Injury and Poisoning Profile in Anabolic Steroid Users

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Study objective: This study investigated the 1-year risk of injuries and poisonings among anabolic androgenic steroid users compared with controls from the general population.

Methods: In a cohort study conducted in Denmark, 1,189 anabolic androgenic steroid users were identified through a national antidoping program and matched with 59,450 controls. Participants were followed for 1 year. Data on hospital contacts, educational length, and occupational status were retrieved from nationwide registries. The primary outcomes were the incidence of injuries and poisonings. The secondary outcomes differentiated between fracture and nonfracture injuries, and medicinal versus nonmedicinal causes of poisonings, and described specific causes of injury-related hospital contacts.

Results: Anabolic androgenic steroid users had significantly higher incidences of injuries and poisonings compared with controls. The risk difference for any injury was 7.8% (95% confidence interval [CI] 5.5 to 10.2) and the adjusted hazard ratio (aHR) was 1.46 (95% CI 1.29 to 1.66). Specifically, the risk of fractures was more than doubled among anabolic androgenic steroid users (aHR of 2.23, 95% CI 1.72 to 2.89), with head injuries being particularly prevalent. The risk difference for any poisoning was 1.2% (95% CI 0.5 to 1.9) and the aHR was 2.98 (95% CI 1.82 to 4.90). Medicinal poisoning was the most common poisoning among anabolic androgenic steroid users, with an aHR of 3.53 (95% CI 1.94 to 6.41).

Conclusion: Anabolic androgenic steroid use is associated with an increased risk of both injuries and poisonings, thereby quantifying a substantial risk of external harm among users. [Ann Emerg Med. 2025;■:1-7.]

Please see page XX for the Editor's Capsule Summary of this article.

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INTRODUCTION

The use of anabolic androgenic steroids presents a major public health challenge given its significant use worldwide.[1] Understanding the broader spectrum of potential adverse effects, including those related to external causes, is important for implementing effective safety measures. Multiple negative health effects associated with use of anabolic androgenic steroids have been described, including infertility, cardiovascular diseases, acne, and even excess mortality.[2-6] Anabolic androgenic steroid users exhibit a more than 3-fold increase in mortality from unnatural causes when compared with the general population.[6] However, although this elevated mortality risk is established, their profile of harm, including injuries and poisonings, has not been previously described. Anabolic androgenic steroid use is associated with increased risk-taking behaviors and psychiatric comorbidities, such as mood swings, aggression, and violent tendencies, which potentially could lead to a higher incidence of accidents, poisonings, and injuries among anabolic androgenic steroid users.[7-9] Furthermore, studies on testosterone exposure in therapeutic doses suggest effects on bone density and structure.[10,11]

We therefore conducted a cohort study to examine the prevalence and patterns of injuries and poisonings among users of anabolic androgenic steroids, using data from the Danish national registries.

METHODS

Study Design

This was a cohort study.

Participants

Anabolic androgenic steroid users were identified from a national antidoping anabolic androgenic steroid test

Editor's Capsule Summary

What is already known on this topic

Anabolic steroid use is associated with numerous adverse effects.

What question this study addressed

What are the 1-year risk of injuries and poisonings among anabolic androgenic steroid users?

What this study adds to our knowledge

In a large cohort study, injuries and poisonings were more common among anabolic steroids than matched nonusers. Differential injury risk was highest for head, face, and low back injuries.

How this is relevant to clinical practice

Educating anabolic steroid users about increased risk may help inform their decisions.

program (description below). This study included all men who were banned from Danish fitness centers as part of the antidoping efforts against anabolic androgenic steroid use. The decision to include only male subjects was driven by the fact that the overwhelming majority of anabolic androgenic steroid users identified in the national antidoping program were men, and thus anonymity within the cohort could be ensured. These sanctions were due to either testing positive for androgens or declining to submit a urine sample, despite being informed that refusal would result in an equivalent doping sanction.[2,6,12-14] We have previously shown that those who refused and those who tested positive had similar rates of side effects directly linked to androgen misuse, such as reduced fertility and gynecomastia.[3] For further details, see Appendix E1 (available at http://www.annemergmed.com). Each included man used an anabolic androgenic steroid and was matched with 50 male control participants, based on date of enrollment and age, from the Danish National Health Registers. We conducted a retrospective analysis of the cohort for 1 year from enrollment to investigate the nature of injuries and poisonings during the initial period after sanction. This 1-year span was defined as the follow-up period.

Antidoping Program

Between January 3, 2006, and March 1, 2018, individuals in Denmark were sanctioned for the use of anabolic androgenic steroids as part of a national antidoping strategy aimed at ensuring a safer and fairer fitness environment.[15,16] A total of 342 fitness centers participated in the program, accounting for 80% of all fitness centers in Denmark.[17] Doping controls were primarily targeted at individuals with a muscular build appearance, and all participants in this study cohort were recreational athletes, defined as individuals who partook in general fitness activities at gyms without involvement in any particular sport or competitive discipline as professionals.

A sanction resulted in exclusion from all participating fitness centers for a period of 2 years.[15,16] Sanctioned individuals were recorded in the confidential antidoping database using their unique personal identification number, enabling linkage to Danish national registries as detailed below.

Registries

In Denmark, all citizens have free access to health care. At all hospital contacts, diagnoses are coded according to International Classification of Diseases, 10th Revision in the Danish National Registry of Patients.[18,19] This applies to both inpatients and outpatients and applies to all hospital departments, including emergency visits.[20] The Danish Civil Registration System maintains detailed records for all residents of Denmark, including information on gender, and emigration.[21] Additionally, information regarding occupational level came from the Danish Register for Evaluation of Marginalization database, and information about the length of highest attained education was obtained from the Danish Registry of Education.[20,22] For further information regarding registries, see Appendix E1.

Outcomes

The primary outcomes were to determine whether anabolic androgenic steroid users have a higher incidence of any injury and poisoning compared with the general population in the first year after anabolic androgenic steroid sanction. The secondary outcomes were to differentiate between both fracture and nonfracture injuries, and medicinal versus nonmedicinal causes of poisonings, as well as to describe the specific causes of injury-related hospital contacts. Outcomes were defined as the first occurrence of any of the prespecified group of diagnoses, see Appendix E1.

All injury and poisoning outcomes were identified as hospital contacts, which include any visits or interactions at a public hospital, based on specific International Classification of Diseases, 10th Revision codes provided in Appendix E1.[18]

Injuries included both head and body injuries, as well as multiple body region injuries.

Poisonings consisted of poisonings by drugs, medicaments, and biological substances, but also nonmedicinal toxic effects such as alcohol, organic solvents, and gases. Because of the study design, the group of poisoning with hormones—including androgens—has been excluded from the poisoning category.

Fatalities resulting from external causes, as recorded in the national death registry, have been published previously for this cohort.[6]

Statistical Analysis

Continuous variables were described using the mean value and SD, whereas categoric variables were presented using counts and percentages. We calculated the absolute risk differences in injury and poisonings between anabolic androgenic steroid users and controls, and estimated hazard ratios (HRs) for each outcome using cause-specific Cox proportional hazards regression models with censoring at death or loss to follow-up. We fitted both an unadjusted model and a model with adjustment for the covariates age, employment status, and length of the highest education attained at time of enrollment. We adjusted for multiple testing of injury subtypes by applying false discovery rate correction using the Benjamini–Hochberg method.

All statistical analyses were conducted using SAS version 9.4 (SAS Institute Inc, Cary, NC), and R version 4.3.2 (R Foundation for Statistical Computing, Vienna, Austria) was used to create the forest plots within the figures.

Ethics

All data were anonymized. To ensure anonymity in the study, values of less than 5 have not been listed in the following. The study was approved by both the Danish Data Protection Agency (BFH-2017-105/05949) and the Danish National Board of Health (FSEID-00003570/FSEID-00006603). In Denmark, research that exclusively uses register data did not require ethical approval from the Committee on Health Research Ethics, as per Section 14 of the Act on Research Ethics Review of Health Research Projects.[23]

RESULTS

Characteristics of Study Participants

The study included 1,189 anabolic androgenic steroid users and 59,450 controls. For further information regarding excluded individuals, see flowchart in Figure 1. The mean age at the point of receiving a doping sanction

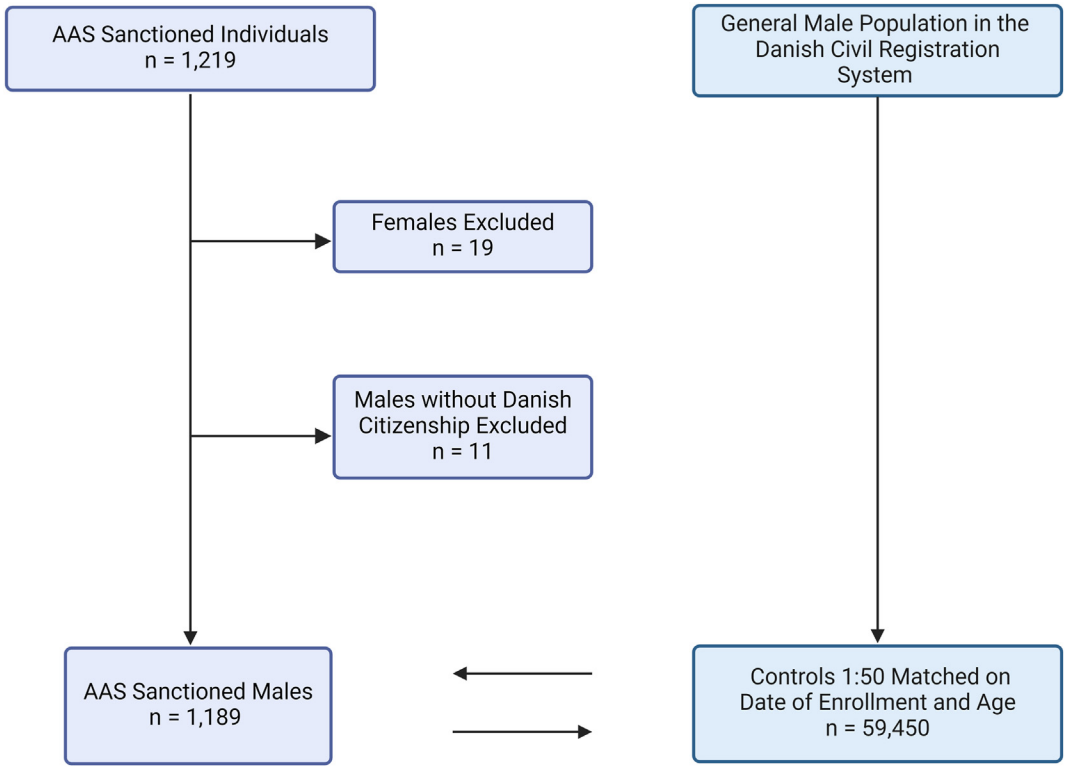

Figure 1. Flowchart illustrating the formation of the study population. *AAS*, anabolic androgenic steroids. This figure was partially created in BioRender.

Table. Cohort characteristics at enrolment.

Characteristic	Anabolic Androgenic Steroids Users (n=1,189)	Controls (n=59,450)
Mean age (SD), y	27.4 (6.9)	27.4 (6.9)
Education length		
≤10 y, n (%)	300 (25.2)	9,290 (15.6)
11-15 y, n (%)	782 (65.8)	36,087 (60.7)
≥16 y, n (%)	72 (6.1)	12,023 (20.2)
Occupational status		
Self-supporting*, n (%)	880 (74.0)	50,319 (84.6)
Sick leave—temporarily, n (%)	44 (3.7)	1,159 (1.9)
Sick leave—permanently, n (%)	38 (3.2)	1,513 (2.5)
Unemployed, n (%)	208 (17.5)	5,916 (10.0)

*Self-supporting: Individuals not receiving any form of public benefits or government assistance. Individuals receiving student grants are regarded as self-supporting.

was 27.4 (SD = 6.9) years and likewise matched controls had a mean age of 27.4 (SD = 6.9) years. Anabolic androgenic steroid users had shorter educations and were more frequently unemployed (Table).

Injuries

Throughout the 1-year follow-up period, 258 men (21.7%) who used anabolic androgenic steroids received an injury diagnosis at a hospital. In the control group, injury was diagnosed in 8,236 men (13.9%). The risk of injuries was significantly higher in the anabolic androgenic steroid group compared with the controls (unadjusted HR 1.62, 95% confidence interval [CI] 1.43 to 1.83 and adjusted HR 1.46, 95% CI 1.29 to 1.66), and the risk of injuries remained significantly higher among anabolic androgenic steroid users when investigating fractures and nonfracture injuries separately. Adjusted and unadjusted HRs for study outcomes are presented in Figure 2. The most pronounced specific injury-related associations were primarily located in the head (Figure 3).

Poisonings

The incidence of poisonings was significantly higher in the anabolic androgenic steroid group compared with the controls (unadjusted HR 4.19, 95% CI 2.63 to 6.70 and adjusted HR 2.98, 95% CI 1.82 to 4.90). During the follow-up period, 19 anabolic androgenic steroid users (1.6%) received a poisoning diagnosis, of which 14 were medicinal. In the control group, poisoning was diagnosed in 227 participants (0.4%), of which 123 were medicinal. Further information regarding study outcomes is presented in Figure 2.

DISCUSSION

Our study found a strong association between being sanctioned for anabolic androgenic steroid use and increased incidences of injuries and poisonings. The findings were not associated with age or socioeconomic factors alone.

The primary strength of this study lies in its relatively large sample size and the use of nationwide high-quality

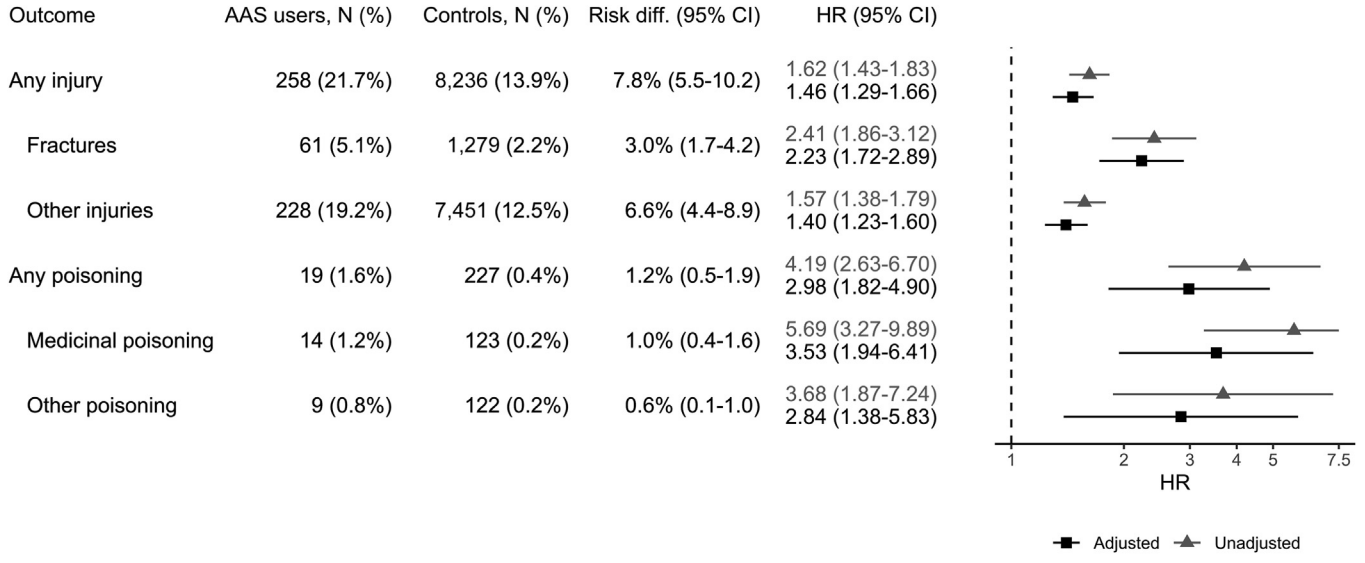

Figure 2. Study outcomes. Injuries and poisonings leading to hospital contacts among AAS sanctioned individuals (a total of 1,189) and controls (a total of 59,450). Risk difference is reported in percentage points. In the adjusted model, age, occupational status, and educational length at time of enrollment were incorporated as covariates. *AAS*, anabolic androgenic steroids; *Risk diff.*, risk difference.

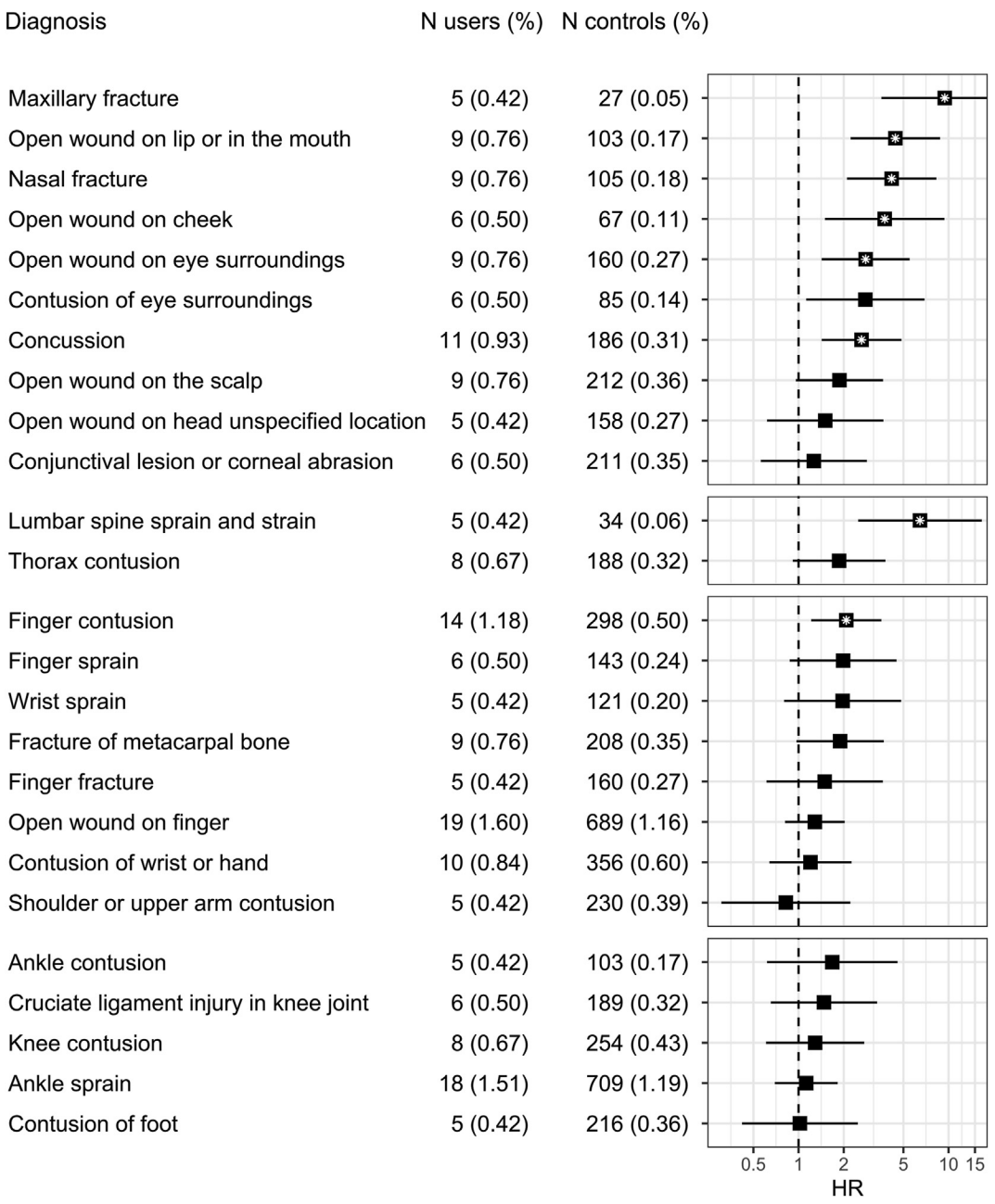

Figure 3. Injury rates. Adjusted HRs for all injuries in anabolic androgenic steroids users (n=1,189) compared with controls (n=59,450) from enrollment through 1 year are illustrated below. Only injuries with a count of more than or equal to 5 events in both the anabolic androgenic steroids and the control group are included. Estimates marked with an asterisk indicate statistical significance after false discovery rate correction for multiple testing. CIs for maxillary fracture and lumbar spine sprain and strain are capped, see Table E1 (available at http://www.annemergmed.com) for exact numbers. This figure was partially created in BioRender.

registries, enabling continuous longitudinal monitoring of individuals.

Although we did not anticipate any systematic differences in accessing health care between anabolic androgenic steroid users and controls leading to potential risk of diagnostic misclassification as well as underreporting of injuries and poisonings, we acknowledge that these could be potential sources of bias. Also, the specific type of injuries observed, such as head, face, and hand trauma, could be fight-associated, and may suggest behavioral factors contributing to these injury patterns. Although we controlled for education and employment in our analysis, future studies could improve on this by including additional variables that capture risk-taking behaviors,

fitness habits, and influence of competitive sports in the analysis. This would help disentangle the effects of anabolic androgenic steroid use from baseline personality differences. Furthermore, a limitation of this study is the lack of more detailed information on the duration and dosage of anabolic androgenic steroid use. It is noteworthy that our cohort represents only a partial sample of anabolic androgenic steroid users, as many individuals engage in anabolic androgenic steroid use without detection.

To the best of our knowledge, the overall extent of injuries among anabolic androgenic steroid users has not been described previously. Regarding poisoning, the literature describes that anabolic androgenic steroid users often combine steroids with other illegal substances.[7,24]

Fractures are known to account for a large proportion of injuries in emergency departments within the general population.[25] Given a relatively high lifetime prevalence of anabolic androgenic steroid use among men, a 2-fold increased risk of fractures among anabolic androgenic steroid users represents a public health concern.[26]

The findings of this study naturally beg the question whether the high incidence of injuries and poisonings can be causally related to the use of anabolic androgenic steroid or is a matter of confounding.

Several studies have shown that anabolic androgenic steroid use is linked to risky and violent behavior, as well as psychiatric diseases.[7-9] Anabolic androgenic steroid use could simply be a symptom of a certain risk-taking personality. Another possibility is that anabolic androgenic steroid in itself induces risky behavior leading to injuries and poisonings. A few studies have investigated the psychological effects of high-dose testosterone in healthy men.[27-29] Su et al[27] found that high-dose testosterone induced significant mood swings, increased self-confidence, and violent feelings, and Pope et al[28] verified these findings and highlighted the risk of manic reactions. On the other hand, Bhasin et al[29] did not find any behavioral or mood-related alterations, when exposing men to supraphysiological doses of testosterone.

The effects of physiologic doses of testosterone have also been studied. The TRAVERSE study randomized more than 5,000 hypogonadal men to either placebo or testosterone in physiologic doses, and found that testosterone improved mood.[30] Furthermore, the TRAVERSE study identified an increased risk of nonosteoporotic fractures, with the most common fractures among those exposed to testosterone occurring in the ribs, ankle, and wrist.[11] Likewise, our study shows a strong signal for fractures, while the relative risk for soft tissue injuries was less pronounced. If the injury signals were solely driven by risk behavior or training, one would have expected a roughly equal increase in soft tissue injuries and fractures. Although speculative, this could suggest that the heightened risk of fractures may not be entirely due to behavioral factors or confounding variables, but rather to effects of testosterone on bone health.

In summary, anabolic androgenic steroid use is associated with an increased incidence of both injuries and poisonings, thereby quantifying an association with higher rate of external harm among users.

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