

Contemporary Patterns of Anabolic Steroids Abuse and Associated Short Term Side Effects in Athletes

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Received: April 22, 2015 Revised: June 9, 2015

Accepted: June 13, 2015

Published online: August 23, 2015

ABSTRACT

INTRODUCTION: Anabolic steroids (AS) are synthetic derivatives of the testosterone molecule. In recent years, AS abuse by athletes of different levels has become more prevalent and circumspect. The objectives of this study were: Recognition of AS abusers, verification of individual biostatistic and demographic parameters, stratification, recognition and evaluation of the AS abuse patterns.

METHODS: We constructed specialized questionnaires used to identify users and collect data. In a time period of 12 years, 5074 people were evaluated and the relevant questionnaires were filled, 4146 (81.7%) by amateur and 928 (18.3%) by recreational athletes. The data provided by the evaluation of the questionnaires were categorized and elaborated. Studied parameters included: types of AS used, percentage of AS abusers in athletic populations, gender percentage, stratification according to severity of abuse, AS used and use parameters, observed side effects.

RESULTS: Categorization of the results has four directions: 1. Separation of users according to sex and athletic category, 2. Stratification of users according to AS abuse severity by use of the Abuse Stratification System (AbuStraS). Categorization of AS regimens (AS frequencies, duration, type and doses) used by the cohort and 4. The immediate results of AS abuse to the users'

organism and the long term influence in a four years time interval.

CONCLUSIONS: Contemporary AS users consistently practice overdose polypharmacy. Knowledge of this type of abuse can be beneficial for the treatment of the side effects.

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Key words: Anabolic steroids; Abuse; Anabolic steroid toxicity

Pagonis TA, Givissis PP. Contemporary Patterns of Anabolic Steroids Abuse and Associated Short Term Side Effects in Athletes. *International Journal of Orthopaedics* 2015; 2(4): 347-352 Available from: URL: <http://www.ghrnet.org/index.php/ijo/article/view/1322>

INTRODUCTION

Anabolic androgenic steroids (AAS) are synthetically manufactured chemical compounds derived from the manipulation of three natural steroid hormones: Testosterone, Nandrolone and Dihydrotestosterone^[1,2], in a controlled effort to diminish the androgenic effects while retaining or optimising the anabolic effects of the parental molecules^[3-5].

Synthetic AAS can be injected or administered orally and even transdermally^[6,7]. Oral AAS^[8] have undergone C-17 alpha alkylation^[9]. Non-alkylated oral compounds use a 17-beta carboxylic acid ester or 1-methylation or a 17-beta enol linkage^[10]. Injectable AAS compounds have esters attached to the 17-beta hydroxyl group, in an effort to increase half-life and activity.

Exercising individuals are commonly using AAS agents^[11] in a continuous effort to increase their muscle mass^[12], strength and performance^[13,14] consistently practicing polypharmacy^[15]. This means that most users will self-administer a combination of various oral and/or injectable compounds, typically in supraphysiological doses^[16]. This type of abuse (polypharmacy) increases the oxidative stress affecting the metabolism while having a combined compound toxicity^[17,18]. There have been numerous case reports of hepatic

damage secondary to AAS use^[19-24] indicated by elevated serum hepatic enzymes, which return to normal once the AAS are discontinued^[25]. This is one of the main reasons forcing athletes to abuse AAS on an intermittent rather than continuous basis^[26].

AAS-induced hepatotoxicity is relatively common and typically occurs with C-17 alkylated agents, while non-alkylated agents are less likely to produce liver damage. As oral AAS formulations are commonly C-17 alkylated agents, they are typically administered by users at doses close to those therapeutically recommended^[27], in order to minimize adverse hepatic effects. Injectable formulations of C-17 alkylated agents appear to have comparable hepatotoxic hazard, but are applied in doses three to six-fold higher than those therapeutically recommended^[28-29].

To our knowledge there have been no validated large cohort studies reporting on the actual combinations and type of compounds used by AAS abusers. Our study reports on the actual way this polypharmacy is happening in a large cohort of exercising individuals.

MATERIALS AND METHODS

Participants

In a time period of 12 years (2000 – 2012), 5074 athletes of various categories were evaluated and the relevant questionnaires were filled. The cohort included athletes from 11 different countries in Europe. Exclusion criteria were age (no minors below 18th year of age) and patients not willing to be included in the anonymized database.

Abuse pattern

AAS users were following regimes that they had obtained themselves. Substances and doses of AAS declared by athletes are presented in table 2, along with the % of athletes using each agent and the therapeutically applied dose (dose used in medicine) for each agent is also depicted for comparison reasons. Subjects were self administering a combination of at least two oral and two injectable AAS in regimens lasting a median of 8 weeks. The maximum number of different AAS used in a single regimen was 3 orals and 3 injectables. The different types of AAS available through the black market provide each abuser with innumerable combinations of different compounds that are easily accessible according to their remarks.

AAS are used by athletes in a regime referred to as “cycle”^[30] which typically consists of an exotic combination of multiple oral and/or injectable formulations of different agents^[31], used in supra physiological doses for the span of numerous weeks (varying from 4 to 12)^[32,33]. This modern type of usage is mainly based on anecdotal information and is supported by a strong belief that a combination of some of the most potent AAS with some milder ones, for a sufficient period of time, will effectively produce dramatic results in muscle mass, strength and overall physique improvement^[34]. Within a “cycle”, doses of each of the individual AAS used are varying from a minimum to a maximum value. The initial modest doses are quickly followed by an escalation in the administered milligrams of each AAS agent which is usually reaching a climax (maximum dose) two weeks before the cycle’s end. This maximum dose is then maintained for the rest of the cycle’s duration.

Some of the AAS users will slowly taper off the different AAS after their cycle ends or on the last two weeks of it and most of them will follow a two to three weeks of an ancillary medication cycle to restore natural testosterone production.

Frequent dosage administration and shortening of available AAS injection sites due to the post-administration muscle soreness^[35]

forces users to invest the biggest portion of their “cycle” budget in numerous different potent anabolic oral compounds and some strong injectable ones. Powerful oral AAS are preferred by all users and are more easily used by the majority of the professionals, due to their short half-life and detection times in doping controls. The biggest challenge for us was the stratification of users into groups of similar severity according to the parameters of the abuse patterns observed in each case.

We used the Abuse Stratification System (AbuStraS)^[36] to stratify users into groups according to the severity of the abuse. For the abuse severity assessment the following abuse parameters were taken into careful consideration: the number (n) of compounds used, the type of AAS (ty), the used dosages (D), the Therapeutic Index (Androgenic activity/Anabolic activity = TI) of the agents, the number of “cycles” used in the past (C), and finally the duration of time (dT) that each “cycle” lasted (Table 1). The severity in each parameter scored arbitrarily from the lighter to the heavier with 1, 2 and 3 points as it is shown in table 1. The total score (Sum) a user receives by addition of the points acquired from each parameter, is used as a categorization quota. According to AbuStraS, the smallest total score a user belonging to the lighter levels of all subscales can acquire is 6

Table 1 Cohort Demographics.

	Cohort	Females	Males	Kruskal-Wallis
n	5074	686 (13.5%)	4388 (86.5%)	
Age (years)	23.9 (18-55)	21.1 (18-32)	25.1 (18-55)	
Gender	-	36.3%	63.7%	
Amateur (%)	22.8%	26.2%	38.8%	
Recreational (%)	27.2%	10.8%	6%	
Body Builders (%)	50%	63%	55.2%	
Light Abuse	517 (10.2%)	91 (13.2%)	426 (9.7%)	p < 0.001
Medium Abuse	2226 (43.9%)	387 (56.4%)	1839 (41.9%)	p < 0.001
Heavy Abuse	2331 (45.9%)	208 (30.4%)	2123 (48.4%)	p < 0.001

Table 2 Characteristics of the Abuse Stratification System (AbuStraS) used for categorization of AAS users. Athletes with less than 12 points are characterised as “light abusers”, those with 12-18 points as “medium abusers”, and those with more than 18 points as “heavy abusers”.

Parameters	Points
1. Number (n) of compounds used.	
a. Less than three (n < 3)	1
b. 3 up to 5 (3 ≤ n ≤ 5)	2
c. More than 5 (n > 5)	3
2. Type of AAS (ty)	
a. Transdermal	1
b. Per os	2
c. Injectable	3
3. Used dosage (D).	
a. Less than the therapeutically used dosage (D < A)	1
b. Equal to the therapeutically used dosage (D = A)	2
c. Greater than the therapeutically used dosage (D > A)	3
4. Therapeutic Index (TI) of the compounds used.	
a. TI varying from 1:13 up to 1:8	1
b. TI varying from 1:7 up to 1:3	2
c. TI varying from 1:2 up to 1:1	3
5. Number of “cycles” used in the past (C).	
a. No previous use (C = 0)	1
b. 1 to 3 “cycles” in the past (1 ≤ C ≤ 3)	2
c. More than 3 “cycles” in the past (C > 3)	3
6. The duration of time (dT) that each “cycle” lasts.	
a. equal to or less than 2 weeks (dT ≤ 2)	1
b. 3 to less than 6 weeks (3 ≤ dT < 6)	2
c. 6 to less than 8 weeks (6 ≤ dT < 8)	3
d. Equal to or more than 8 weeks (dT ≥ 8)	4
Categorization	
Light Abuse	Total score < 12
Medium Abuse	12 ≤ Total score ≤ 18
Heavy Abuse	Total score > 18

Table 3 Types and doses of AAS (oral or injectable) used by athletes along with percentage of users for each steroid. For comparison purposes, the dose recommended in clinical practise is also shown.

Substance	Clinical dose*	Range of abused dose	Mean abused dose	% of users
Oral agents (mg per day)				
Fluoxymesterone	10-40	20 to 40	37.5	23
Methyltestosterone	10-25	50 to 90	76.5	31
Oxandrolone	10-20	20 to 30	26.0	65
Oxymetholone	50	50 to 150	125.5	71
Stanozolol	5-15	25 to 75	70.0	85
Ethylestrenol	10-20	30 to 50	45.5	16
Methandrostenolone	5-10	30 to 100	89.5	92
Methenolone acetate	25-50	80 to 170	155.0	17
Testosterone undecanoate	40-160	320 to 450	442.5	9
Quinbolone	20-40	80 to 120	115.5	22
Methylandrostenediol	5-15	30 to 50	45.0	77
Norethandrolone	10-20	40 to 60	55.5	20
4 - Chlorodehydromethyltestosterone	10-20	50 to 150	135.0	5
Mesterolone	25-75	25 to 100	75.0	19
Injectable agents (mg per week)				
Nandrolone decanoate	50-100	200 to 600	525	76
Nandrolone phenylpropionate	25-50	200 to 400	345	54
Nandrolone cypionate	50-100	200 to 600	475	34
Nandrolone hexylophenylpropionate	50	200 to 600	425	12
Nandrolone undecanoate	80,5	241.5 to 644	483	41
Nandrolone laurate	50-100	400 to 600	425	5
Nandrolone cyclohexylpropionate	50	100 to 400	325	6
Testosterone enanthate	100	250 to 1000	750	79
Testosterone cypionate	100	200 to 600	425	69
Testosterone propionate	50-125	300 to 600	525	95
Testosterone cyclohexylpropionate	148-296	592 to 888	740	23
Testosterone phenylpropionate	25-50	300 to 500	400	11
Dromostanolone propionate	100	200 to 400	350	6
Methenolone enanthate	100	200 to 400	325	21
Methylandrostenediol	50-100	200 to 500	375	22
Trenbolone hexahydrobenzylcarbonate	76-152	228 to 456	342	31
Oxabolone cypionate	25-50	300 to 600	525	4

* Recommended by the manufacturing companies and patent holders.

Table 4 Side effects observed and percentage per gender.

Side Effects	Percentage per gender	
	Males	Females
Water retention	100%	100%
Acne	86%	98%
Gynaecomastia	36%	-
Aggression	100%	69%
Hypertension	68%	56%
Cardiovascular disease	8%	1%
Palpitations	62%	20%
Cardiac muscle hypertrophy	2%	-
Virilization	-	79%
Migraines	78%	89%
Impotence	96%	-
Stomach pain	46%	79%
Jaundice	4%	1%
Muscle rupture	8%	1%
Prostate enlargement	78%	-
Hair loss	68%	5%
Stunted growth	24%	46%
Insomnia	98%	100%
Infertility	86%	100%
Anaphylactic reactions	12%	2%
Psychological disorders	100%	100%

points and the higher 12 points, a user belonging to the middle levels of all subscales is from 12 up to 18 points, and a user belonging to the heavier levels of all subscales is above 18. Therefore, an athlete with less than 12 points is characterised as “light abuser”, with 12-18 points as “medium abuser”, and with more than 18 points as “heavy abuser”.

Each athlete was monitored solely for the time equivalent of a single “cycle” he was putting himself into and for side effects reported during the cycle and after that. Validity and homogeneity of

all groups was safeguarded by random doping control tests (testing of urine samples by means of gas chromatography/mass spectrometry) on all three groups, according to the International Olympic Committee’s Protocol and guidelines. Each athlete was categorised by receiving an individual identification number. All numbers were incorporated into a random number generator program (RNG version 3.0 for Windows, ALT-Pro Inc., Hellas, Hellenic Republic). On hundred and thirty-eight random doping control tests were performed during the study in athletes identified by the numbers produced by the generator. All doping control results were within the expected range, proving the group allocation of tested athletes.

Statistical Methods

Values are presented as Mean \pm Standard Deviation. Mann-Whitney/Wilcoxon Two-Sample non-parametric Test (Kruskal-Wallis test for two groups) was used to compare not normally distributed data. Differences between groups were considered significant at a p value < 0.05 . All reported P values are two-sided. SPSS version 9.0 for Windows (SPSS, Inc., Chicago, Illinois, USA) was used for all statistical analyses.

RESULTS

In a time period of 12 years (2000-2012), 5,074 athletes of various categories were evaluated and the relevant questionnaires were filled. Out of the original cohort, 4,146 (81.7%) were amateur and 928 (18.3%) were recreational athletes. Athletes included in this study were all habitual abusers of AAS, who had frequently and consistently used different compounds in the past and present.

Participants’ age ranged from a minimum value of 18 years to a maximum of 55, with a mean value of 23.9 years. 36.3% were

females and 63.7% were males. 50% of the athletes in the study were Body-Builders, 22.8% amateurs and 27,2% were recreational athletes. Demographics are presented in table 1.

As it is shown in table 3 abusers were using various per os and injectable AAS in daily or weekly doses significantly higher than the clinically recommended.

Abuse stratification according to AbuStraS showed that 426 (9.7%) athletes were “light abusers” and of them 517 (10.2%) were female and 91 (13.2%) were male (Table 1). There were 2226 (43.9%) “medium abusers” and of them 387 (56.4%) were female and 1839 (41.9%) were male (Table 1). 2331 (45.9%) were classified as “heavy abusers” with 208 (30.4%) being female and 2123 (48.4%) being male (Table 1).

Of the oral AAS used, 65% of users were preferring Oxandrolone, 71% Oxymetholone, 85% Stanozolol, 95% Methandrostenolone and 77% Methylandrostenediol (Table 2). Of the AAS injectables used, 76% used Nandrolone Decanoate, 79% Testosterone Enanthate, 69% Testosterone Cypionate and 95% Testosterone Propionate (Table 2). Percentages of selected oral and injectable AAS are presented in Table 2. The results show a trend for supraphysiological doses far exceeding recommended dosage in most AAS abused. The side effects recorded are demonstrated in table 4 and there is a comparable recurrence in most side effects recorded. Females seemed to suffer from virilization (79%) while men suffered from prostate enlargement (78%), impotence (96%) and gynaecomastia (36%). Water retention, psychological disorders, insomnia were comparable in both gender groups (Table 4).

Seven per cent of female AAS abusers were using 1-3 different compounds while 93% were using 3-6 while there were no users abusing more than 6 AAS (Figure 1). In males there were 8% abusers using 6+ different compounds, 28% abusing 3-6 compounds while the vast majority (64%) were using 1-3 AAS (Figure 2). Females were mostly using AAS for a duration of 6 to 8 weeks (52%) (Figure 3) while men were in “cycles” for 8+ weeks mostly (52%) (Figure 4).

DISCUSSION

The results of this study show a widespread abuse of AAS in the athletic community with a disparate and differing trend between women and men. A multitude of oral and injectable compounds are used in what the users refer to as a “cycle” that may last more than 8 weeks. The doses used are sometimes similar to the ones recommended for therapeutic use, but mostly they exceed those several times over.

Abuse patterns seem to be associated with gender differences and selection of AAS is also affected by the need or lack thereof for a doping control test. A simple example would be the use of testosterone, where athletes prone to undergo a doping control test would select the cypionic compound (undetectable after 4-5 days according to anecdotal reports) while the enanthate compound is detectable for more than two weeks. The same applies for Nandrolone Decanoate which although highly preferred by abusers, is shunned by people prone to be tested due to its detection time spanning more than 18 weeks according to anecdotal reports.

To our knowledge, there is no other study reporting on the adversity of AAS abuse and on the different compounds, dosages and duration of abuse in a large cohort. This is the first presented large cohort where a thorough categorization of compounds, dosages, side effects and abuse parameters has been performed. This is also the first study that stratifies a large cohort according to abuse parameters into light, medium and heavy abuse.

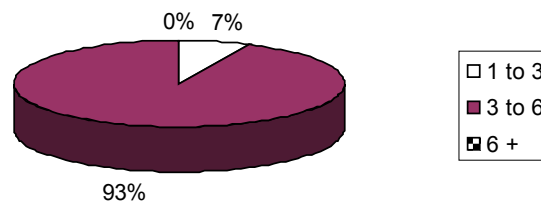


Figure 1 Number of AAS abused by females (%).

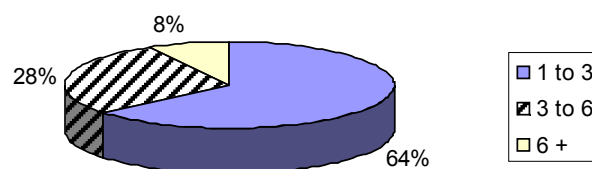


Figure 2 Number of AAS abused by males (%).

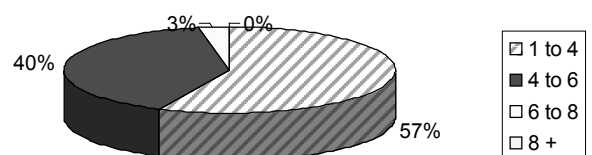


Figure 3 Percentage of females' Abuse Duration (Weeks)

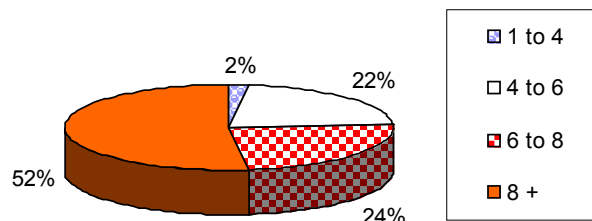


Figure 4 Percentage of males' Abuse Duration (Weeks)

Hopefully, our results will help anti-doping committees and organizations to better understand AAS abuse and formulate appropriate detection protocols. The information contained therein should also act as a pointer for treating physicians and sport’s medicine specialists in their effort to cope with the side effects of AAS abuse by understanding the nature, design and implementation of AAS abuse.

CONFLICT OF INTERESTS

There are no conflicts of interest with regard to the present study.

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