of drug cycles, and total annual use. Respondents were asked to list the types of AAS used, whether they administered the drugs orally or by intramuscular injection, and any unsafe injection practices such as sharing needles or sharing multidose vials. Questions were also asked regarding the individual subject's source of illegal drugs.

From a list of potential subjective side effects, subjects were asked to select any adverse symptoms they had personally experienced as a result of AAS use. Inquiry was also made regarding the use of medications to minimize or treat AAS-related complications, and whether the subjects had sought medical advice or undergone laboratory studies to evaluate their health status. Finally, respondents were asked about the use of other performance-enhancing drugs or herbal over-the-counter aids, as well as whether they had experienced any legal, health, or relationship problems as a result of their drug use.

TABLE 1. Age distribution of AAS users.

Age (yr)	No. of Users	% of Users
<18	5/500	1
18–24	150/500	30
25–30	142/500	28.4
31–35	108/500	21.6
>35	95/500	19

Range, 16–62 yr.

TABLE 3. AAS dose per week.

Dose (mg) per Week	No. of Users	% of Users
<500	23/500	4.6
500–1000	179/500	35.8
1000–1500	166/500	33.2
1500–2000	69/500	13.8
>2000	63/500	12.6

Completed questionnaires were submitted electronically to the research e-mail address and then sequentially downloaded for analysis based on the date and time of submission. Incomplete questionnaires, in which respondents failed to answer all 30 items, were discarded from the study. The first 500 complete questionnaires were evaluated using standard statistical methods. The survey was removed from the Internet sites after the 3-month study period.

RESULTS

Demographics. The first 500 completed questionnaires were entered into the study. Males represented 98.8% (494/500) of the respondents. The age distribution is shown in Table 1, with teens representing only 2.6% of the respondents. Table 2 summarizes the ages at which participants began their AAS use. Although teens represented only 2.6% of the sample, 26% (130/500) of respondents stated that they began using AAS during their teenage years. The majority of the participants (78.4%, 392/500) were recreational athletes and bodybuilders who did not participate in any organized competitive sporting events.

AAS dosages. The doses of AAS self-administered by the respondents in this sample ranged from 70 to 6000 mg of testosterone or its equivalent per week, as summarized in Table 3. Whereas 40.4% (202/500) of the sample reported taking a weekly dose < 1000 mg, 59.6% (298/500) admitted to using a weekly dose ≥ 1000 mg. Combinations of two or more different types of AAS were taken to achieve such megadoses by the majority of respondents (95%, 478/500). The types of oral and injectable AAS steroids used by the study respondents are listed in Table 4.

Patterns of AAS use. The duration of AAS administration (steroid "cycle") ranged from 4 to 20 wk. The total annual duration of AAS use in months per year was as follows: < 3 months (6.2%, 31/500), 3–6 months (48.8%, 244/500), and 6+ months (45%, 225/500). Whereas over 93% of the sample (469/500) self-administered AAS in drug cycles, 6% (31/500) of this sample reported continuous AAS use for 52 wk of the year. Table 5 outlines the respondents' cumulative number of years of AAS use, which ranged from 8 wk to 25 yr. The interval or drug holiday between steroid cycles varied widely between users, lasting from weeks to months. Some users reported the practice "time-on cycle equals time-off drugs."

Drug administration practices. Of the 500 participants, 496 (99.2%) reported using injectable AAS or a combination of injectable and oral substances. Hazardous injection practices were reported as follows: 13% (65/500) reported reusing needles for IM injections, 8.2% (41/500) reported sharing multidose vials, and 1% (5/500) admitted to sharing injection needles with another person.

Adverse effects. Of this sample, 99.2% (496/500) reported subjective side effects as a result of AAS use, and > 70% (355/500) experienced at least three or more of these complications. The most common adverse symptoms were acne, insomnia/sleep disturbances, fluid retention/edema, mood alterations, gynecomastia, testicular atrophy, stretch marks (striae), sexual dysfunction, and injection-site pain. Other less frequently reported side effects included alopecia, hypertension, and high cholesterol. Table 6 summarizes the side effect profile reported in this sample. Of those who experienced subjective side effects, 96% (477/496) reported taking additional medications to alleviate unwanted symptoms rather than discontinuing their AAS use. Medications taken to treat AAS-induced side effects are listed in Tables 7 and 8. Of the respondents who reported hypertension and high cholesterol as side effects, less than 25% of them admitted to taking blood pressure or cholesterol-lowering medications.

TABLE 2. Starting age of AAS use.

Age (yr)	No. of users	% of Users
<16	8/500	1.6
16–19	122/500	24.4
20–24	188/500	37.6
25–30	97/500	19.4
>30	85/500	17

Range, 14–58 yr.

TABLE 4. List of AAS formulations used.

Injectable Preparations	Oral Preparations
Nandrolone (Deca-Durabolin)	Methandrostenolone (Dianabol)
Boldenone (Equipoise)	Oxymetholone (Anadrol)
Methenolone (Primobolan)	Oxandrolone (Anavar/Oxandrin)
Drostanolone (Masteron)	Chlorodehydromethyl testosterone (Turinabol)
Stanozolol (Winstrol-V)	Stanozolol (Winstrol)
Trenbolone (Parabolan/Finaplix)	Fluoxymesterone (Halotestin)
Testosterone blend (Sustanon/Omnadren)	Methyl testosterone (Android)
Testosterone suspension	
Testosterone propionate	
Testosterone cypionate	
Testosterone enanthate	

Trade names are in parentheses.

TABLE 5. Cumulative years of AAS use.

Years of Use	No. of Users	% of Users
<1	22/500	4.4
1–3	269/500	53.8
4–6	115/500	23
7–10	33/500	6.6
>10	61/500	12.2

Polypharmacy. Of the respondents, 96% (481/500) admitted to using other drugs in addition to AAS. These accessory drugs are added for a variety of reasons and include adjuvant anabolic agents, stimulants, fat-loss drugs, sedatives, and medications to alleviate AAS-induced side effects. Table 7 lists the accessory drugs used by respondents, along with the reasons for use. The most common accessory drugs and doses used by the AAS users in this sample are summarized in Table 8.

Drug sources. Eleven percent (58/500) stated that they obtained AAS legally with a physician's prescription. However, the 89% (442/500) majority of AAS users had acquired the drugs through other sources, as summarized in Table 9. Participants reported obtaining AAS from a variety of geographic origins including Mexico, Australia, Asia, United States, and Europe. The most common foreign source country was Mexico, with 37.4% (187/500) of respondents stating that they had used AAS manufactured in Mexico. Of particular interest was the finding that 56% (280/500) of respondents reported using AAS produced in "bootleg" or underground illicit laboratory facilities.

Health attitudes. Of the respondents, 61.4% (317/500) admitted that they were concerned about possible detrimental effects of AAS on their health, and 64.4% (322/500) stated that they have routine health and/or laboratory checks to monitor their health while taking AAS. Thirty-seven percent (185/500) had discussed AAS use with a physician, and 91.6% (458/500) stated that they would prefer to use AAS legally under the direct supervision of a knowledgeable physician.

Other consequences of AAS use. When asked whether they had suffered any medical, legal, or relationship problems as a direct result of their AAS use, respondents replied as follows: 7% (35/500) reported that they had sought medical care for an AAS-induced complication, 5% (25/500) admitted to experiencing legal problems, and 11.8% (59/500) reported marital or relationship problems as a consequence of their drug use.

TABLE 6. Side effect profile.

Side Effect	No. of Users	% of Users
Testicular atrophy	(318/500)	63.6
Acne	(317/500)	63.4
Fluid retention/edema	(261/500)	52.2
Insomnia	(256/500)	51.2
Injection site pain	(245/500)	49.0
Stretch marks (striae)	(222/500)	44.4
Mood alterations	(214/500)	42.8
Sexual dysfunction	(123/500)	24.6
Gynecomastia	(115/500)	23.0
None	(4/500)	0.8

TABLE 7. Accessory medications and reason for use.

Drug Names	Reason for Use
Accessory anabolic agents	
Growth hormone	Anabolic/repartitioning agent
Insulin	Anabolic agent
Insulin-like growth factor-1	Anabolic agent
Stimulants/fat loss	
Ephedra/ephedrine	Stimulant/appetite suppressant
Amphetamine	Stimulant/appetite suppressant
Thyroid (T_3/T_4)	Metabolic stimulant
Clenbuterol	Fat loss
Caffeine	Stimulant/fat loss
Yohimbine	Fat loss
Dinitrophenol	Metabolic uncoupling agent
Sedatives	
Benzodiazepines	Sleep
Gamma-hydroxybutyrate	Sleep/growth hormone release
Miscellaneous	
Diuretics	Fluid retention/weight loss
Medications to alleviate side effects	
Tamoxifen	Gynecomastia
Antiaromatases (anastrazole, letrozole)	Fluid retention/gynecomastia
Clomiphene	HPTA suppression/testicle atrophy
Finasteride	Alopecia/prostatic hypertrophy
Human chorionic gonadotropin	HPTA suppression/testicle atrophy

DISCUSSION

This study profiles a sample of 500 AAS users and represents the largest and most in-depth survey of this kind to date. Whereas the results presented here lend support to previous surveys, there are some striking differences suggesting a worrying trend that current AAS users are taking greater health risks than observed a decade ago.

Demographics. AAS use is not a practice unique to elite athletes seeking to enhance performance. Four out of five steroid users (78.4%) in this study were noncompetitive

TABLE 8. Commonly used accessory medications and dose ranges.

Drug Names	No. of Users	% of Users	Dose Range
Accessory anabolics			
Growth hormone	128/500	25.6	2–32 IU·d^{-1}
Insulin	125/500	25	2–60 U·d^{-1}
Insulin-like growth factor-1	48/500	9.6	20–120 μg·d^{-1}
Stimulants/fat loss			
Ephedra/ephedrine	341/500	68.2	25–250 mg·d^{-1}
Caffeine	318/500	63.6	50–800 mg·d^{-1}
Clenbuterol	292/500	58.4	20–200 μg·d^{-1}
Thyroid (T_3/T_4)	228/500	45.6	10–300 μg·d^{-1}
Yohimbine	143/500	29.2	2.5–10 mg·d^{-1}
Dinitrophenol	65/500	13	100–600 mg·d^{-1}
Miscellaneous			
Diuretics	48/500	9 6	Variable
Medications to alleviate side effects			
Clomiphene	297/500	59 4	50–150 mg·d^{-1}
Antiaromatases (anastrazole, letrozole)	293/500	58.6	0.25–2.5 mg·d^{-1}
Tamoxifen	267/500	53.4	10–30 mg·d^{-1}
Human chorionic gonadotropin	195/500	39	100–5000 U per dose

TABLE 9. Drug sources.

Source	No. of Users	% of Users
Internet dealer	354/500	70.8
Gym member/dealer	121/500	24.2
Foreign mail order	94/500	18.8
Physician	58/500	11.6
Internet pharmacy	43/500	8.6

athletes, recreational bodybuilders, and nonathletes who self-administered AAS for cosmetic reasons with the sole intention of improving physical appearance. Nearly 60% of steroid users in this sample were younger than 30 yr of age, and approximately one in four steroid users stated that they began using AAS during their teenage years. These findings suggest that body image presents a significant concern in young males who resort to AAS use as a means of enhancing physical appearance. Over 40% of this sample admitted to habitual steroid use for longer than 4 yr, and 10% report chronic AAS use lasting $\geq$ 10 yr.

AAS drug regimens. As might be expected with self-administered drug use, steroid doses reported in this survey varied widely, ranging from 70 to 6000 mg·wk^{-1} of testosterone or its equivalent. Remarkably, nearly 60% of steroid users this sample reported using a dose of at least 1000 mg·wk^{-1}. Comparing current data with that from previous studies indicates that self-administered AAS doses may have increased during the past decade. The majority of AAS users in a survey published in 1997 (9) reported a weekly dose $\leq$ 500 mg, whereas in the current sample, the majority of users take at least 1000 mg·wk^{-1}. Although historical controls make comparisons difficult, there may be a trend among AAS users toward increasing doses that greatly exceed the recommended therapeutic doses used for testosterone replacement therapy (1).

Of AAS users in the current sample, 95% reported combining two or more different formulations of AAS simultaneously, a practice known as steroid "stacking," in order to meet the large supraphysiological doses that are required to elicit a significant anabolic response in skeletal muscle. Recent scientific studies support AAS users' theory that "the bigger the dose, the bigger the muscle" (8). The anabolic effect of testosterone is dose dependent, and androgen receptors can be upregulated by exposure to exogenous AAS (4,15,26). Nearly 100% of those surveyed reported using injectable formulations to facilitate their supraphysiological dose regimens. Typical drug combinations reported by steroid users this sample are shown in Table 10. Nine out of 10 steroid users reported self-administering AAS in "drug cycles," typically using steroids for periods of 4–20 wk. The time interval between steroid cycles, or "off-cycle," is more variable. Whereas regular users take a 4- to 6-wk drug holiday to "clear the system," less frequent users may remain drug-free for several months. One half of steroid users this sample reported using the drugs for 6 months or more per year. Only a small proportion (6%) of steroid users admitted to a continuous drug use for 52 wk of the year.

Side effects. Nearly 100% (496/500) of this sample reported subjective side effects with AAS use. Seventy percent experienced three or more adverse symptoms. The most common subjective side effects were acne, testicular shrinkage, insomnia, sexual dysfunction, injection site pain, striae, fluid retention, mood alterations, and gynecomastia. Five of the nine most common side effects reported were experienced by more than 50% of survey participants, with acne and testicular atrophy being reported in nearly two thirds of users. Although it is not possible to confirm or evaluate subjective AAS-induced side effects reported during a self-administered survey, it is evident that these complications were bothersome enough to be recognized by users. None of the participants admitted to suffering any serious complications as result of AAS use. Because the majority of steroid users admitted to polypharmacy, with more than 50% of users simultaneously taking several AAS formulations and up to five other accessory drugs, it may be difficult to pinpoint an individual medication as the direct cause of adverse symptoms.

In previous surveys (5,9), 88 and 96.4% of steroid users reported subjective side effects, and data suggest that the prevalence of side effects increases with increasing doses and number of AAS taken concurrently (5). AAS-induced adverse effects do not deter users from taking increasingly larger doses of AAS. Rather than reducing AAS use, a common practice is to self-administer additional medications to alleviate or prevent AAS-induced side effects.

Furthermore, these AAS users often begin in their teen years and continue on a habitual path of use for many years. Chronic AAS users have been shown to have a

TABLE 10. Sample AAS drug regimens.

Drug Regimen	AAS Used	Dosing Protocol	Total Weekly AAS Dose (mg)
Simple cycle (8 wk)	Methandrostenolone	25 mg·d^{-1} PO, weeks 1–8	675
	Testosterone cypionate	500 mg·wk^{-1} IM, weeks 1–8	
Moderate cycle (12 wk)	Sustenon (testosterone)	750 mg·wk^{-1} IM, weeks 1–12	1500
	Nandrolone Decanoate	400 mg·wk^{-1} IM, weeks 1–12	
	Methandrostenolone (switch to) Oxymetholone	40 mg·d^{-1} PO, weeks 1–4 50 mg·d^{-1} PO, weeks 5–8	
Complex cycle (20 wk)	Methandrostenolone (switch to) oxymetholone	50 mg·d^{-1} PO, weeks 1–5 100 mg·d^{-1} PO, weeks 6–10	3500
	Testosterone cypionate	1500 mg·wk^{-1} IM, weeks 1–20	
	Boldenone undecylenate (switch to) nandrolone decanoate	800 mg·wk^{-1} IM, weeks 1–10 800 mg·wk^{-1} IM, weeks 11–20	
	Stanozolol (switch to) trenbolone acetate	700 mg·wk^{-1} IM, weeks 1–10 700 mg·wk^{-1} IM, weeks 11–20	
	Growth hormone Insulin (Humalog)	6 IU·d^{-1} × 20 wk 15 U·d^{-1} (post-workout)	

mortality rate 4.6 times higher than non-AAS users (20). The data from this study suggest that AAS users are not only using higher doses than previously documented, but are also staying on the drugs for longer periods of time, increasing their risk of potentially severe health complications in the long term.

Injection practices. Close to 100% of steroid users surveyed admitted to self-administering AAS by intramuscular injection, and one half of this sample reported experiencing injection site pain. Several factors may contribute to injection-related complications, including a lack of training in sterile injection technique, the use of poor quality bootleg and veterinary products, and the frequent large-volume injections needed to sustain a megadose drug regimen. Of the steroid users surveyed, approximately 1 in 10 reported hazardous injection practices: 13% reported reusing needles, 8.2% admitted to sharing multidose vials, and 1% reported sharing needles with another steroid user. These unsafe injection practices may be explained by a lack of available injection equipment and a lack of education in sterile injection techniques.

Drug sources. The majority (89%) of steroid users surveyed reported obtaining drugs from illegal sources; only 11% obtained AAS legally with a physician's prescription. Although some illegally acquired drugs may be from legitimate pharmaceutical manufacturers, there is a growing bootleg industry supplying drugs of questionable quality, content, and sterility. Seventy percent of steroid users purchased drugs via the Internet, and more than 50% reported the use of bootleg AAS manufactured in illicit laboratories. More than one third of users (37.4%) had obtained drugs manufactured in Mexico, where most AAS are produced by veterinary pharmacies.

Foreign-made, veterinary, and bootleg drugs may be of inferior quality and dubious sterility, thereby increasing the potential for injection-related and other health complications. Furthermore, unregulated bootleg drugs may be subject to mislabeling, and such products may not contain the drug concentration listed on the label. The growing reliance on potentially mislabeled bootleg drugs may partly explain why the self-administered AAS doses in this survey are higher than those reported previously.

Polypharmacy. Drug use by AAS users is not limited to anabolic steroids. More than 95% of AAS users admit to taking a mix of muscle-shaping drugs and accessory medications (Table 7) in addition to "stacking" different types of steroids. Accessory drugs are used for a variety of reasons, such as adjuvant anabolic effects, stimulants, fat loss, and medications to combat the side effects of AAS.

Compared with previous surveys, the proportion of AAS users taking GH and insulin as adjuvant anabolic agents has increased. In a 1997 survey, 12% of steroid users reported using GH, and 2% had used insulin (9). A striking observation from the current study is that 25% of the steroid users admit to the unsupervised use of both GH and insulin. The anabolic effects of GH on target tissues are not direct, but are the result of increased production of IGF-1 in the liver and peripheral tissues (25). Nearly 10% of AAS users surveyed report using recombinant injectable IGF-1 preparations in their anabolic arsenal. The prevalence of IGF-1 use has not been previously documented among AAS users. In addition to the effects mediated by IGF-1, GH is a powerful stimulant of lipolysis in central and peripheral adipose cells (12). Whereas the true effectiveness of GH as a potent anabolic substance remains in question, powerful nutrient-partitioning and fat-loss properties have been documented (25). Long-term GH administration in normal individuals may lead to cardiac instability, hypertension, development of insulin resistance, and possibly type 2 diabetes (25).

Unsupervised insulin regimens reported by AAS users in this study typically consisted of a fast-acting insulin (Humulin R, Humalog) formulation self-administered after a postworkout meal. Some users report using a glucometer to minimize their risk of unwanted hypoglycemic events. The anabolic effect of insulin is manifest by an artificially induced hyperinsulinemic state that increases amino acid transport into muscles inhibiting protein breakdown and stimulating overall bulk protein synthesis when in the presence of concomitant hyperaminoacidemia (2).

The reported use of thermogenic stimulants like ephedrine, caffeine, and clenbuterol is similar to that found by a previous survey (9); however, the use of thyroid medications to aid in fat loss has risen from 2% to more than 45%. The use of yohimbine and dinitrophenol (DNP) has not previously been documented in AAS users. Yohimbine is an α_2-adrenergic receptor blocker that indirectly increases epinephrine and norepinephrine levels and functions as a fat-loss agent. DNP is a powerful uncoupling agent of oxidative metabolism that functions by inhibiting the oxidative production of adenosine triphosphate, causing a substantial increase in metabolic activity and heat production. This drastic increase in metabolic activity and heat production has led to hyperthermia and death with overdose of DNP (18).

Accessory medications are also taken to alleviate AAS-induced side effects. Almost 100% of AAS users in our study complained of one or more side effects, and more than 95% reported taking medications to treat these effects. More than half of the participants noted taking clomiphene, antiaromatases, and tamoxifen, with nearly 40% using human chorionic gonadotropin (HCG). Clomiphene and HCG are commonly used to reverse the endogenous testosterone suppression experienced by users, in an effort to "kick start" natural hormone production at the end of a steroid cycle and reverse testicular atrophy. Tamoxifen and antiaromatase medications block or alleviate the symptoms of gynecomastia that result from the aromatization of testosterone to estrogen. Antiaromatases are also used to alleviate the inevitable fluid retention of heavy androgen use.

It is noteworthy that some of these "accessory" drugs are potentially much more dangerous than AAS. The unsupervised use of insulin, diuretics, stimulants, and thyroxine can precipitate a number of medical emergencies (8). Little if any information exists with regards to the myriad of possible

interactions and increased health risks of these polypharmaceutical practices. During the evaluation of a known or suspected steroid user, it is of paramount importance that the physician take a detailed drug history, keeping in mind the widespread use of these accessory medications.

Health issues. Despite evidence that AAS users are taking increasing health risks with respect to drug megadoses, accessory medications, unsafe injection practices, and illicit drug sources, 6 out of 10 (61.4%) of steroid users surveyed indicated that they were concerned about the potential health ill effects of their AAS use. Although this may seem somewhat contradictory, it is supported by the observation that a similar proportion (64.4%) of steroid users undergo routine health checks and/or laboratory screenings. Only 37% of those surveyed, however, report discussing their AAS use with a physician. This barrier to communication between AAS users and their physicians may exist for several reasons, such as fear of legal consequences, the stigma of illegal drug use, and a perceived lack of physician knowledge regarding AAS. Nevertheless, more than 90% of steroid users surveyed noted that they would prefer to use AAS legally and under the supervision of a knowledgeable physician. It is possible that medically supervised AAS use could deter some of the emerging dangerous trends of unsupervised AAS use and possibly decrease the likelihood of preventable health complications.

Limitations. There are some limitations to this self-selected, self-reported survey. Recruiting AAS users on a voluntary basis exposes this kind of study to selection bias, and information bias may arise when the participants recall their experience. Our findings cannot be generalized to all AAS users, and current data cannot easily be compared with previous studies or historical controls. However, AAS users present a difficult group to assess, and studies reporting the unsupervised drug habits of AAS users are relatively few. Despite the limitations, consistencies and similarities between this study and previously published surveys support and validate the results.

CONCLUSIONS

The results of this survey reveal several trends in the nonmedical use of AAS. Nearly four out of five AAS users are nonathletes who take these drugs with the sole intention of improving physical appearance. AAS users in the current survey are taking larger doses than previously recorded, with more than half the respondents using a weekly AAS dose in excess of 1000 mg. Close to 100% of steroid users surveyed admitted to self-administering AAS by intramuscular injection, with approximately 1 in 10 users reporting hazardous injection techniques. An 89% majority of AAS users obtain drugs from illegal sources, with more than 50% admitting to the use of bootleg drugs manufactured in illicit laboratories. Polypharmacy is practiced by more than 95% of AAS users surveyed. One in four users takes growth hormone and insulin, suggesting that the use of adjuvant anabolic agents is rising. Finally, that nearly 100% of AAS users experience subjective side effects suggests that concern over health risks does not influence the patterns of drug use.

REFERENCES

1. BAGATELL, C. J., and W. J. BREMNER. Androgens in men—uses and abuses. *N. Engl. J. Med.* 334:707–714, 1996.
2. BANADONNA, R. C., M. P. SACCOMANI, C. CABELLI, et al. Effect of insulin on system A amino acid transport in human skeletal muscle. *J. Clin. Invest.* 91:514–521, 1993.
3. BHASIN, S., T. W. STORER, N. BERMAN, et al. The effects of supraphysiological doses of testosterone on muscle size and strength in normal men. *N. Engl. J. Med.* 335:1–6, 1996.
4. BHASIN, S., L. WOODHOUSE, R. CASABURI, et al. Testosterone dose-response relationships in healthy young men. *Am. J. Physiol. Endocrinol. Metab.* 281:E1172–E1181, 2001.
5. BOLDING, G., L. SHERR, and J. ELFORD. Use of anabolic steroids and associated health risks among gay men attending London gyms. *Addiction* 97:195–201, 2002.
6. BUCHANAN, T., and J. L. SMITH. Research on the Internet: validation of a World-Wide Web mediated personality scale. *Behav. Res. Methods Instrumental Comput.* 31:565–571, 1999.
7. BUCHANAN, T., and J. L. SMITH. Using the Internet for psychological research: personality testing on the World-Wide Web. *Br. J. Psychol.* 90:125–144, 1999.
8. EVANS, N. A. Current concepts in anabolic-androgenic steroids. *Am. J. Sports Med.* 32:534–542, 2004.
9. EVANS, N. A. Gym & Tonic: a profile of 100 male steroid users. *Br. J. Sports Med.* 31:54–58, 1997.
10. EYSENBACH, G., and J. WYATT. Using the Internet for surveys and health research. *J. Med. Internet Res.* 4:e13, 2002.
11. FERRANDO, A. A., K. D. TIPTON, D. DOYLE, et al. Testosterone injection stimulates net protein synthesis but not tissue amino acid transport. *Am. J. Physiol.* 275:E864–E871, 1998.
12. GRAVHOLT, C. H., O. SCHMITZ, L. SIMONSEN, et al. Effects of a physiological GH pulse on interstitial glycerol in abdominal and femoral adipose tissue. *Am. J. Physiol.* 277:E848–E854, 1999.
13. GREENHALGH, T., and R. TAYLOR. Papers that go beyond numbers (qualitative research). *BMJ.* 315:740–743, 1997.
14. INOUE, K., S. YAMASAKI, T. FUSHIKI, et al. Androgen receptor antagonist suppresses exercise-induced hypertrophy of skeletal muscle. *Eur. J. Appl. Physiol.* 69:88–91, 1994.
15. KADI, F., P. BONNERUD, A. ERIKSSON, et al. The expression of androgen receptors in human neck and limb muscles: effects of training and self-administration of androgenic-anabolic steroids. *Histochem. Cell Biol.* 113:25–29, 2000.
16. KERSEY, R. D. Anabolic-androgenic steroid use by private health club/gym athletes. *J. Strength Cond. Res.* 7:118, 1993.
17. KUHN, C. M. Anabolic steroids. *Recent Prog. Horm. Res.* 57:411–434, 2002.
18. MCFEEM, R. B., T. R. CARACCIOM, M. A. MCGUIGAN, et al. Dying to be thin: a dinitrophenol related fatality. *Vet. Hum. Toxicol.* 46:251–254, 2004.
19. NATIONAL INSTITUTE ON DRUG ABUSE (NIDA). About anabolic steroid abuse. *NIDA Notes* 15:15, 2000.
20. PARSSINEN, M., and SEPPALA. Steroid use and long-term health risks in former athletes. *Sports Med.* 32:83–94, 2002.

21. PARSSINEN, M., T. KARILA, V. KOVANEN, et al. The effect of supraphysiological doses of anabolic androgenic steroids on collagen metabolism. *Int. J. Sports Med.* 21:406–411, 2000.
22. PERRY, H. M., D. WRIGHT, and B. LITTLEPAGE. Dying to be big: a review of anabolic steroid use. *Br. J. Sports Med.* 26:259–261, 1993.
23. PERRY, P. J., K. H. ANDERSEN, and W. R. YATES. Illicit anabolic steroid use in athletes: a case series analysis. *Am. J. Sports Med.* 18:422–428, 1990.
24. POPE, H. G., and D. L. KATZ. Psychiatric and medical effects of anabolic-androgenic steroid use: a controlled study of 160 athletes. *Arch. Gen. Psychiatry* 51:375–382, 1994.
25. RENNIE, M. J. Claims for the anabolic effects of growth hormone: a case of the emperor's new clothes? *Br. J. Sports Med.* 37: 100–105, 2003.
26. SHEFFIELD-MOORE, M., R. J. URBAN, S. E. WOLF, et al. Short-term oxandrolone administration stimulates net muscle protein synthesis in young men. *J. Clin. Endocrinol. Metab.* 84:2705–2711, 1999.
27. SINHA-HIKIM, I., J. ARTAZA, L. WOODHOUSE, et al. Testosterone-induced increase in muscle size in healthy young men is associated with muscle fiber hypertrophy. *Am. J. Physiol. Endocrinol. Metab.* 283:E154–E164, 2002.
28. URBAN, R. J., Y. H. BODENBURG, C. GILKISON, et al. Testosterone administration to elderly men increases skeletal muscle strength and protein synthesis. *Am. J. Physiol.* 269:E820–E826, 1995.
29. YESALIS, C. E., N. J. KENNEDY, A. N. KOPSTEIN, et al. Anabolic-androgenic steroid use in the United States. *JAMA.* 270: 1217–1221, 1993.