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Anabolic Androgenic Steroids and Criminality

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Abstract

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Anabolic Androgenic Steroids (AAS) have been associated with adverse psychiatric effects, aggression and violent behaviour. The use of them has spread to a larger subpopulation, and the use has been connected to different risk behaviours, such as use of other illicit substances and carrying a gun. Case reports tell about a connection between AAS use and violent crimes, including homicide. The aim of this thesis is to investigate the proposed connection between AAS and crime, focusing on violent crimes, and to inquire into whether this proposed connection between AAS and criminality is affected by other risk factors for criminal behaviour.

The first two studies of this thesis investigated the registered criminality of individuals testing positively for AAS, with individuals testing negatively serving as control groups. In the two last studies individuals at a clinic for substance abuse treatment (Paper III) and in a prison (Paper IV) were asked about their use of AAS, and their history was assessed using the Addiction Severity Index.

The main finding of Paper I was the development of criminal patterns over time, with a clear increase of the proportion of violent crimes and weapons offences seen only among the pure AAS users. In Paper II an increased risk for weapons offences among AAS users was reported. In Paper III an increased risk of having been prosecuted for violent crimes and of having been physically abused was seen among the AAS users. In Paper IV, the main finding was the close resemblance of users and non users.

In summary, this thesis have concluded that the violence previously reported as connected to use of AAS can, to a large extent, be accounted for by other risk factors. There seems, however, to be a connection between use of AAS and a heavy, more planned form of criminality.

Keywords: Anabolic steroids, Violence, Crime, Substance abuse

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Till mina föräldrar

List of papers

Paper I: **Klötz F**, Petersson A, Isacson D, Thiblin I. Violent crime and substance abuse: A medico-legal comparison between users of anabolic androgenic steroids and abusers of illicit drugs. *Forensic Sci Int.* 2007 Nov 15;173(1):57-63

Paper II: **Klötz F**, Garle M, Granath F, Thiblin I. Criminality among individuals testing positive for the presence of anabolic androgenic steroids. *Arch Gen Psychiatry.* 2006 Nov;63(11):1274-9

Paper III: Petersson A, **Klötz F**, Voltaire-Carlsson A, Bengtsson J, Granath F, Thiblin I. Use of anabolic androgenic steroids at an outpatient substance abuse clinic in Stockholm, Sweden. *Manuscript*

Paper IV: **Klötz F**, Petersson A, Hoffman O, Thiblin I. The significance of anabolic androgenic steroids in a Swedish prison population. *Manuscript*

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Abbreviations

AAS	Anabolic Androgenic Steroids
AASpos-subst.neg	AAS-positive, substance abuse negative
AASpos-subst.pos	AAS-positive, substance abuse positive
ACEs	Adverse Childhood Experiences
ASI	Addiction Severity Index
BMI	Body Mass Index
CI	Confidence Interval
CNS	Central Nervous System
CS	Central Stimulants
DSM IV	Diagnostic and Statistical Manual of Mental Disorders, 4 th edition
FFMI	Fat Free Mass Index
HMO	Health Maintenance Organization
PAG	Periaqueductal Gray Matter
RR	Relative Risk
Subst.pos-AASneg	Substance abuse positive, AAS negative
THC	Tetrahydrocannabinol
VTA	Ventral Tegmental Area

Introduction

Definitions

Definition of Anabolic Androgenic Steroids

Anabolic androgenic steroids (AAS) are substances with a promoting effect on muscle growth (i.e. anabolic effect) and on the development and maintenance of secondary male sexual characteristics (i.e. androgenic effect) [1, 2]. The term AAS comprises the male sexual hormone testosterone and other endogenous androgenic hormones, as well as synthetically derived substances structurally related to testosterone [1, 3].

Definition of violence

Violence is a term that can be defined in various ways related to psychiatric, biological and sociological conceptions. Even when narrowing the concept down to violent crimes there still is difficulties in defining what is to be considered violence. As Levi et al. write in their chapter on violent crimes in the Oxford Handbook of Criminology [4], there are disputes around whether, for example, deaths and injuries due to reckless driving or corporate negligence should be considered as acts of violence. When studying crimes there also is a question whether to try to study all crimes committed, crimes reported to the Police or crimes that have led to conviction. In this thesis, violence in the shape of violent crimes that have been brought to court is studied, and the term “crime of violence” does in the first two studies include homicide, attempted homicide, manslaughter, assault, aggravated assault, causing bodily harm, robbery, serious case of robbery, unlawful detention and assaulting or threatening a civil servant. In the two second studies “crime of violence” also includes arson and rape. The reason we chose to study only crimes brought to court is to be found in the source of data available; for explanation in detail please see the Methods section.

When discussing violence, aggression also needs to be taken in to consideration. There seems to be an ongoing confusion regarding how these two concepts are to be defined, and the two words are sometimes even used virtually synonymously [5]. Richard Mizen suggests in a review 2003 that

“Violence can be distinguished from aggression, but it is related to it, aggression being a substrate of violence.” [5].

Background

The history of AAS

The endocrine function of the testis was discovered 1849 by Berthold. He saw clear changes in physical appearance and behaviour among roosters after castration, and found that those changes were prevented by transplanting testis into the abdominal cavity [6]. Some years later Brown-Séquard demonstrated the effects of the substances produced by the testis on him self [7-9]. By the end of 1889 the news about the substances Brown-Séquard had discovered had spread all over the western world and were sold as a “Elixir of Life” [8, 9]. In the 1920s the search for a method of assay for these new substances began and by 1930 several groups of scientists had developed methods for extracting concentrates of this new substance, termed as the “male hormone”, from urine [10]. Over the following years it became apparent that the male body produces more than one hormone with effects that had been attributed to this “male hormone”, and that these hormones had both androgenic and anabolic effects [10]. In 1934, androsterone was synthesized from cholesterol, and the year after it was followed by testosterone [6]. The therapeutic possibility of especially testosterone, being the more anabolic of the two, was quickly recognised by scientists. Testosterone has been used to treat patients with different conditions, e.g. hypogonadism in men, anemia, menorrhagia in women, and lately to counteract the weakness and muscle wasting of AIDS-patients [11]. The virilizing effect is, however, still a problem, especially in women and children, and several attempts to modify the structure of the testosterone molecule to create a substance with pure anabolic effects have been made, but so far without success [12]. Therefore, the term Anabolic Androgenic Steroids is the most accurate to use [1, 13].

In the early 1950s the word of AAS started to spread and it is believed that American West Coast bodybuilders [11] and Soviet weightlifting teams were the first to experiment with them outside the labs [10]. After this the use of AAS seem to have spread with the rumour of their effectiveness to other strength-intensive sports, and over the last three decades the use of AAS have become more and more common among both Olympic athletes and athletes at college and high school level [10, 11].

The use of AAS today

Today AAS are no longer used only by athletes, but used by a larger subpopulation that mainly employs them to improve their appearance [14-16]. The prevalence of AAS-use among athletes differs and range between 6.2 and 38.4% in different studies; the prevalence of AAS-use among non-athletes range between 0.4–6.7% [13, 17-19]. Among American high school students the prevalence was 5.4% for males and 2.9% for females in project EAT 2002 [20]. This was a survey concerning personal, socio-environmental and behavioural factors related to nutrition and obesity.

AAS are usually taken in cycles, meaning episodes of use that usually last for four to twelve week or more followed by a period of similar length without AAS [21, 22]. Users also often take several types of AAS at the same time. This is referred to as “stacking”. The theories behind this use are that it activates more steroid receptors in the muscles, and that some steroids work synergistic when combined [10, 22].

The effects of AAS

It is by now clear that AAS both affect the body and the mind in various ways. Below the psychiatric effects as well as the more common physical effects and side effects of AAS use are described.

AAS in animal studies

Animal studies, principally on rodents, have demonstrated that AAS affect a wide range of neurotransmitters in many different brain regions. For instance, effects on the brain reward system and on neural pathways involved in aggression have been described. Testosterone induces a conditioned place preference in rats and mice, and is voluntarily consumed through oral, intravenous, and intracerebroventricular self-administration in hamsters [23]. Male rats develop a conditioned place preference to testosterone injections into the nucleus accumbens, an effect blocked by dopamine receptor antagonists, thus suggesting that androgen reinforcement is mediated by the brain. Moreover, testosterone appears to act through the mesolimbic dopamine system, a common substrate for drugs of abuse [23]. It has also been demonstrated that AAS affects the opioid system in the ventral tegmental area (VTA) of the rat [24].

A great number of animal studies have attempted to assess whether there is a connection between AAS and aggressiveness (for review see McGinnis 2004 [25]). These studies have in general implied that rodents exposed to AAS, in doses comparable to those taken by human AAS users, demonstrate a significant increase of aggression. There has, however, been clear signs of variable behavioural patterns depending on which AAS that was used in the

study [25]. E.g., testosterone propionate clearly increased aggression [26, 27] but nandrolone was shown both to increase and have no effects on aggression [28-31]. Stanozolol did not seem to induce aggression at all, or even, in some studies, inhibited aggression [26, 28, 32]. There has also been indications on that chronic AAS exposure does enhance aggression, but not indiscriminate and unprovoked aggression corresponding to the described “roid rage” among human users [31]. Most AAS users usually take several AAS at the same time [21, 22], and prediction of human behaviour from animal models is complicated. Thus, drawing any firm conclusions based on these studies regarding the reactions on AAS in humans is difficult.

When it comes to possible neurobiological mechanisms regarding AAS and aggressive behavior it is hard to give a general view of the scientific data. According to a PubMed-search, there are more than a hundred animal studies describing AAS related aggression as correlated to changes in a wide range of transmitter systems in brain areas such as the periaqueductal gray matter (PAG), hypothalamus and amygdala, all known to be involved in the regulation of aggressive behavior [33]. Unfortunately, there seems not to be any review attempting to bring these data together. For this reason, the central mechanism by which AAS affects aggression will not be commented upon further in the present thesis, more than calling attention to the fact that AAS are likely to have direct effects on the central regulation of aggression.

Physical effects

There is clear evidence regarding the performance enhancing and muscle growing effects of AAS [34, 35]. However, the use of AAS is also connected to severe physical side effects, both aesthetically undesirable and life threatening. Aesthetical side effects include severe acne vulgaris [36] and gynecomastia [37, 38], the latter being permanent. Among the less visible, but more fatale side effects observed in case reports are morbid changes of the heart [39-43], stroke [43-48] and disturbed liver function [49-52]. Furthermore, some studies have found disturbances in blood coagulation [53] and thyroid function [54, 55]. However, the long term effects of supraphysiologic doses of AAS use have not yet been elucidated [56] and controlled clinical studies investigating the matter might be not possible to perform [13].

Psychiatric effects

AAS are psychoactive substances, with an apparent potential for causing dependence [2, 57, 58]. Several case reports and survey studies (among e.g. bodybuilders) have indicated that AAS may trigger aggressive and/or violent behaviour [37, 59-64]. Hypomania or manic episodes [37, 65], depression

and suicide [37, 66-69] and even psychotic episodes [21] are other states that have been reported to be connected to the use of AAS. Furthermore, three randomised placebo-controlled studies [62, 70-73] have demonstrated hyperactive, mania like symptoms in individuals receiving high-dose AAS treatment, suggesting that use of AAS may correlate to pathological effects on mood and cognition (e.g. irritability, mood swings, violent feelings, hostility, distractibility, forgetfulness, confusion, euphoria and sexual arousal). However, in another placebo-controlled study, involving comparable doses of AAS, no mania-like effects were observed [74].

Testosterone and aggression

Testosterone can in many ways be regarded as the “basic” AAS. In animal studies, the relationship between testosterone and aggression is well demonstrated through correlation and experimental studies, but in humans, this relationship seems to be more complex [75]. Several studies have investigated to what extent the levels of testosterone correlate to different types of behaviour, i.e. aggression, dominance and parenting [76, 77]. A meta-analysis of these studies concluded that there is a positive but weak correlation between testosterone and aggression [78]. Studies made on prisoners imply that the testosterone–aggression/violence relationship is stronger in certain populations and correlated to the social context of the individual (for review see Harris 1999 [77]). The idea that the social environment might affect the response to an increase of testosterone levels has also been stated in other publications [76]. Future studies are needed to clarify this matter.

The use of AAS and other risk behaviours/factors

Several studies have demonstrated that AAS-users report a higher frequency of use of other drugs, compared to non-users [15, 16, 79-84]. This has been described for cocaine, injected drugs, alcohol, marijuana, cigarettes, and smokeless tobacco [82]. There have also been reports of AAS-users sharing needles [79, 82]. Middleman et al. [84] found that use of AAS was associated with other high-risk behaviours, such as carrying a gun, the number of sexual partners within the past three months, not using a condom during last intercourse, injury in a physical fight requiring medical attention, etc. They therefore suggested that AAS use is part of a “risk behaviour syndrome”, rather than an isolated behaviour. Additional risk factors associated with use of AAS include dissatisfaction with school, frequent truancy and living alone at an early age [83]. AAS users have also been reported to have poorer relationships with their fathers than non users [85], poor social support [86] and low self-esteem and/or self-confidence [64, 87].

Other illegal substances and crime

The link between substance abuse and criminal behaviour is well documented and a positive correlation between severity of abuse and frequency of criminal acts has been reported [88, 89]. Sinha and Easton have suggested that there are two sets of variables that are critical for understanding this link [88]: First, the influence of specific pharmacological effects of different psychoactive substances on the behaviour, cognition and judgment of substance abusers and those who are not addicted but may be especially predisposed to committing crimes; and second: the impact of substance abuse among individuals with serious psychopathologies such as personality disorders, psychosis, organic brain syndromes and development disorders. This suggestion may apply to the use of AAS as well. However, this remains to be explored.

AAS and violent crimes

The reports of a connection between AAS and violent behaviour described above have sometimes even included homicide [59-61, 90]. It has also been suggested that some users take AAS mainly with the purpose of facilitating the commitment of crimes, in particularly crimes that involve threats and violence [59]. This proposed connection between AAS and violent crimes has motivated two attempts of epidemiological confirmation. When Pope et al. [91] interviewed 133 individuals incarcerated for violent crimes, only two maintained that their violence was a consequence of AAS use. However, approximately half of the individuals who were approached declined to participate. In a Swedish study [92], out of 50 individuals arrested for crimes of violence, none tested positive for AAS. Sixteen additional individuals arrested were asked to participate but refused. The high, probably systematic, rates of non-participation in these studies makes it hard, if not impossible, to draw any firm conclusion regarding any association between AAS use and violent crimes.

Risk factors for violent and other crimes

Use of alcohol is strongly connected to violence [93-97], and to crime in general [88]. Substance abuse has been reported to be much more prevalent in criminal populations [88, 98, 99] and severe mental disorders are more common among incarcerated individuals than in the main population [98]. Studies have also shown higher rates of violence in substance abusers with psychiatric comorbidity, when compared to people with only one diagnosis [100, 101]. However, the existence of a connection between substance abuse and crime might be clear, but the nature of this connection remains complex [89, 93].

Another factor observed to increase the risk for criminal behaviour is abuse and neglect during childhood. Widom et al. have showed that childhood victimization has a significant impact on the risk of committing crimes in general and violent crimes in particular [102, 103]. Furthermore, moderate to severe childhood trauma has been reported by 50 % of prisoners in a German study [104]. Still, the risk factors described here are all intertwined and what is causing what remains somewhat unclear.

Aim of the thesis

The aim of this thesis is primarily to investigate the proposed connection between AAS and criminality, and in particular the possible connection between AAS and violent crimes. It also aims to inquire into whether this proposed connection between AAS and criminality is affected by other risk factors for criminal behaviour.

Materials and methods

Participants and settings

Paper I

In the first study (Paper I), data on the 55 male deceased individuals in Sweden who tested positive for AAS in connection with post-mortem medico-legal examination between January 1, 1992, and March 31, 2005, was collected. The individuals were divided into two subgroups on the basis of whether they tested positive for other illegal substances (AASpos-subst.pos, n = 31) or not (AASpos-subst.neg, n = 24). A group of deceased, forensically autopsied male substance abusers, testing negative for AAS formed the control group (subst.pos-AASneg, n = 67).

Paper II

In the second study (Paper II), the social security numbers of all individuals tested for AAS at the Doping Laboratory, Huddinge University Hospital, Stockholm, Sweden between January 1, 1995, and December 31, 2001, were collected. The individuals were separated into two groups, one AAS-positive (n = 241) and one AAS-negative (n = 1199), and compared regarding their criminal history. To investigate whether use of other illegal substances affects the connection between AAS and criminality, analyses were also made after the exclusion of individuals referred to the Doping Laboratory from centres for treatment of substance abuse.

Paper III & IV

In the two latter studies (Papers III and IV) the subjects were patients at a clinic for substance abuse treatment and inmates at a prison, respectively. All participants in both studies were asked whether they ever had used AAS, with those answering no serving as control groups. In Paper III 175 men participated, of whom 21 admitted previous use of AAS. Corresponding numbers in Paper IV were 59 participating and 33 admitting AAS-use.

Instruments

Paper I & II

In Paper I and II, the criminal records of the participants were compiled and the incidences of five categories of crime described below were calculated. The criminal records came from a criminal register created by the National Swedish Police Board, who since 1973 archives all criminal convictions of individuals older than 15 years in Sweden. From this register, we collected the criminal records of our subjects with help of their social security numbers. The different types of offences found in the criminal records of the individuals included in the studies were sorted into a number of categories, four of which were selected for evaluation in the two studies: (1) crime of violence; (2) weapons offence; (3) crime against property; and (4) fraud. In Paper II, a fifth category, sexual offences, was added. Subsequently, these categories were used for comparing individuals who tested positively and negatively for AAS regarding their criminal history.

In Paper I the estimations of criminality was based on the number of convicted individuals and of the number of separate convictions during the three years immediately preceding death and during the first three years after the first conviction. The registered criminality of the individuals in the three groups during the two different periods of time was compared to obtain a longitudinal perspective on their criminal activity. To establish whether the AAS-positive individuals had been using AAS for a prolonged period, the differences in mean body mass index (BMI) of the individuals in the three groups were calculated, assuming that a high BMI in this population indicates long-term use.

In the Paper II, the criminal records of the participants during the time the tests were made (1995-2001) were compiled. The incidences of the different types of crime, as well as number of convicted individuals, were calculated for both groups and compared.

Paper III & IV

In Paper III and IV the Addiction Severity Index (ASI) was used to assess the history of drug abuse among the participants. The ASI is a form for structured interviews, designed to provide diagnostic information on a client prior, during and after treatment for substance use-related problems. The information is collected through structured interviews and thoroughly covers seven different areas of the patient's life: General information, medical status, alcohol/drug use, employment/support, family/social relationships, legal status and psychiatric/psychological status. All participants in both studies were asked whether they ever had used AAS. In Paper IV those who

answered in affirmative were asked in more detail about this use, using an additional structured interview form. The AAS users were compared with the non users with regards to the different parameters in the ASI and the results of the additional interview regarding their AAS use were presented on group level.

Statistics

The statistical analyses of the papers included in this thesis demanding use of computer software were performed using the GraphPad InStat® Version 3.05 software. In Paper III Statistical Analysis System® (SAS) package, version 9.1 also was used.

Paper I & II

The incidence of each type of crime was calculated by dividing the number of convictions with the number of person-years at risk. The crime incidences of the two groups were subsequently compared by estimating the ratio (expressed as relative risk (RR)), using the AAS-negative group as reference group (denominator). The 95% confidence intervals (CI) for the incidences of criminal conviction (assuming a Poisson distribution) and for the ratios (using the approximation of normal distribution) were determined. When analysing differences in number of convicted individuals the Chi-square-test was used, with a p-value < 0.05 considered statistically significant. In Paper I changes in criminal activity over time were investigated by analysing changes in the proportion of incidence of criminal convictions. Differences in BMI of the individuals in the three groups in Paper I were analysed using one-way ANOVA, followed by the Tukey-Kramer Multiple Comparisons Test for post hoc comparisons.

Paper III & IV

Categorical variables were compared using Fischer's exact test. Continuous variables were checked for normality with the Kolmogorov-Smirnov test and subsequently analyzed by Students' t-test (with Welch's correction in the case of unequal standard deviations) or the Mann-Whitney U-test, as appropriate. Since the age distributions in Paper IV were different for the AAS and control groups, the ASI summary data, consisting of interviewers' ratings in seven different problem areas, were analyzed for all ages by Students' t-test and the Mann-Whitney U-test, followed by an age-adjusted ANCOVA. In Paper IV, variables demanding an age adjusted control group were analyzed after age restriction, using a cut-off point at 45 years old. A p-value below 0.05, two-tailed, was considered significant.

Main findings and comments

Paper I

Findings

The three study-groups were compared regarding the incidence of crime during the last three years of life, and a significantly higher incidence of fraud and crimes against property was seen in the subst.pos-AASneg group. Concerning crimes of violence and weapons offences, no significant differences were seen. The proportion of incidence of criminal convictions was also investigated, and a comparison between the first three years after the first conviction and the last three years before death was made. In this comparison, a marked increase in the proportion of crimes of violence and weapons offences, together with a decrease in the proportion of crime against property among the AASpos-subst.neg individuals was found between the first and second period. In contrast, no such change was observed for the other two groups. Regarding BMI, the mean values of the two AAS-positive groups did not differ significantly but were both significantly higher than the corresponding value for the subst.pos-AASneg group.

Comments on the findings

Methodological considerations

This study was based on the 55 male deceased users of AAS that had been identified at any of the six departments of forensic medicine in Sweden. There was only one inclusion criterion, v.i.z. an urine sample positive for AAS. Since one aim with this study was to investigate the possible role of other risk factors for criminality among AAS-users, the AAS-subjects were divided into those who were positive for both AAS and illicit drugs (AASpos-subst.pos, n=31) and those who were positive for AAS, but not for illicit drugs (AASpos-subst.neg, n=24). An obvious draw back of the subdivision is the loss of statistical power. The dividing of the AAS cases can be questioned by the fact that the toxicological data only reflects the acute drug intake preceding death, for which reason it cannot be ruled out

that some subjects classified as AASpos-substneg actually had a history of a general drug abuse.

The reason for making this division was based on an earlier exploration of this material in a study that focused on the manner of death and the toxicological findings [80]. In short this exploration revealed quite similar drug profiles concerning illicit drugs in the AASpos-subst.pos subjects and in the AAS-negative substance abusers (n = 67) who were used as controls, at the same time as the BMI for the AASpos-subst.pos subjects tended to be in between the BMI for the AASpos-subst.neg and the substance abusers. Taken together these data clearly indicate that the AASpos-subst.neg group consists of individuals who are engaged in intense weight training and who probably have AAS as their main drug, whereas the AASpos-subst.pos subjects should probably be regarded as drug addicts who also do some doping aided weight training. For this reason this division of the AAS subjects is probably appropriate, despite the loss of statistical power.

The controls employed in this study were gathered consecutively during a limited period of time. In practise 70 drug addicts (of which three were later excluded) without a history or bodily signs indicating AAS experience were tested. This strategy ended up with a control group having a higher mean age, which is unfortunate when investigating criminality. For this reason one should be careful when interpreting the data concerning frequency of crime, since this variable is clearly age dependent (with higher degree of criminality at young age) [105, 106].

There are also other methodological limitations concerning the criminal data, which are thoroughly discussed in the original paper. In conclusion, these limitations probably have low impact on the validity of our findings, for which reason they will not be gone in to detail here.

Interpretation of the findings

With the methodological considerations taken into account, the main finding of this study was the striking difference in the development of the patterns of criminal activity of the investigated groups over time. A pronounced increase in the proportion of incidence of violent crimes and weapons offences, with a marked reduction in the proportion of incidence of crime against property as result, was observed only among the AAS-positive/substance abuse-negative subjects. This finding taken together with the fact the only 5 (21%) of these individuals were sentenced for violent crime at the last study period indicates that the use of AAS can, in some predisposed individuals, counteract a more general, age-dependent decrease in violent criminal activity.

Paper II

Findings

The risk of having been convicted for a weapons offence or fraud was significantly higher among individuals testing positively for AAS. The risk of having been convicted for weapons offence remained significantly higher when individuals referred from centres for substance abuse were excluded, and the difference between the two groups with respect to fraud vanished. Another comparison made was regarding the proportions of individuals convicted for the different types of crime. Also here, an overrepresentation of weapons offences were clearly seen among the AAS-positive individuals, and this overrepresentation remained statistical significant when the individuals referred from centres for treatment of substance abuse were excluded. As far as sexual offences were concerned, no difference was seen between the two study groups.

Comments on the findings

Methodological considerations

This study was based on individuals tested for AAS during the period 1995-2001 at the national Doping Laboratory, which serves all care units, the police and other authorities throughout Sweden. Since the analyses were done upon request from the care taker/authority the frequency of testing was not uniformly distributed. In other words some subjects were tested many times and others only once. Furthermore, there was no information concerning the way the AAS were used (e.g. doses) among the positive subjects. Thus, there is no way of knowing the duration or the doses of AAS use among the 241 positive subjects. This limitation also imply that there may have been individuals among the controls (n=1199) who may have used AAS during the study period, but not in connection with the testing. This means that there might have been subjects with only moderate or even insignificant experience of AAS in the positive group and subjects with considerable AAS experience among the controls. Obviously these possible limitations would result in loss of power, i.e. that the findings of this study are weakened. An indication of that this is really the case is that we found a significant overrepresentation of crime against violence in the AAS-group if those 121 AAS negative subjects who had been convicted for trading with or possession of doping agents were withdrawn from the control group (not reported in the original article). The idea to exclude these subjects from the control group was rejected by one of the journal's referees, a standpoint that can be questioned.

Other limitations discussed in Paper II are the validity of the crime data and the quality of the control group with respect to other risk factors for criminality than AAS. In conclusion these methodological issues do probably not have a significant influence on the interpretation of the data.

Interpretations of the findings

The main finding of this paper is clearly the overrepresentation of weapons offence in the AAS group. The most reasonable interpretation of this finding is that many criminals use AAS. Whether AAS are used for “strategic reasons”, i.e. in preparation for crime, as suggested earlier [59, 64], or for more common reasons, e.g. improve weight lifting results, cannot be answered on the basis of the available data in this study. This issue and other related issues, for instance, whether use of AAS does influence the nature of violence among criminals, emphasizes the need for additional, more “qualitative” studies.

As touched upon above the methodological limitations of this study makes it difficult to state that there was no difference between the AAS-positive and AAS-negative subjects concerning the frequency of violent offences. However, even if there is such a difference it should be rather limited. Moreover only 90 (37%) of the AAS-positive subjects had been sentenced for violent crime, thus indicating that far from all users of AAS become violent.

One of the themes of this thesis is to consider other risk factors, such as substance abuse, for criminality in AAS users. In this study the exclusion of subjects referred from substance abuse centres had little influence on the results, especially the main finding of an overrepresentation of weapons offences, thus corroborating that AAS indeed have a particular connection to this crime type.

Paper III

Findings

The proportion of individuals that had been prosecuted for violent offences, crime against property, and crime against the law on illicit drugs in this study was significantly higher among the AAS-using individuals than in the control group, whereas the overrepresentation of crimes labelled as “other” crimes did not reach statistical significance.

Illicit drugs were significantly more often stated as main drug of abuse in the AAS group; whereas abuse of alcohol was significantly underrepresented. The most common illicit substances were THC and opiates, both stated as main drug of abuse by 20% (n=4) of the AAS users. The lifetime incidence of experiencing physical abuse was significantly

higher among the AAS-using individuals. The proportion of individuals with immigrant origin was significantly higher among the AAS users.

Comments on the findings

Methodological considerations

In this Paper 175 male patients 50-years-old or younger were asked about use of AAS in connection with their admittance interview at a substance abuse centre. For practical reasons the study period was limited to two months. This ended up with a group of 20 subjects stating experience of AAS and 155 controls without AAS experience. The rather small number of AAS users resulted in weak statistical power. This problem was further complicated by the fact that the age distributions were different in the AAS-group compared with the 155 controls.

Interpretations of the findings

The patients in the AAS group were significantly more often convicted of violent and drug offences. At the same time the AAS group significantly more often had drugs other than alcohol as their main drug of abuse, a finding that remained after controlling for age. Thus, it could be that the criminality seen among the AAS users in this particular study to some degree was related to abuse of other substances than alcohol.

Another interesting finding was an overrepresentation of having been exposed to physical violence in the AAS group. In the discussion of the original paper the possible importance of so called Adverse Childhood Experiences (ACEs) for violence and drug abuse is discussed in some detail. In a recent Swedish study at another substance abuse centre similar findings were reported [107]. Thus, it could be that individuals who abuse both illicit drugs and doping agents often are burdened by more ACEs than is usually the case even among drug addicts, which if so may contribute to the relatively high degree of violent offences seen among AAS using drug addicts. This since ACEs have been connected to a higher risk of developing a criminal behaviour later in life [102, 103].

The finding that AAS users more often were immigrants is supported by other studies [83, 86], but the explanation of this association is so far unclear. The use of AAS has earlier been connected to low self-esteem [64, 85, 87] and perhaps the low social status of some groups of immigrants might cause a feeling of insecurity and low self-esteem, creating a breeding ground for AAS use.

Paper IV

Findings

The only statistically significant difference regarding criminal activity that appeared in Paper IV was that AAS users more often were prosecuted for crimes belonging to the category “other offences”.

Regarding substance abuse no differences appeared, nor were any significant differences regarding psychiatric health, previous physical or mental abuse or demographic variables such as immigrant status observed. The substances most commonly stated as main drug of abuse among the AAS users were central stimulants, i.e. amphetamine and cocaine (n=11, 37%).

Eight AAS users stated that they had committed violent offences as a result of AAS use, in five of this cases AAS were combined with alcohol, in one case also cocaine.

Comments on the findings

In this paper half of the 188 inmates at the prison (n = 59) agreed to take part in the study. 33 (55.9%) admitted previous use of AAS. The control group (n=23) had several rather old long-term abusers of amphetamine that due to age restriction were excluded from most the comparative analyses, leaving a control group consisting of 14 individuals. Thus, this study is hampered by weak statistical power. As pointed out in the discussion in the original paper, it seems impossible to perform this kind of study without getting a considerable proportion of non participants. This problem with statistical power has to be kept in mind when interpreting the results of this study.

There are also other thinkable methodological problems related to the ASI, recall bias and more. However, these possible problems are probably of minor concern. For a detailed discussion of these issues, please see the original paper.

Interpretations of the findings

The main finding of this study was that, with the exception for “other crimes”, there were no statistically significant differences in the criminal history, nor any differences with respect to drug abuse patterns between the AAS group and the age adjusted controls. Still, eight subjects stated that they had committed violent offences, five as a result of the combined action of AAS and alcohol, in one case also cocaine. The most reasonable interpretation of these data is that AAS may contribute to violent acts also in a criminal population, but not to a degree that affects the frequency of such crimes at a noticeable level. Unfortunately, the nature of the crimes, e.g.

degree of provocation or the intensity of the violence cannot be judged on the available data.

Another noteworthy observation was that nobody stated “strategic reasons” (in preparation for crime) as a motive for AAS use, something that has been previously suggested [59, 64]. Instead, the dominating motives were related to the anabolic properties of AAS, just as is the case for other groups of AAS users [14-16, 87, 108].

General discussion

Methodological considerations

In all four papers the controls were constituted by individuals who had either tested negatively for AAS in urine samples or stated non-experience of AAS. The controls were selected from the same type of populations that were examined with respect to use of AAS. These populations were deceased users of AAS, patients from different kinds of care centres/hospitals (and a few from the police and customs), patients at a substance abuse treatment centre, and prisoners, respectively. It can be suspected that all four populations to some extent represent individuals with maladjustment problems and probably several risk factors for criminality. The question is whether these presumed risk factors were reasonably similar in the AAS and control groups?

Paper I is a retrospective study based on information from autopsy protocols and police records. Such basic data provide little information concerning psychosocial factors and mental morbidity, thus making it difficult to judge the adequacy of the control group. However, the mere fact that both the AAS cases and the controls had died at relatively young ages and in unnatural manners suggests a similar problem profile between these groups. In Paper II the age and gender distribution were similar between the AAS- and control cases, which together with the fact that the controls had been tested for AAS and were referred from similar care centres as the AAS cases again suggest that the AAS cases and the controls had similar problem profiles. That this line of reasoning also applies for Paper III and Paper IV is obvious, since all subjects investigated were recruited from a substance abuse centre and a prison, respectively. Thus, it is reasonable to assume that the different control groups in the Papers of this thesis are satisfactory for the purpose of investigating AAS as a criminogenic factor.

As pointed out in the comments on the separate papers, there is a power problem in each study. This problem was most apparent for crimes of violence for which there were some “not quite significant” results. One way to roughly overcome the power problem could be to add the cases in all four studies. Such a procedure gives 137 (39%) violent offenders among the AAS users and 456 (32%) violent offenders among the AAS-negative subjects (RR=1.23; 95 % CI: 1.06 – 1.43, $p = 0.011$), thus yielding a statistically significant but modest overrepresentation for violent crime among the AAS

users. This suggests that the insignificant findings regarding violent offences may be due to other causes than weak statistical power, something that will be discussed below.

Considering the similarities in methods in Paper III and IV, it is possible to closer compare the individuals in the two papers. Among the AAS users in Paper III, 11 of 20 (55%) had been prosecuted for violent crimes, among the AAS users in Paper IV the corresponding figures were 22 of 33 (66%) (RR: 1.21; 95% CI: 0.76 – 1.93; $p = 0.559$). When comparing the controls of these two studies a different picture emerged. In Paper III 38 of 155 (25%) had been prosecuted for violent crimes, corresponding numbers in Paper IV were 12 of 23 (52%), and the difference seen was statistically significant (RR: 2.13; 95% CI: 1.32 – 3.44; $p = 0.011$). This finding might at first sight look like an indication of that AAS surely can lead to violent crimes. However, one should take into consideration that the AAS users in Paper III show a closer resemblance to the AAS users and the controls in Paper IV than to the controls in Paper III, both regarding substance abuse and other risk factors of criminality, e.g. previously having been abused.

Discussion

In Paper III, a higher risk for having been prosecuted for violent crimes was seen among AAS users, as well as a higher risk for drug offences and crimes against property. However, no statistically significant increase of violent crimes was seen in Paper IV, where the same method was used, or in Paper I and II. The fact that violent crimes only were overrepresented among AAS users in one of four studies was somewhat surprising. Surprising since AAS frequently have been associated with increased aggressiveness and feelings of hostility [61, 62], and that there are case reports suggesting an association between use of AAS and violent acts [60, 63, 64, 90]. However, in Paper III AAS users more often reported previous exposure to physical abuse compared to controls, and being abused and neglected as a child has been connected to a higher risk for both violent crimes and other types of criminality [102, 103]. Unfortunately, the ASI does not reveal when the abuse took place. However, as mentioned earlier (p. 26), an association between use of AAS and adverse childhood experiences (ACEs) was recently described in a Swedish interview study comparing 52 AAS users with 259 nonusers. Here a history of mental or physical abuse during childhood was significantly more common in AAS users compared to nonusers [107]. Regarding ACEs, the consequences have been studied thoroughly from many perspectives. In a prospective study of high school seniors ACEs were found to be linked to various adverse mental effects (depression, drug abuse, and antisocial behaviour) in both men and women [109]. However, early antisocial behaviour was more strongly associated

with ACEs in males. When studying 17,337 adult HMO members, Anda et al. found high risks of developing psychiatric morbidity following ACEs (including sexual abuse, substance abuse, and aggression-related disorders) [110]. In addition to this, Jonson et al. found that childhood abuse and neglect may contribute to the onset of some personality disorders [120]. It has also been suggested that a feeling of insecurity and low self esteem could cause AAS use in both men and women [20, 22, 64, 85, 87]. In other words, individuals with an adverse psychiatric history may be particularly prone to use AAS. This idea also gains support from the findings in Paper IV, where the AAS users and controls shared the same risk factors and no difference regarding violent crimes were seen. One could therefore speculate that the violent crimes committed by the AAS users in Paper III, as well as other violent deeds earlier associated to use of AAS, in fact often are due to other risk factors, such as childhood abuse, and that use of AAS is a marker for a psychiatric morbidity that sometimes might lead to violence rather than a cause of violent behaviour in itself. However, increased aggression is a well known side effect of AAS use [61, 62] and aggression has been described as the substrate of violence [5]. Thus, AAS should still be considered as a possible contributing factor for violence, at least in particularly vulnerable individuals.

In scientific literature, violence reported to be triggered by use of AAS quite often has been brutal and easily triggered [63, 64, 90, 111]. The data investigated in this thesis does unfortunately not contain any information on the circumstances surrounding the violent crimes or the nature of the violence. It is therefore not possible to explore these observations further here. But, these reports concerning possible precipitation of violent behaviour by AAS are anecdotal, and a causal connection has yet not been proven to exist. In light of the other risk factors that seem to burden the users of AAS, alternative explanations should be considered. If use of AAS often leads to brutal violence, would we not, considering the increase of AAS use over the last decades, see a clear increase in brutal violent crime? This would be expected at least among bodybuilders, who are known to frequently use AAS, but there is no such evidence [22]. Thus, it seems safe to assume that only a minority of AAS users commit intense violent acts. One possible explanation of the reports on brutal AAS-precipitated violence could be dissociation, a phenomenon defined in the Diagnostic and Statistical Manual of Mental Disorders, 4th ed., (DSM IV) as “a disruption in the usually integrated functions of consciousness, memory, identity, or perception of the environment” [112]. Dissociation have been associated with violence [113, 114], and descriptions of so called “roid rage” [59-61, 90] resemble descriptions of violence connected to dissociation [114], where seemingly “normal” individuals suddenly committing terrible violent deeds. Dissociation has also been connected to childhood abuse [113, 114] and has been suggested as an important factor in maintaining “the circle of violence”

[115, 116]. Another resemblance between “roid rage” and dissociative states is the association to alcohol. Several of the perpetrators in cases with violent crimes seemingly associated to AAS use were reported to be under the influence of alcohol or other substances [59, 61], and a link between different dissociative states and alcohol has been suggested [114]. Yet another possibility is, of course, that the use of AAS in individuals burdened by the risk factor discussed above could trigger a dissociative state leading to violence. This remains to be investigated.

A connection between possibly AAS-induced violence and alcohol was also seen in Paper IV in this thesis. Eight users (24%) reported that they had personal experience of use of AAS leading to violent crimes in the form of physical abuse, five of them in connection with alcohol (one alcohol and cocaine). At first sight this finding clearly points towards a causal connection between AAS and violent behaviour. However, also here alternative explanations might be significant. At least one placebo controlled study of the psychiatric effects of AAS has shown that aggression and frustration in connection with use of AAS might be explained more by the subjects’ expectations rather than by real psychoactive effects [117]. For the five individuals in Paper IV who were under the influence of alcohol it is also hard to tell what roll the alcohol played. One should remember that alcohol use is one of the greatest risk factor for violence in general [93-97], even though the question of causality also here remains somewhat unclear (Sic!) [89, 96]. Another explanation to why these individuals explained their violent behaviour with their use of AAS might be the very human wish to blame someone or something else for your wrongdoings, which in this case might be particularly easy considering the way use of AAS sometimes is pictured in the media as a proven cause of violent behaviour.

However, the lines of argument above are probably more accurate for impulsive acts of violence than more instrumental kinds of violence. In Paper II a higher risk for weapons offences was seen among the AAS users, and this might be connected to a heavy, more planned form of criminality. The idea behind this suggestion is that criminals involved in heavy criminal activities, such as robbing banks and collecting crime-related debts, derives an advantage from being physically strong and having a heavy build and therefore use AAS. This notion also gains support from a Swedish study investigating manner of death among homicide victims, where all AAS-positive victims had been shot [118]. Another interesting observation in this context is the suggested connection between AAS and low clinical ratings of empathy [119]. In Paper IV weapons offences were suspected to be hidden in the category “other crimes”, which was more common among the users of AAS. In Paper I, no differences in the incidence of violent crimes or weapons offences were seen. Still, the proportion of violent crimes and weapons offences clearly increased over time among AAS users that did not test positively for other substances. This was something not observed in the

other two groups. This might be due to that crimes related to a lifestyle marked by organised, heavy criminality probably are closer connected both to the means of financial support and an individual's persona than impulsive violence. Therefore, these crimes will not decrease with age and the less crime prone life style that usually comes with it [106]. In other words, use of AAS seems to be connected to heavy, planned criminality.

Yet, no increased risk of "other crimes" was seen among the AAS users in paper III. This would be expected consider: A) that the discussion above concluded that use of AAS are associated to weapons offences (and therefore to heavy forms of criminality) and that this kind of offences are likely to be concealed in this category of crimes; and B) that the AAS users in Paper III showed closer resemblance to the criminal users and controls in Paper IV than to the controls in paper III. However, the AAS users in Paper III and Paper IV showed quite different substance abuse patterns. In Paper III, 20% (n=4) of the AAS users stated opiates as their main drug of abuse, and none mainly used central stimulants (CS), i.e. amphetamine or cocaine. In Paper IV, on the other hand, 37% (n=11) stated CS as the main drug of abuse and only 7% (n=2) mainly used opiates. One can speculate that the violent crimes in both papers mainly are explained by the different risk factors earlier discussed, and that the different patterns of substance abuse are markers for different subgroups of AAS users: One group, marked by a lifestyle connected to heavy, more planned criminal behaviour and mainly using CS; and one group, burdened by a more impulsive kind of criminality and mainly using opiates.

Concluding remarks

Conclusion

This thesis leads to the conclusions that violence previously reported as connected to use of Anabolic Androgenic Steroids (AAS) can, to a large extent, be accounted for by other risk factors shared by many users, such as childhood victimization and substance abuse. Furthermore, criminals involved in heavy, more planned form of criminality often use AAS.

Future Perspectives

This thesis clearly demonstrates that there is no straight forward connection between AAS and violent crimes. However, many issues remain to be elucidated, and some aspects stand out as more important:

Firstly, the results presented here do not support the notion that AAS use is a strong independent predictor for violence. But, as touched upon above, this stands in contrast to the many case reports suggesting such a connection. One explanation for this could be, that AAS contributes to the emerging of particularly intense violence, for which reason these violent deeds attracts much attention from both the Police and the public media. This possibility should encourage future research focusing on predictors for violence characterised by a high level of brutality.

Secondly, information from the police, customs and the Anti-doping Hot Line (Dopinjouren) strongly indicates that the use of AAS outside sports has increased rather drastically during the last decade; at the same time professionals at emergency care units claim that there has been a marked increase in patients treated for severe injuries obtained in physical assaults. However, both the alleged increase in AAS usage and alleged increase in severely injured victims remain to be proven scientifically. A scientific confirmation or refutation of this temporal relationship appears to be a question of vital importance. This since another refutation would suggest that no noteworthy connection between AAS and any kind of violence exist, and a confirmation would motivate further research on AAS as a risk factor for a rare but particularly brutal kind of violence.

Finally, the results of this thesis strongly suggest that use of AAS is a marker for sever psychiatric morbidity, a morbidity that in many cases could be the explanation of the proposed association between AAS and violence.

Further investigations of the psychiatric health, with focus on early traumatic events, should therefore be an essential part of the work with forming guidelines for the clinical work with AAS users.

Sammanfattning på svenska [Summary in Swedish]

Anabola androgena steroider (AAS) har visats kunna orsaka ökad irritabilitet och aggression hos användare som tar höga doser av dem. Under de senaste 15 åren har AAS även föreslagits som en orsak till våldsamt beteende, misshandel och till och med mord. Denna avhandling syftar till att undersöka denna påstådda koppling mellan AAS och brottslighet. Särskilt fokus ligger på våldsbrott och på hur eventuella andra riskfaktorer påverkar denna koppling.

I avhandlingens två första studier undersöktes brott i belastningsregistret för personer som testade positivt för AAS, och jämfördes med brott begångna av dem som testade negativt. I de två sista studierna tillfrågades patienter på ett center för missbruksbehandling (studie III) och interner på ett fängelse (studie IV) om deras bruk av AAS. Studiedeltagarnas historia kartlades med Addiction Severity Index, ett intervjuformulär som fokuserar på bland annat tidigare missbruk, psykiatrisk problematik, familjehistoria och kriminalitet.

I den första studien sågs det att de rena AAS-användarna över tid utvecklade ett annat brottsmönster än kontrollerna, med en proportionell övervikt av vålds- och vapenbrott. I den andra studien noterades en klart ökad risk för att vara dömd för vapenbrott bland AAS-användarna. I den tredje studien visade det sig att AAS-användarna oftare var åtalade för flera olika typer av brott, däribland våldsbrott. AAS-användarna hade också oftare varit utsatta för fysisk misshandel. Huvudfyndet i den fjärde och sista studien var att AAS-användarna och kontrollgruppen inte skiljde sig alls från varandra, förutom att AAS-användarna uppvisade en högre risk för att ha varit åtalade för brott som föll under kategorin ”andra brott”.

Sammanfattningsvis så är slutsatsen av denna avhandling att våldet som tidigare ansetts vara starkt kopplat till användandet av anabola androgena steroider i hög grad tycks kunna förklaras av andra riskfaktorer, faktorer som delas av många AAS-användare. Vidare tycks det finnas ett särskilt samband mellan AAS och tung, organiserad brottslighet.

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