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Anabolic androgenic steroids used as performance and image enhancing drugs in professional and amateur athletes: Toxicological and psychopathological findings

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Authorship
DP and GS contributed equally to this paper; they oversaw study design, coordinated data collection activities, including participant recruitment and participant interviews, and were responsible for manuscript preparation and editing. GDK provided strategic direction for data analysis activities and contributed to manuscript preparation and editing. SC, LL, and SR contributed to data collection activities, including participant interviews, and provided manuscript edits. FF conducted data analysis. PF provided coordination support to implement the study. VF took care of the research agreements with the fitness centres included in the study and provided strategic direction to implement the study. LL provided significant contribution to the data interpretation and to manuscript preparation and editing. All authors approved the final version of the manuscript and agreed to its submission to Human Psychopharmacology.

Conflict of Interest
No conflicts of interest have been declared.

Abstract

Objective: Anabolic androgenic steroid (AAS) use as performance and image enhancing drugs (PIEDs), once restricted to professional athletes, now involves amateurs and regular gym visitors. AAS use is associated with psychopathology, yet this relationship is complex and not fully understood. We aimed to assess the presence of AASs and other misused substances in athletes' biological samples and link toxicological to psychopathological findings.

Methods: A multicentre, cross-sectional study in fitness centres in Italy recruited 122 professional and amateur athletes (84 men; age range=18-45 years) training in several sports. Athletes completed questionnaires, interviews, and toxicology testing for AASs, other PIEDs, illicit drugs, and non-prescribed psychotropics. Toxicology was conducted in blood, urine, and hair.

Results: Self-reported and toxicologically detected use rates of AASs and other misused substances showed slight-to-fair agreement (Fleiss' κ=0.104-0.375). There was slight-to-moderate agreement among the three biological samples used for AAS testing (κ=0.112-0.436). Thirty-one athletes (25.4%) tested positive for AASs. More sport hours/week, narcissistic or antisocial personality disorders, and higher nonplanning impulsiveness scores correlated with AAS use. AAS users did not differ significantly from non-users in major psychopathology, but their Hypomania Checklist-32 score, which also correlated with AAS use, was significantly higher, suggesting increased odds for cyclothymic disorder or subthreshold hypomania.

Conclusions: Our results have implications for studying AAS users, as they identify a cluster of variables that may be relevant in future understanding of AAS use risks (for example, personality disorders). Possible disagreements between AAS assessment methods should be considered when implementing harm reduction interventions and surveillance programmes.

Keywords

Athletes; Anabolic Androgenic Steroids; Performance and Image Enhancing Drugs; Psychopathology; Toxicology

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Introduction

Professional athletes started using banned substances like anabolic androgenic steroids (AASs) in the 1950s with the aim to increase physical strength and endurance, thus improving sports performance. However, since national and international sports competitions are sources of community pride and financial revenue, and AASs provide an unfair advantage, diminishing the value of talent and training in athletic performance, efforts were made to detect and prevent their use (Catlin & Murray, 1996). AASs are among the most common performance and image enhancing drugs (PIEDs), with a worldwide prevalence rate of approximately 5% in men and 1% in women (Anawalt, 2019). PIEDs are defined as muscle building, fat burning, and energy boosting substances, taken by individuals to modify physiological or psychological states "with the intention of changing their physical appearance and enhancing their sporting performance" (Alcohol and Drug Foundation, 2020). AASs include the synthetic derivatives of testosterone as pills, injections, or topical and transdermal formulations. National anti-doping agencies affiliated with the

World Anti-Doping Agency (WADA) use sophisticated monitoring systems and together produce the yearly WADA Prohibited List of Substances and Methods (World Anti-Doping Agency, 2021). Furthermore, the WADA instituted the Athlete Biological Passport, a longitudinal monitoring programme consisting in the assessment of blood and urinary markers of AASs or other banned drugs (World Anti-Doping Agency, 2019). Assessment occurs at baseline, prior to the first competition with anti-doping regulations, and then randomly. Despite anti-doping measures being able to reliably detect sport truancy, many athletes persist in trying to circumvent detection. AAS use spread from professional athletes to other groups like amateur athletes and regular gym visitors during the 1980s for a variety of reasons, including the increasing Western cultural emphasis on body image. AAS use has, therefore, become an important public health problem.

AAS use detection requires that the substance is identified in the individual's biological samples and its use disclosed, with the latter being difficult to obtain, given the stigma attached to AAS use (Pope, Khalsa, & Bhasin, 2017); the threat of sanctions from sports agencies/WADA; and the risk of being convicted in countries whose legislations consider AAS possession, use, and sale a criminal offense (Landy, Walco, & Bartels, 2017). For example, in Italy, according to the "Regulation of health standards in sports activities and the fight against doping" (Law of December 14, 2000, n. 376), an athlete using prohibited substances and the trainer or physician who provides, prescribes, or even encourages their use are punishable, along with their supplier. Athletes, trainers, and physicians are sanctioned to a €2,580-51,645 fine and ¼-3-year imprisonment, while suppliers pay €5,164-77,468 and are imprisoned for 2-6 years. For all the above reasons, the prevalence of AAS use, which is commonly assessed via questionnaires and interviews, is often underestimated, as individuals tend not to disclose the use of these substances (Anawalt, 2019). Consequently, some studies have used hypothetical questions, such as the Goldman dilemma ones (Connor, Woolf, & Mazanov, 2013), or randomised response techniques (de Hon, Kuipers, & van Bottenburg, 2015; Ulrich et al., 2018), yielding higher and more accurate AAS use rates. Up to now, there has been a dearth of studies assessing AAS use via toxicology. Blood and urine testing are considered the standard techniques for detecting AASs by the WADA, but they provide information only on the recent use of AASs (Thevis, Geyer, Tretzel, & Schänzer, 2016). Although hair is not yet a standard validated specimen for the WADA, its use can complement blood or urine by providing a broader detection window (weeks to months) for AASs (Kintz, Gheddar, Ameline, Arbouche, & Raul, 2020).

AAS use is associated with a range of physical and psychological adverse effects (Ip et al., 2012; Piacentino et al., 2015; Moore, Hart, Fraser, & Seear, 2020). The nature of the relationship between AAS use and psychopathology is complex. Athletes with personality disorders pre-existing the use of AASs, such as narcissistic, antisocial, and borderline ones (Yates, Perry, & Andersen, 1990; Porcerelli & Sandler, 1995), may be more prone to use AASs. This hypothesis, dating back to the 1990s, is corroborated by recent studies that link AAS use to irritability, hostility, and aggressive behaviour (van Amsterdam, Opperhuizen, & Hartgens, 2010; Börjesson et al. 2020a). Pre-existing psychiatric disorders, such as eating disorders (EDs), may also increase athletes' likelihood of AAS use (Goldfield, Blouin, & Woodside, 2006, Goldfield, 2009). A possible explanation is given by motivation to exercise; when it is more extrinsic and focused on appearance and weight control (the so-called “self-objectification”), rather than intrinsic and focused on enjoyment and health improvement, it may facilitate a type of training based on high performance levels (Prichard & Tiggemann, 2008). This may trigger psychiatric symptoms and herald the onset of AAS use. There is also evidence of a link between AAS use and subsequent development of mood disorders, from major depressive disorder (MDD) to bipolar disorders (BDs) (Pope & Brower, 2009; Lindqvist et al., 2013; Sanjuan, Langenbucher, & Hildebrandt, 2016; Griffiths, Jacka, Degenhardt, Murray, & Larance, 2018), and generalised anxiety disorder (GAD) (Lindqvist et al, 2013; Ip et al., 2015). This link may simply reflect the established comorbidity between substance use and psychiatric disorders or, alternatively, AASs might induce psychiatric symptoms by determining neuroadaptive changes in the reward neural circuit (Mhillaj et al., 2015) or by affecting stress vulnerability and neurotrophism that lie at the core of psychiatric disorders (Krishnan & Nestler, 2008). Evidence regarding the association between AAS use and substance use disorders (SUDs) is controversial. AAS users aim to improve body function and appearance, rather than harm them with illicit drugs (Brower, 1994). Indeed, some studies report a low prevalence of illicit drug use in AAS users (Brower, 1994; (Kanayama, Gruber, Pope, Borowiecki, & Hudson, 2001; Dunn, 2009). Differently, some studies found illicit drug use to be a risk factor for future AAS use (Kanayama, Pope, Cohane, & Hudson, 2003; Sagoe et al., 2015). The opposite was also hypothesised, with AASs providing a gateway for the use of illicit drugs, especially opioids (McBride, Williamson, & Petersen, 1996), possibly due to their analgesic action on muscle pain caused by overtraining (Wines, Gruber, Pope, & Lukas, 1999) or to their ability to counteract AAS-induced insomnia/irritability or AAS-withdrawal-induced depression (Skarberg, Nyberg, & Engstrom, 2009; Hakansson, Mickelsson, Wallin, & Berglund, 2012). Additionally, athletes make a black-market contact to buy AASs and dealers may push them to purchase illicit drugs (Kanayama et al., 2003; Arvary & Pope, 2000). Last, it has been suggested that AAS-induced functional alterations of the endogenous opioidergic system may be involved in the interaction between AAS and opioid use, leading to increased sensitivity to opioids (Thiblin, Lindquist, & Rajs, 2000; Kanayama, Brower, Wood, Hudson, & Pope, 2009; Nyberg & Hallberg, 2012). AAS users who also take illicit drugs may fall in two substance user profiles, one turning to “cosmetic doping” and using AASs with other PIEDs to gain muscle, lose fat, and enhance or suppress AAS effects (Kanayama et al., 2009), the other – also known as the “You Only Live Once” type (Zahnow et al., 2018) – consuming AASs and illicit drugs in the pursuit of novelty seeking (Christiansen, Vinther, & Liokaftos, 2016). The bidirectional comorbidity between AAS use and psychopathology does not reflect a linear relationship, but rather a circular process (Hughes, Rady, & Smith, 1998; McEwen, 2010; Pluchino et al., 2013), making it difficult to establish a clear cause-effect relationship.

We conducted a multicentre, cross-sectional study in fitness centres in Italy with the aim to: (i) detect AASs and other misused substances in the biological samples of professional and amateur athletes training in a variety of sports; (ii) measure the agreement between self-reported and toxicologically detected use of AASs and other misused substances, as well as among the three biological samples used for toxicology testing; (ii) compare the psychopathology of athletes testing positive for AASs based on any of blood, urine, and/or hair screening (“AAS users”), with that of athletes testing negative (“AAS non-users”). Two studies assessed AAS use via a self-report questionnaire and sampling of urine (Malone, Dimeff, Lombardo, & Sample, 1995) or both blood and urine (Börjesson et al., 2020b). However, these studies were conducted in individuals who all admitted to using AASs; thus, they were unable to measure the extent of AAS use underreporting based on questionnaires. As far as we know, no study compared self-reported and toxicologically detected rates of AASs and other misused substances in the blood, urine, and hair of athletes, subsequently linking toxicological findings to psychopathological ones. In line with the literature, we anticipated low reliability of professional and amateur athletes' self-reported AAS use. We also hypothesised toxicology-confirmed AAS-using professional and amateur athletes to be more affected by MDD, BDs, and GAD than athletes not using AASs, due to the adverse effects of AASs; to present with more EDs and dysfunctional personality traits due to the greater vulnerability to the stress associated with physical performance and body image enhancement; and to be less affected by SUDs, due to the greater focus on fitness and a balanced lifestyle, possibly leading to the avoidance of substances capable of impairing physical performance.

Methods

Participants

Recruitment took place in the cities of Rome, Latina, L'Aquila, and Perugia (Italy) from June 2015 to February 2018 via research agreements with gyms and training centres in these cities. We explained the purpose of the study to the athletes exercising in these facilities, elucidating risks (fatigue during questionnaire completion, minor bruising from the blood draw), as well as potential benefits for them (free medical examination and assessments, including complete blood count, blood chemistry, and electrocardiogram) and for the entire community of athletes (prevention of AAS-related psychopathology). We also explained to the athletes that the study was covered by a Certificate of Confidentiality to protect their personal information and ensure their privacy. Specifically, we explained that their data and samples would be stored using codes that we assigned and only study personnel would access them. Data would be kept in password-protected computers. Samples sent to collaborators conducting toxicology analyses would be completely de-identified and none of these collaborators would have access to any data that might allow them to lead to personal identification. Participants did not receive remuneration or other incentives. All participants provided written informed consent. The study was approved by the Ethical Committee of the Italian Ministry of Research (No. RBFR12LD0W_002) and fully complied with the 1964 Declaration of Helsinki and its later amendments. We enrolled athletes of both sexes, with or without self-reported recent (past 12-month) AAS use. Inclusion criteria were age >18 years and athlete professional or amateur status (i.e., being paid, or not, for athletics performances). Exclusion criteria were known medical conditions, cognitive impairment, lack of fluency in Italian, and unwillingness or inability to provide informed consent. A total of 15 athletes declined to participate (non-response rate of 12.2%), the most common reasons being "lack of time", "not interested" and "do not want to do it". Their sociodemographic characteristics did not differ significantly from those of the final sample.

Toxicology testing

Toxicology is fundamental whenever AAS use is suspected, as it is the most objective means to detect AASs; hence, all the athletes meeting inclusion criteria were screened for AAS presence in blood, urine, and hair samples. In each athlete, the three samples were collected on the same day. In the screening, we included other PIEDs capable of improving strength or appearance (e.g., amphetamine-like substances, sympathomimetics, thyroid hormones, clenbuterol), illicit drugs (e.g., cannabinoids, cocaine, opioids, amphetamines, methamphetamine, MDMA, which are all banned by the Italian legislation), and psychotropic medications used without a medical prescription (e.g., non-prescription anxiolytics, antidepressants, sleep inducers, or antipsychotics). When any of these substances were found in any biological sample (blood, urine, and/or hair), athletes were considered positive to the screening. Blood was analysed through gas chromatography-mass spectrometry (GC-MS), urine through enzyme-linked immunosorbent assay (ELISA) followed by confirmatory GC-MS, and hair through liquid chromatography/orbitrap-high resolution mass spectrometry (LC-HRMS) (Appendix S1).

Psychometric Instruments

Participants were administered the following interviews and questionnaires: Self-Report Sociodemographic Questionnaire (which included questions on AAS and other substance use), Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-I), Structured Clinical Interview for DSM-IV Axis II Disorders (SCID-II), Hamilton Depression Rating Scale (HDRS), Hamilton Anxiety Rating Scale (HARS), Young Mania Rating Scale (YMRS), Hypomania-Checklist-32 (HCL-32), Mood Disorder Questionnaire (MDQ), Sick, Control, One, Fat, Food Eating Disorder Screening Test (SCOFF), Barratt Impulsiveness Scale (BIS-II) (Appendix S2). Both the HCL-32 and the MDQ were used to screen for bipolar disorders, as they their psychometric properties have shown to differ in different populations (Wang et al., 2019). Interviews were conducted by trained clinicians (DP, GS, and SR) with substantial agreement (mean Fleiss' kappa [k]=0.782 for SCID-I and k=0.798 for SCID-II),

Statistical analysis

The statistical analysis included four steps (descriptive statistics, bivariate analysis, multivariate analysis, multicollinearity), as detailed in Appendix S3.

Results

Descriptive statistics

A total of 122 professional and amateur athletes were included in our study. Their median age was 34 years (range 18-45) and the majority (84/122, 68.8%) were men; 40/122 (32.8%) were professionals and 82/122 (67.2%) amateurs. All participants were Caucasian. Their main sociodemographic, toxicological, and psychopathological characteristics are shown in Tables S1–S3. Based on Fleiss' κ, we found slight-to-fair agreement when comparing self-reported and toxicologically detected rates of AAS and other substance use. Of the athletes, 4/122 (3.3%) reported recent (past 12-month) use of AASs, but a higher proportion (31/122, 25.4%) tested positive for AASs (k=0.104). Other PIEDs were reportedly used in the past 12 months by 28/122 (22.9%) athletes, but a higher proportion (63/122, 51.6%) tested positive for these substances (k=0.342). Furthermore, 19/122 (15.6%) athletes admitted to recent (past 12-month) use of illicit drugs, but a higher proportion (40/122, 32.8%) tested positive for these substances (k=0.375). Last, 14/122 (11.5%) athletes reported taking non-prescribed psychotropic medications in the past 12 months, but a higher proportion (29/122, 23.8%) tested positive for these substances (k=0.364). It must be noted that several athletes tested positive for two or more AASs, due to the practice of "stacking" AASs together, in the belief that their interaction produces a greater effect than that of each AAS individually (Trenton & Currier, 2005). The other tested substances were also often used in combination by the athletes (e.g., caffeine, ephedrine, and clenbuterol). Additionally, we found slight-to-moderate agreement among the three sample types (blood, urine, and hair) used for AAS testing (κ=0.112-0.436), with blood testing being able to detect testosterone only in our athletes and extending to the few days or weeks prior; urine testing being able to detect a much wider range of AASs in our athletes (i.e., testosterone, nandrolone, stanozolol, oxandrolone, methandienone, methenolone) and extending to approximately the two months prior (at least for oral AASs); and hair testing being able to detect a similar wide range of AASs compared with urine testing in our athletes (i.e., testosterone, nandrolone, stanozolol, oxandrolone, androstenedione, methandienone, stanozolol, methenolone), but extending further backwards in time compared to the latter. We considered as AAS use levels of naturally occurring hormones in males such as androstenedione and testosterone when these levels were above two standard deviations over the upper normal limit for the hormone. Based on self-report, the use of AASs and other PIEDs was recommended by the athlete's personal trainer or physician in 23.1% cases and by a friend or acquaintance in 20% cases. In 56.9% cases, these substances were used at the athlete's initiative.

Bivariate analysis

In regard to sociodemographic characteristics, AAS users, compared with non-users, were significantly more frequently professional athletes (p<0.001), of male sex (p=0.029), training significantly more hours/week (p<0.001), had significantly higher BMI (p<0.030), higher daily coffee consumption (p=0.006), and higher self-reported recent (past 12-month) use of PIEDs (p=0.042), illicit drugs (p=0.007), and non-prescribed psychotropic medications (p=0.034). Self-reported recent (past 12-month) non-psychotropic medication use was higher in AAS users but failed to reach statistical significance (Table S1). Toxicology testing showed that AAS users consumed significantly more PIEDs (p=0.036), illicit drugs (p=0.011), and non-prescribed psychotropic medications (p<0.001) than non-users (Table S2). Regarding psychopathology, we found a significantly higher proportion of SCID-II current and past psychiatric diagnoses in AAS users (N=9/31, 29.0%) than non-users (N=4/91, 4.4%) (p=0.002), with the former affected mostly by the narcissistic (N=5) and antisocial (N=3) personality disorders. AAS users, compared to non-users, scored significantly higher on the total HCL-32 (p<0.001), total BIS-II (p=0.002), and BIS-II nonplanning impulsiveness (p<0.001). Significantly more AAS users than non-users were likely affected by anorexia or bulimia nervosa (p<0.001). We found no significant differences in depression, mania, and anxiety scores between AAS users and non-users (Table S3).

Multivariate analysis and collinearity

Characteristics that differed significantly at bivariate analysis between AAS users and non-users were included in a backward stepwise logistic regression (Table S4). Characteristics as "predictors" for AAS use were regarded as potential confounders and considered actual confounders if their distributions were substantially different in the two samples. We found five variables, i.e., athlete professional status, number of sport hours/week, SCID-II diagnosis, HCL-32 total score, and BIS-II nonplanning impulsiveness score, to be confounders, resulting in a distortion of the actual relationship between the independent and the dependent (AAS use) variables considered in the model. Nagelkerke's pseudo-R^2 was 0.769, meaning that our regression model explains 76.9% of the variance of the dependent variable. A correlation matrix showed a strong intercorrelation between professional status and number of sport hours/week in the determination of our results (r=0.821, p<0.0001), thus we performed two binary logistic regressions with a combination of the previously identified categorical (professional status, SCID-II diagnosis) and continuous (number of sport hours/week, HCL-32 total score, BIS-II nonplanning impulsiveness score) independent variables. In the first regression model, we excluded the number of sport hours/week (Table 1), in the second the professional status (Table 2), to evaluate which model best fitted our data.

By excluding number of sport hours/week and keeping professional status in the regression model, Nagelkerke's pseudo-R^2 was 0.616, meaning that this regression model explains a considerably lower proportion (61.6%) of the variance of the dependent variable (AAS use), compared to the backward stepwise logistic regression (76.9%).

By excluding professional status and keeping number of sport hours/week in the regression model, Nagelkerke's pseudo-R^2 was 0.665, meaning that this regression model explains a lower proportion (66.5%) of the variance of the dependent variable (AAS use), compared to the backward stepwise logistic regression (76.9%), but a higher proportion than the previously performed binary logistic regression (61.6%). Thus, this model, in which the four independent variables are number of sport hours/week, SCID-II diagnosis, HCL-32 total score, and BIS-II nonplanning impulsiveness score, best fits our data.

Discussion

In this study, we assessed AAS use via a self-report questionnaire and toxicology testing (blood, urine, and hair) in professional and amateur athletes training in sport centres in Italy. We also investigated the relationship of AAS use with psychopathology. Of 122 athletes, 31 (25.4%) tested positive for AASs. The prevalence rate of AAS use at gyms and training centres varies significantly among countries, possibly due to societal and cultural differences in AAS use, as well as differences in anti-doping legislations. This variability makes it difficult to compare our results to those of other studies. When comparisons among countries were made, the prevalence estimates at sport centres were, overall, significantly higher than those of the general population (Kanayama, Gruber, Pope, Borowiecki, & Hudson, 2001; Striegel et al., 2006; Baker, Graham, & Davies, 2006). Specifically, an estimated 14-39% of professional athletes (de Hon et al., 2015) and 4-6% of amateur athletes (Sagoe, Molde, Andreassen, Torsheim, & Pallesen, 2014) reportedly used AASs.

Our study aligns with these findings, with 47.5% professional and 14.6% amateur athletes using AASs. Our higher rates in both types of athletes most likely reflect the true prevalence of AAS use as assessed via toxicology testing. The fact that professional athletes were more likely to use AASs than amateurs could indicate that performance is more important in the former.

We found slight-to-fair agreement between self-reported and toxicologically detected rates of AAS, PIED, illicit drug, and non-prescribed psychotropic medication use. The level of agreement was particularly low for AASs, possibly due to the covert nature of their use in sport centres (Pope et al., 2017). The athletes of our study – especially professional ones – may have had difficulty admitting the use of AASs when completing the Self-Report Sociodemographic Questionnaire, because of the social undesirability of this practice, with consequent AAS use underreporting (Landy et al., 2017). The underestimation of the actual rates of AAS use is an issue for data validity and for a long time has prevented AAS use from receiving the necessary attention of physicians, with little coverage in medical textbooks and, until recently, limited attention in medical literature (de Ronde & Smit, 2020). Contrary to our expectations, more than half of toxicologically confirmed AAS users took other PIEDs banned from elite sports by the WADA. Furthermore, about one-third were illicit drug users and about one-fourth took non-prescribed psychotropic medications. Substance use detected by toxicology was significantly higher in AAS users than non-users, yet it did not correlate with AAS use, as it did not survive multivariate analysis. One of the factors that most strongly correlated with AAS use was intensive training (number of sport hours/week), which also strongly intercorrelated with athlete professional status. Other factors correlating with AAS use were SCID-II personality disorders, especially narcissistic and antisocial, and high BIS-II nonplanning impulsiveness scores. AAS users did not differ significantly from AAS non-users in terms of mood and anxiety disorders, based on the SCID-I and the self-report questionnaires, as we initially hypothesised based on the existing literature (Pope & Brower, 2009; Lindqvist et al., 2013; Ip et al., 2015; Sanjuan et al., 2016; Griffiths, et al., 2018); however, AAS users scored significantly higher on hypomania than non-users, and hypomania was correlated with AAS use. All these features characterise the AAS-using professional or amateur athlete profile of our study.

Our findings are in line with previous work showing that intensive training is associated with AAS use (Goldfield et al., 2006; Razavi, Moeini, Shafiei, & Bazmamoun, 2014). For many years, AAS use was limited to professional athletes. Indeed, a study showed that AAS-using elite bodybuilders, compared to those not using AASs, trained more frequently and for longer periods (Lindström, Nilsson, Katzman, Janzon, & Dymling, 1990). With the publication of books on how to use AASs and the creation of Internet websites for selling and buying AASs (McBride, Carson, & Coward, 2018), their use spread from the sports world to the general population. Currently, many AAS users are not professional athletes, but rather amateur weightlifters, bodybuilders, or other non-élite athletes who use AASs mainly to look leaner and more muscular.

When examining personality traits and disorders that may distinguish AAS users and non-users, severe narcissistic personality traits, including exhibitionism and entitlement, and impulsiveness traits (exploitativeness) were observed in AAS-using weightlifters and bodybuilders, compared with non-users (Yates et al., 1990; Porcerelli & Sandler, 1995; Galligani, Renck, & Hansen, 1996). AAS users also exhibited more hostility and paranoia when using, than when not using AASs (Perry, Yates, & Andersen, 1990). Furthermore, AAS use was associated with irritability (Petersson, Bengtsson, Voltaire-Carlsson, & Thiblin, 2010), as well as with pre-existing hostility, low self-esteem, childhood conduct disorder, and tendency to high-risk behaviour (van Amsterdam et al., 2010). A recent study reported a high rate (52%) of SCID-II diagnoses, especially antisocial and borderline ones, in male AAS users (Börjesson et al., 2020a). Further research should determine whether personality pathology and reckless behaviour are risk factors for or the result of AAS use.

The observed lack of association between AAS use and mood or anxiety disorders, which is in contrast with previous study (Pope & Brower, 2009; Lindqvist et al., 2013; Ip et al., 2015; Sanjuan et al., 2016; Griffiths, et al., 2018), may be due to our sample size being not adequately powered. On the other hand, despite the small sample, we did find higher scores of hypomania in AAS users than non-users. It has been reported that AAS-using athletes, compared to non-users, showed more hypomanic symptoms during AAS use and more depressive symptoms during AAS withdrawal, although never meeting full DSM criteria for a manic or a major depressive episode (Perry et al., 1990; Gruber & Pope, 2000). The reason may lie in the intensive training and the long exercise weekly hours that characterise the AAS-using professional and amateur athletes. Their hyperactivity, combined with their mood elevation, enhanced sense of well-being, and inflated self-esteem, are typical of subclinical BDs or hypomania (Koirala et al., 2019). Indeed, had AAS users developed clinically evident manic or depressive symptoms or GAD, these could impair sports performance (Currie et al., 2019).

Some studies report low rates of illicit drug use among AAS users (Brower, 1994; Kanayama, Gruber, Pope, Borowiecki, & Hudson, 2001; Dunn, 2009). We hypothesised that the AAS-using athletes would be more focused than non-users on being fit and would not take other PIEDs, illicit drugs, or non-prescribed psychotropic medications, nor be affected by SUDs, which may harm their health and impair their sports performance. Athletes pay attention to diet and exercise (Hoff, 2012), even those who use AASs, who defend their habit as a healthy lifestyle choice and are persuaded that AASs are beneficial, ignoring their side effects (Monaghan, 2002; Grogan, Shepherd, Evans, Wright, & Hunter, 2006; Alsaeed & Alabkal, 2015). Our assumption proved to be wrong, with AAS users consuming more PIEDs, illicit drugs (mostly cannabinoids and opioids), and non-prescribed psychotropic medications than non-users. Although the association between the use of AASs and other PIEDs/illicit drugs/non-prescribed psychotropic drugs did not survive multivariate analysis, it nevertheless had statistical (*and* clinical) significance at bivariate analysis. Concurrent use of AASs and other drugs has been described by a number of studies in athletes, often in a context of polysubstance use (Skarberg et al., 2009; Gruber & Pope, 2000; Dodge & Hoagland, 2011; Bonnecaze, O'Connor, & Aloi, 2020). A recent US web-based survey (Ip et al., 2012; Ip et al., 2015) highlighted a higher PIED and illicit drug use in AAS-using male strength trainers *versus* non-users. PIED use may be a consequence of some athletes exercising not as a health-promoting activity, but rather to achieve high sports performance and an idealised muscular, physically strong body (Angoorani, et al., 2012). The use of alcohol, illicit drugs, and psychotropic (and analgesic non-psychotropic) medications may be driven by the effort to relieve the pain of strenuous workouts (Wines et al., 1999), by increased novelty seeking, risk taking, and underlying propensity for general drug use (Striegel et al., 2006; Laure, Lecerf, Friser, & Binsinger, 2004; Christiansen et al., 2016), and/or by close contact with the black market (Yesalis, Kennedy, Kopstein, & Bahrke, 1993; Kanayama et al., 2003; Arvary & Pope, 2000). In the case of illicit drugs, "gateway" and "slippery slope" hypotheses have suggested that "soft" drug use may pave the way for the use of "hard" ones (Vanyukov et al., 2012; Roy & Goswami, 2016). A specific gateway hypothesis has linked AAS and opioid use, with athletes who use AASs going on to use opioid agonist-antagonists, such as nalbuphine (McBride et al., 1996; Wines et al., 1999), or even classical opioids, such as heroin and morphine (Arvary & Pope, 2000; Thiblin et al., 2000; Kanayama et al., 2009; Nyberg & Hallberg, 2012). However, it is important to note that the gateway hypothesis in the addiction field remains controversial and not all studies support it (Fredriksson et al., 2017).

Our athletes reported that the main sources of supply of AASs and other PIEDs were trainers and physicians (23.1%), followed by friends and acquaintances (20%). Similarly, in a study of regular gym visitors using AASs and PIEDs, half obtained these substances illegally through the healthcare system (via physicians by prescription or, less frequently, via pharmacies without the required prescription) and the other half through the black market (via other gym visitors or, less frequently, via outside dealers) (Laure et al., 2004). In a sample of bodybuilders, one-third was introduced to opioids by a fellow bodybuilder (Arvary & Pope, 2000). In contrast, while more than half of our athletes reported to have taken AASs on their own initiative, an Italian survey of 1,015 athletes showed that most of them resorted to doping practices or illicit drug use under external pressure, whereas only 28% had themselves decided to do so (Scarpino et al., 1990).

In our study, at bivariate analysis, AAS-users were more affected than non-users by EDs. Even if this finding was not confirmed by the multivariate analysis, it is worthy of mention. In fact, athletes are frequently affected by anorexia or bulimia nervosa, as well as binge eating (Goldfield et al., 2006; Goldfield, 2009; Piacentino et al., 2017). The prevalence of these disorders has increased over the years, with the current fitness culture and physical appearance concerns among the main reasons (Williams, Goodie, & Motsinger, 2008; Griffiths et al., 2018).

Limitations and strengths.

A strength of our study is the objective assessment of AAS and other substance use via the analysis of multiple matrices (blood, urine, and hair), a critical aspect lacking in most of the previous studies – especially hair testing. Although the latter does not replace blood testing or urinalysis (Brower, Catlin, Blow, Eliopulos, & Beresford, 1991), it complements them, by providing retrospective information on AAS use well beyond the time window covered by urine or blood (i.e., given an average growth rate of 1 cm/month, each cm of hair in the vertex region represents what has circulated in the body during the corresponding month) (Kintz et al., 2020). Another strength of our study is the comparative analysis of psychopathology, which allowed us to identify a cluster of variables that may be relevant to understand the risk of AAS use in future longitudinal studies. The main limitation of our study is the high number of interviews and questionnaires that were administered to a relatively small number of athletes. Also, this small sample may have caused type I and/or II errors. As such, our findings need to be confirmed in a larger and independent sample, with a more balanced gender representation. Furthermore, our results were obtained on a Caucasian-only, Central Italy population, and this may limit their generalizability. Moreover, we did not obtain sociodemographic data from people unwilling to participate, so to compare them with those of participants; hence we may not rule-out selection bias. Last, although exploring potential differences in toxicology and psychopathology associated with professional or amateur status was not a goal of this study, we acknowledge that several factors, including the likelihood of sports agencies/WADA to perform random drug testing, as well as the dissimilar incentives for training (e.g., monetary achievement and rewards for professionals, sport's enjoyment and challenges for amateurs), may have had an effect on our outcomes.

Knowing that AAS users are less likely to seek treatment than traditional illicit drug users, since the former do not suffer to the same extent as the latter from impaired socio-occupational functioning, complaints from significant others, or subjective distress (Pope & Brower, 2008), much effort should be directed at preventing individuals from gaining access to AASs. Some data suggest that AAS users may be reluctant to seek treatment because they mistrust healthcare professionals and doubt about their knowledge of AASs (Pope, Kanayama, Ionescu-Pioggia, & Hudson, 2004; Bonnecaze et al., 2020). Several authors have commented on the need for professionals to become more familiar with AASs, in response to these issues (Dawson, 2001; Kutscher, Lund, & Perry, 2002; Pope & Brower, 2008; Fraser, Fomiatti, Moore, Seear, & Aitken, 2020). The effort of increasing professional education about AASs should be paralleled by international policy coordination towards AAS trafficking.

Conclusion

Our results have implications for the study of AAS users, as they identify a cluster of variables that may be relevant to understand the risk of AAS use in future longitudinal studies. The association between AASs and personality disorders, and the possible concurrent PIED, illicit drug, and non-prescribed psychotropic medication use, make both professional and amateur athletes an appropriate target group for AAS treatment and prevention. Such efforts should focus on factors associated with AAS use, such as the ones that have emerged from our study. Last, a possible disagreement between the different assessment methods of AAS use (self-report measures *vs*. toxicology testing) should be considered when implementing harm reduction policies and WADA surveillance programmes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Binary logistic regression with professional status, SCID-II diagnosis, HCL-32 total score, and BIS-II nonplanning impulsiveness score as independent variables and AAS use as the dependent variable

Variable	B	S.E.	Wald	d.f.	*P*	Exp(B)
Professional status	2.801	0.677	17.098	1	**0.000**	16.457
SCID-II diagnosis	1.861	0.943	3.894	1	**0.048**	6.430
HCL-32 total score	0.159	0.053	8.839	1	**0.003**	1.172
BIS-II nonplanning impulsiveness score	0.268	0.065	16.781	1	**0.000**	1.307
Constant	−10.830	2.085	26.971	1	**0.000**	0.000

Significant p-values in **bold**. Abbreviations: B=Unstandardised Beta Coefficient; BIS-II=Barratt Impulsiveness Scale; d.f.=Degrees of Freedom; Exp(B)=Exponentiation of the Beta Coefficient; HCL-32=Hypomania-Checklist-32; SCID-II=Structured Clinical Interview for DSM-IV Axis II Disorders; S.E.=Standard Error; Wald=Wald *Chi*-Squared test.

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Table 2.

Binary logistic regression with number of sport hours/week, SCID-II diagnosis, HCL-32 total score, and BIS-II nonplanning impulsiveness score as independent variables and AAS use as the dependent variable

Variable	B	S.E.	Wald	d.f.	*P*	Exp(B)
Hours of sport/week	0.392	0.009	15.676	1	**0.000**	1.480
SCID-II diagnosis	1.673	0.964	3.011	1	**0.083**	5.327
HCL-32 total score	0.172	0.056	9.360	1	**0.002**	1.369
BIS-II nonplanning impulsiveness score	0.314	0.077	16.734	1	**0.000**	1.369
Constant	−13.977	2.730	26.216	1	**0.000**	0.000

Significant p-values in **bold**. Abbreviations: B=Unstandardised Beta Coefficient; BIS-II=Barratt Impulsiveness Scale; d.f.=Degrees of Freedom; Exp(B)=Exponentiation of the Beta Coefficient; HCL-32=Hypomania-Checklist-32; SCID-II=Structured Clinical Interview for DSM-IV Axis II Disorders; S.E.=Standard Error; Wald=Wald *Chi*-Squared test.