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Health Complications Associated with Anabolic-Androgenic Steroid Use in Physically Active Men: A Literature Review

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Abstract

Aim. The aim of this study was to review the current scientific literature on the adverse effects of anabolic-androgenic steroids (AAS) use in physically active men and to highlight the need for further research in this field.

Introduction. The use of anabolic-androgenic steroids among physically active individuals is an increasing public health concern and is associated with significant health risks. In recent years, the use of these substances has expanded beyond professional athletes to include recreationally active individuals.

Methods. A literature review was conducted using the PubMed and Google Scholar databases. The search included studies published between 2017 and 2025 focusing on the health effects of AAS use in physically active men.

Results. Analysis of the available literature indicates that supraphysiological doses of AAS are associated with numerous adverse effects. The most significant complications involve the cardiovascular system (including hypertension and atherosclerosis), the endocrine system (particularly suppression of endogenous testosterone production and infertility), and psychiatric health (including mood disorders and increased aggression). Additional complications affecting the liver, kidneys, and skin have also been reported.

Discussion. The findings suggest that AAS use poses a serious health risk, particularly due to its multi-system effects and the potential for long-term complications. The increasing prevalence of AAS use among recreational athletes further emphasizes the need for greater clinical awareness and early identification of affected individuals.

Conclusion. Increasing awareness of the health risks associated with AAS use among both patients and healthcare professionals is essential for effective prevention and management. Further research is needed to better understand the long-term consequences of AAS use.

Keywords: anabolic-androgenic steroids; adverse effects; cardiovascular complications; endocrine disorders; bodybuilders; hormonal doping

1. Introduction

In recent years, the use of anabolic-androgenic steroids (AAS) has become a significant public health problem [1,2]. These substances, originally used for medical purposes, for example, in the treatment of hypogonadism, Klinefelter syndrome, or androgen deficiency syndrome, are becoming increasingly common for non-medical purposes [2, 12, 13]. AAS are used not only by professional athletes but also by recreational exercisers, with men who want to improve their appearance and athletic performance being a particularly large group of people at risk of AAS use [11 - 14].

The non-medical use of AAS is associated with socio-cultural factors, including the growing emphasis on a muscular physique, body image promotion on social media, the pressure to achieve ever-higher results in sports, and easy access to these substances [11, 13, 14, 17]. The use of these substances is prohibited in professional and amateur sports by the World Anti-Doping Agency. Nevertheless, a significant number of gym users choose to use them, obtaining AAS from illegal sources and using them in supraphysiological doses without medical supervision, sometimes simultaneously taking other substances [1, 16, 17, 18].

Anabolic-androgenic steroids are a group of hormones including testosterone and its derivatives, which bind to androgen receptors in target cells, resulting in an anabolic effect – increased muscle mass and strength – and an androgenic effect – the induction and maintenance of primary and secondary male sexual characteristics [2, 3, 4, 12]. These mechanisms can also contribute to the development of numerous adverse effects. The effects of AAS on the human body are complex and depend on factors such as dosage, duration of use, and individual susceptibility [4]. Studies have shown that non-medical use of AAS can cause numerous side effects, particularly those affecting the cardiovascular, hormonal, and psychiatric systems [1-9]. Furthermore, adverse effects on the liver, kidneys, and skin have also been described [1, 3, 6, 9, 12]. Despite the growing number of studies on the complications of AAS abuse, their actual incidence may be underestimated due to the illegality of non-medical use of these substances and the reluctance of users to report AAS use [1, 2]. The aim of this paper is to review the latest literature and gather information on the complications of anabolic-androgenic steroid use in physically active men, and to highlight the likelihood of an increase in the number of individuals presenting with these complications to family physicians and emergency departments [19].

2. Methods

The literature review was conducted based on publications available in the PubMed and Google Scholar databases, as well as the official WADA website. Publications published after 2017 were primarily analyzed to provide the most up-to-date knowledge on AAS. The keywords used to search for data included "anabolic androgenic steroids," "hormonal doping," and "AAS adverse effects."

3. Research results

3.1 Cardiovascular complications of anabolic steroid use:

The impact on the cardiovascular system is the most widely documented negative effect of AAS. Numerous studies have shown that AAS can significantly increase the risk of cardiovascular morbidity and mortality in individuals without previously diagnosed cardiovascular disease [4, 8, 17, 19].

AAS have atherogenic effects because they cause adverse changes in the lipid profile. They have been shown to increase low-density lipoprotein (LDL) levels while decreasing high-density lipoprotein (HDL) levels. Furthermore, they can cause endothelial dysfunction, oxidative stress, vasoconstriction, and have prothrombotic and proinflammatory effects. All of these factors promote the development of atherosclerosis and contribute to an increased risk of coronary heart disease [1, 3, 4, 6, 8]. A study conducted in men who used AAS for at least two years throughout their lives showed a higher atherosclerotic plaque volume in coronary arteries in AAS users compared to non-users, and a relationship between the atherosclerotic burden of coronary arteries and the lifetime dose of AAS [7].

Anabolic-androgenic steroids also exhibit prothrombotic effects associated with changes in coagulation factors and increased platelet aggregation. This results in an increased risk of thrombosis, which may manifest clinically as myocardial infarction, ischemic stroke or pulmonary embolism [4].

AAS use is also associated with the development of chronic hypertension, which may contribute to structural changes in the heart. Long-term use of AAS at doses exceeding physiological norms may promote pathological cardiac remodeling, including myocardial fibrosis, what can lead to cardiac hypertrophy, reduced left ventricular systolic and diastolic function, and reduced cardiac efficiency [4, 7, 8]. These changes can result in cardiomyopathy, heart failure, and cardiac arrhythmias, which in turn can lead to sudden cardiovascular events or sudden cardiac death, even in young individuals without typical cardiovascular risk factors [1, 2, 4, 6, 8, 9].

The degree of reversibility of cardiovascular complications resulting from chronic AAS abuse is not easy to estimate because the occurrence and severity of complications depend on the type of substance taken, cumulative dose, method of administration and duration of exposure [4, 7, 9]. Once myocardial fibrosis and cardiomyopathy have occurred, the changes are irreversible, but their progression and impact on cardiovascular function can be limited. Therefore, prompt discontinuation of AAS use at unphysiological doses and appropriate patient education are crucial.

3.2 Endocrine complications of anabolic steroid use:

Exogenous administration of AAS disrupts the physiological regulation of the hypothalamic-pituitary-gonadal axis, resulting in numerous hormonal disorders. AAS act on the hypothalamus and pituitary gland through a negative feedback mechanism, resulting in inhibition of the secretion of gonadotropin-releasing hormone, luteinizing hormone, and follicle-stimulating hormone [10, 17]. This inhibition leads to reduced endogenous testosterone production and impaired spermatogenesis [1, 3, 5, 6, 10]. Consequently, clinical symptoms observed in AAS users include hypogonadism, which may persist after discontinuation of AAS use, and male infertility [1, 4, 10]. Reduced sperm concentration and motility, as well as abnormal sperm morphology, have been observed in AAS users [2, 10]. Long-term exposure to high doses of androgens may lead to chronic impairment of fertility, although in some cases these changes are reversible [2, 5, 10, 17]. Furthermore, inhibition of endogenous testosterone production can result in testicular atrophy. Reduced testicular volume is a direct consequence of reduced gonadotropin stimulation and impaired spermatogenic activity [3].

Another significant endocrine complication is the development of gynecomastia, which results from an imbalance between androgens and estrogens. Excess androgens are aromatized into estrogens, and elevated estrogen levels stimulate the proliferation of breast tissue, which may be irreversible and, in advanced stages, may require surgical intervention [3, 10].

AAS use has also been observed to affect other hormonal pathways. Some studies suggest that androgens misuse may contribute to insulin resistance, thereby increasing the risk of metabolic disorders [4]. Long-term administration of AAS may affects the activity of the hypothalamic-pituitary-thyroid axis, resulting in reduced total thyroid hormone levels and the development of subclinical hypothyroidism [4]. Although the effects of AAS on these hormonal pathways are not extensively described in the literature, the metabolic and psychological consequences of this effect should be considered.

The reversibility of endocrine disruptions depends on several factors, including the duration of AAS supplementation, dosage, and individual susceptibility. Therefore, some individuals

experience recovery of hormonal function after discontinuing AAS use, while others may develop chronic hypogonadism requiring long-term treatment [2, 3, 5, 10, 17]. Furthermore, after discontinuing AAS use, some individuals may experience decreased libido and erectile dysfunction associated with hypogonadism, which may result in the need to return to androgen abuse [1, 2, 3, 12, 17]. Some publications suggest that cyclic administration of AAS results in fewer endocrine complications, but there is currently insufficient research on this topic [10].

3.3 Psychiatric complications of anabolic steroid use:

Mental and behavioral disorders associated with AAS abuse are receiving increasing attention, as they significantly impact quality of life and social functioning. These disorders are multifactorial and may result from both direct neurobiological mechanisms and psychosocial factors related to expectations regarding performance, strength, and body image [11, 15].

AAS abuse can lead to mental disorders. Literature highlights increased aggression and irritability, which are often referred to as "roid rage" [1, 12, 13]. Increased impulsivity, mood instability, and reduced stress tolerance can lead to interpersonal conflicts and risky behaviors [12, 17]. These behavioral changes can lead to dysfunctional behaviors that are outward-facing, such as destruction of public property, domestic violence, child abuse, violent assault, or murder, or inward-facing, such as self-harm or suicide [12].

Mood disorders have also been observed among AAS users. Studies indicate an increased incidence of depressive symptoms, particularly after discontinuation, which is likely related to the suppression of endogenous testosterone production. In some cases, full-blown depression, anxiety disorders, and emotional lability may develop. On the other hand, the literature reports the development of hypomanic or mania symptoms in individuals actively using AAS, including elevated mood, excessive energy levels, and decreased sleep requirements [12, 13, 17, 20].

Another significant psychiatric complication of chronic AAS use is the potential development of addiction, characterized by compulsive use of anabolic steroids despite awareness of the negative health consequences or even despite the occurrence of these consequences [4, 18, 20]. Withdrawal symptoms include fatigue, depressive symptoms, and decreased libido, which can exacerbate further use and perpetuate the addiction cycle [1, 13].

A relatively new psychiatric diagnosis is bigorexia, which can develop as a result of chronic AAS use or whose symptoms can be exacerbated by the use of these substances [11, 15, 20]. Bigorexia, also known as muscle dysmorphia, involves a distorted body image in which muscular individuals with a well-developed physique perceive themselves as insufficiently

muscular. The typical image of a person suffering from bigorexia is a man training excessively, controlling his diet, and using AAS [2, 11, 15].

The neurobiological mechanisms underlying psychiatric complications associated with AAS use are not fully understood, but they are believed to involve alterations in neurotransmitter systems, including serotonergic and dopaminergic pathways and changes in the limbic system. These alterations can affect mood regulation, reward and punishment systems, and behavioral control [12, 13, 17].

Accurately examining the prevalence of mental health disorders among AAS abusers is very difficult because these individuals often do not report their use to physicians. This can delay the diagnosis and appropriate treatment, or result in the psychiatric symptoms never being linked to AAS.

The reversibility of psychiatric symptoms varies and may depend on the duration and intensity of AAS use. While some symptoms resolve upon discontinuation, others, particularly mood disorders and dependence, may persist and require long-term psychiatric intervention [17, 20].

3.4 Other complications of anabolic steroid use:

In addition to complications related to the cardiovascular, endocrine and psychological systems, the literature also mentions the effects of long-term AAS use on other organs, particularly the liver, kidneys and skin. Symptoms from these organs may be the reason for an androgen-dependent person to consult a doctor, and therefore should also be taken into account.

Hepatotoxicity is a well-documented complication, particularly severe with oral administration of 17α-alkylated AAS [1, 3, 17]. These compounds are characterized by reduced hepatic metabolism, which increases their bioavailability and the likelihood of liver damage [3, 17]. Observed hepatotoxic effects of AAS include elevated liver enzymes, cholestasis, fatty liver, and, in rare cases, the development of liver tumors [1, 3, 6, 9, 12]. The risk of liver damage likely depends on the dose and duration of ASS use [3, 12].

Some publications also mention the negative impact of AAS use on renal function, although this problem appears to be more complex and multifactorial. The mechanisms of nephrotoxicity are believed to include direct toxic effects on renal tissue, increased glomerular filtration pressure, and secondary damage associated with hypertension and rhabdomyolysis [3, 12]. Cases of focal segmental glomerulosclerosis and acute kidney injury have also been reported in AAS users, particularly those using these substances long-term and consuming high amounts of protein [3].

Dermatological complications are frequently reported among AAS users. These include acne, seborrhea, and sometimes even androgenic alopecia, which are primarily related to the

androgenic effects of AAS on the sebaceous glands and hair follicles [3, 12]. Additional skin complications, not directly related to the androgenic effects of AAS, include stretch marks, which can occur as a result of rapid muscle tissue volume gain and infection at the AAS injection site [13, 19].

A relatively newly discovered complication of AAS use is the acceleration of brain aging and cognitive dysfunction. AAS penetrate the blood-brain barrier and affect cells of the central nervous system. Supraphysiological doses of AAS can induce neuronal apoptosis and, consequently, exacerbate neurodegenerative processes in the brain [12, 20]. This effect of AAS has not yet been sufficiently studied, the mechanisms of development and reversibility of this complication should be the subject of future research and publications.

These complications are often perceived as less serious than cardiovascular and hormonal ones, but they can significantly impact the overall health and quality of life of people using AAS, which is why a holistic approach to the complications associated with the abuse of these substances is important.

4. Discussion

Anabolic-androgenic steroid abuse is a serious health problem among physically active individuals, especially men participating in recreational sports [13, 14, 18]. Available literature describes numerous adverse health effects of AAS use, affecting multiple organs. The most clinically significant and common complications include the cardiovascular, endocrine, and mental systems [17, 19, 20]. Based on the analysis of AAS users, it is difficult to create a single, specific image of an AAS abuser, as users are a heterogeneous group driven by different motivations for using AAS. However, the characteristics most frequently recurring among users depict an educated, working man who exercises at the gym approximately five hours a week, obtains AAS from illegal sources, and uses them without medical supervision [18, 19].

Cardiovascular complications appear to be the most widely described in the literature, they are very serious, and can potentially be life-threatening in individuals using AAS. Disturbances in lipid metabolism, the development of hypertension, and structural and functional changes in the heart can increase the risk of atherosclerosis, sudden cardiovascular events, and even result in sudden cardiac death [17, 19]. These complications can affect young individuals without traditional cardiovascular risk factors, highlighting the clinical significance of AAS toxicity [2, 4, 8]. Endocrine disruptions are primarily related to suppression of the hypothalamic-pituitary-gonadal axis and include hypogonadism, infertility, and testicular atrophy. These complications

can have long-term consequences, particularly in men who use AAS for long periods. The extent of recovery from AAS use is variable and unpredictable, but some of these complications may be reversible upon discontinuation [2,10].

Another important aspect of AAS use is psychiatric complications, which impact both the user and those around them. Aggression, mood disorders, and the risk of addiction can impair an individual's social functioning. Some studies also highlight the complex interaction between the use of these substances and body image disturbances such as muscle dysmorphia. This relationship may drive the need to continue using AAS despite awareness and the occurrence of negative health consequences [2, 4, 11, 13].

Analysis of the available literature has shown that AAS use is also associated with hepatotoxicity, nephrotoxicity, and dermatological disorders. Although these complications are less extensively described in publications than cardiovascular and endocrine complications, they constitute a significant component of the reduced quality of life and health of individuals abusing anabolic steroids [19]. Primary care physicians may often be unaware that the symptoms they observe in a patient may be related to anabolic androgenic steroid abuse. Certain clinical signs may raise suspicion and facilitate diagnosis in the primary care setting. A physician who has been caring for a patient for a long time may observe changes in the patient's appearance and behavior during subsequent visits. Acne, stretch marks, rapid muscle mass gain, the development of gynecomastia, mood changes, aggression, and anxiety may be observed. Additionally, laboratory test results such as dyslipidemia, elevated liver enzymes, and decreased endogenous testosterone levels may raise the suspicion of AAS use. Clinical indicators of anabolic-androgenic steroid use in primary care are summarized in Table 1.

Table 1. Clinical signs and features that may suggest anabolic-androgenic steroid use in primary care.

Category	**Clinical features**
General	Rapid increase in muscle mass, disproportionate physique
Cardiovascular	Hypertension, chest pain, arrhythmias, acute coronary syndromes
Endocrine	Gynecomastia, testicular atrophy, decreased libido

Dermatological	Acne, alopecia, stretch marks
Psychiatric	Aggression, mood swings, irritability, depressive symptoms, problems with memory and concentration
Laboratory findings	Dyslipidemia (↑LDL, ↓HDL), elevated liver enzymes, low endogenous testosterone

Despite the growing number of studies and publications on complications associated with AAS use, several limitations affecting the reliability of the results must be considered. Many studies are observational in nature, which limits the ability to establish cause-and-effect relationships, small groups of individuals are studied and the populations are heterogeneous, which may contribute to the generalizability of the results [1, 2]. Another significant limitation is the underreporting of AAS use by users of these substances, often due to fear of legal or social consequences [1, 2]. Furthermore, there is significant variation in the types, doses, and duration of AAS use between individuals, making it difficult to compare study results and draw clear conclusions [1, 2]. “Stacking” - the phenomenon of concurrent use of multiple substances - also exists, further complicating the study of the specific effects of individual substances [1, 2, 18].
The results of our review highlight the importance of increasing awareness of the potential adverse effects of AAS use among both healthcare professionals and users. Physicians should be aware of the potential for AAS use in young, physically active men presenting with unexplained or sudden-onset cardiovascular or endocrine symptoms. Furthermore, physicians should be aware of more subtle symptoms of androgen abuse, such as dermatological changes or changes in behavior and sexual drive. Early recognition of AAS use can allow for prompt intervention and reduce the risk of developing or persisting complications.
Given the popularity of these substances among recreational athletes, public health initiatives can play a key role in reducing their use and complications. Therefore, preventive strategies should be developed that focus on education and raising awareness of the potential negative health effects associated with AAS use.
Further research, particularly long-term studies, is needed to better understand the long-term effects of AAS use, particularly assessing the reversibility of adverse effects and the impact of AAS dosage and duration. Future studies should focus on large, well-designed cohorts, considering the impact of different dosing regimens, duration of use, and concurrent use of

multiple substances. A better understanding of the impact of these factors may contribute to planning an effective preventive strategy and improving clinical management.

5. Conclusion

Anabolic-androgenic steroids are increasingly used by physically active individuals, posing a significant public health problem. Numerous adverse effects caused by the abuse of this group of substances have been described in the literature, including those affecting the cardiovascular, endocrine, and mental systems, as well as the liver, kidneys, and skin. Further research on the complications of AAS use and increasing awareness among both AAS users and primary care physicians are key steps toward limiting their use by recreational athletes.

6. Author Contribution Statement

Conceptualization, U.K. and M.M.; methodology, Z.B. and M.C.; data curation, M.R. and J.K; writing—original draft preparation, U.K., Z.B., J.K. and M.C.; writing—review and editing, M.R. and M.M. All authors have read and agreed to the published version of the manuscript.

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No new data were created or analyzed in this study. Data sharing is not applicable to this article.

11. Conflicts of Interest

The authors declare that they have no conflicts of interest.

12. Declaration of the Use of Generative AI and AI-Assisted Technologies:

ChatGPT was utilized for two specific purposes in this research. To assist in polishing the academic English of the manuscript, ensuring clarity, coherence, and adherence to scientific writing standards. ChatGPT was used for additional linguistic polishing of the article, ensuring correct grammar, style, and clarity of the text. Furthermore, ChatGPT was used to create a Vancouver-style bibliography. It is important to emphasize that all AI tools were used solely as supporting instruments under human supervision. The AI tools were primarily used for linguistic polishing and bibliography creation, not to replace human judgment.

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