



Research Article

# Anabolic Androgenic Steroids Misuse in the Fitness Industry

Kulman Nyssanbayeva<sup>ID 1,\*</sup>, Venera Abdulla<sup>ID 2,3</sup>, Zhanar Andassova<sup>ID 3</sup>, and Natalya Glushkova<sup>ID 4</sup>

<sup>1</sup>Department of Propaedeutics of Internal Diseases, Asfendiyarov Kazakh National Medical University, Almaty, Kazakhstan

<sup>2</sup>Regional Anti-Doping Organization of Central Asia, Almaty, Kazakhstan

<sup>3</sup>Department of Physical Medicine and Rehabilitation, Sport Medicine, Asfendiyarov Kazakh National Medical University, Almaty, Kazakhstan

<sup>4</sup>Department of Epidemiology, Biostatistics and Evidence Based Medicine, Al-Farabi Kazakh National University, Almaty, Kazakhstan

## Abstract

Anabolic-androgenic steroids (AAS) are synthetic variations of the male sex hormone testosterone. They mimic testosterone's effects, primarily promoting muscle growth (anabolic effects) and enhancing male traits (androgenic effects). The misuse of AAS has extended beyond high-performance athletes and is now prevalent among the general population, particularly among fitness and gym enthusiasts. Epidemiological data highlight the widespread abuse of these substances, driven by the aspiration to enhance muscle mass, strength, and overall physical performance. The misuse of AAS in the fitness industry poses significant health risks and ethical concerns. This review highlights the prevalence, consequences, and prevention strategies related to AAS misuse in the fitness industry.

**Keywords:** anabolic-androgenic steroids, fitness, gym, toxicity, prevention

Corresponding Author: Kulman Nyssanbayeva; email: whereabouts kaz@gmail.com

**Received:** 28 April 2024

**Accepted:** 23 July 2024

**Published:** 26 September 2024

Production and Hosting by  
KnE Publishing

© Kulman Nyssanbayeva et al. This article is distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use and redistribution provided that the original author and source are credited.



## 1. Introduction

Anabolic androgenic steroids (AAS) are synthetic derivatives of testosterone developed over the past 75 years. They have a narrow range of medical applications, primarily for treating hypogonadism [1]. However, their misuse for performance enhancement and bodybuilding has become increasingly prevalent, particularly among the general population engaging in fitness activities [2]. It is important to note that AAS are controlled substances, and their nonmedical use is banned in many countries due to their potential health risks. Before 1980, the nonmedical use of AAS was mainly prevalent among elite athletes and bodybuilders. In recent decades, however, the use of anabolic androgenic steroids for performance enhancement and muscle gain has been increasing among the general population [3]. The global lifetime prevalence rate of AAS misuse is estimated to be 3.3%, with a significantly higher rate among men (6.4%) compared to women (1.6%) [4]. The vast majority of AAS users are regular gym and fitness center patrons, primarily men, who utilize these substances to improve their appearance rather than for competitive athletic purposes [5]. Commercial interests have driven the development of uncontrolled intake of various doping substances, particularly AAS, in the fitness industry [6]. Uncontrolled AAS intake can lead to serious health consequences, including cardiovascular problems, psychological issues, and hormonal imbalances [7]. These risks may increase the healthcare burden and require additional resources to address the effects of AAS misuse. In this regard, many researchers recognize the emergence of doping as a societal and public health issue within the context of strength training and fitness culture, particularly in gyms and fitness centers [8]. This review aims to summarize the research in scientific literature regarding AAS abuse among gym-goers and within the fitness industry. The novelty of this review lies in its focus on a specific population and offers healthcare professionals critical information to address a growing public health concern.

## 2. Materials and Methods

The search and analysis of scientific publications were conducted using the following databases: Google Scholar, PubMed, and ResearchGate. This research aims to describe the prevalence of nonmedical use of AAS among athletes visiting fitness clubs and gyms. The following key search terms served as the basis for the search strategy: AAS, doping, performance-enhancing drugs (PED), fitness, and gym. The inclusion criteria for the study were publications concerning misuse and abuse of AAS among visitors of fitness clubs and gyms, whereas the exclusion criteria were publications unrelated to the review topic, those containing insufficient information relevant to the research topic, and duplicates.

### 3. Prevalence of AAS use Among Amateur Athletes in the Fitness Industry

The prevalence of AAS misuse among amateur athletes in the fitness industry worldwide has received considerable attention in research. Studies have primarily focused on AAS usage patterns among gym-goers and fitness enthusiasts across Western Europe, America, and selected Middle Eastern nations. However, accurately determining the exact prevalence of AAS misuse in this demographic poses challenges due to potential underreporting. Despite these difficulties, research suggests that AAS utilization among amateur athletes in the fitness sector exceeds that of the general population. The nonmedical use of AAS is on the rise among attendees of gyms and fitness clubs, particularly among those who prioritize enhancing their physical appearance [8]. A meta-analysis examining global AAS misuse prevalence within this group revealed a significantly high rate of 18.4% [9].

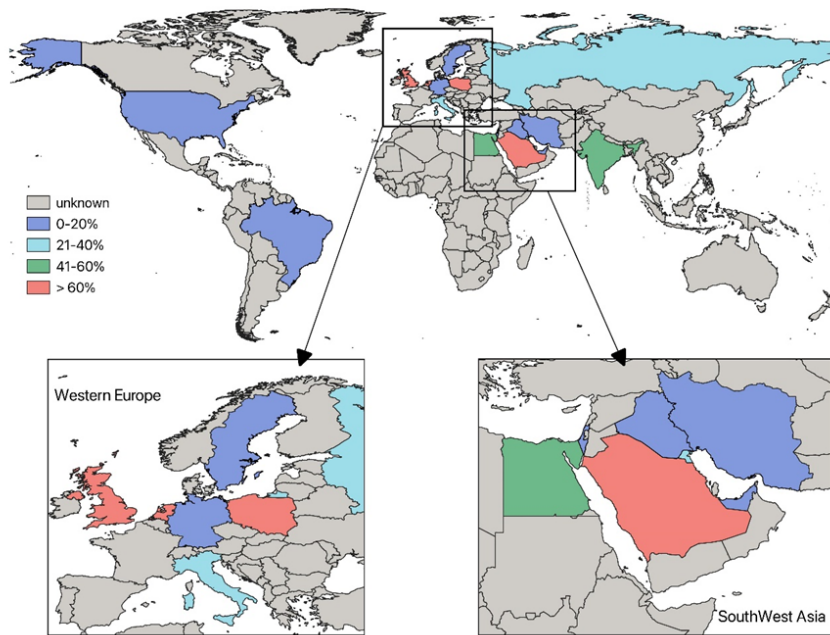
The United Kingdom and the Netherlands exhibited the highest prevalence rates of AAS use among gym-goers, with percentages around 70%. Similarly, studies conducted in Russia and Poland revealed notable rates of 30.1% and 30.4%, respectively [10, 11].

Variations in AAS usage levels across European countries were observed. In the Middle East, studies indicated high prevalence rates among fitness center visitors, with figures reaching 70.4% in Iraq [11], 45% in India [13], 24.5% in Saudi Arabia [14], and 22.7% in Kuwait [15]. Figure 1 illustrates the global prevalence of AAS use among fitness center and gym visitors.

Some studies lacked data on female users or current AAS usage patterns. It was also noted that a significant proportion (80%) of AAS users practiced polypharmacy, involving the simultaneous use of multiple drugs without medical supervision or necessity. This phenomenon is prevalent among AAS users, with up to 80% engaging in polypharmacy. Commonly used substances in this context include ephedrine, growth hormone, tamoxifen, clenbuterol, insulin, human chorionic gonadotropin, diuretics, and thyroid hormones [16, 17].

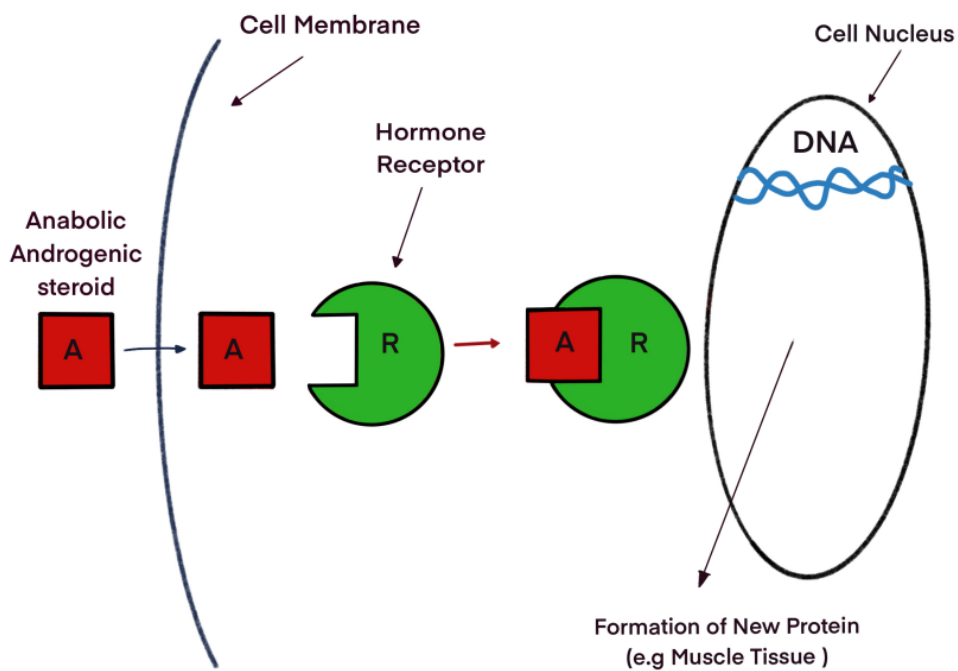
### 4. Action Mechanism and Motivations to Use AAS

AAS are synthetic hormones named for their steroid nucleus chemical structure and dual biological effects: anabolic and androgenic [18]. The secondary sexual characteristics of men, reproductive system, nature of hair growth, and the activity of the sebaceous glands are a few that fall under androgenic effects. In addition, AAS exhibits anabolic effects, enhancing nitrogen retention and protein synthesis, which, in turn, leads to increased collagen production, muscle hypertrophy, and improved bone metabolism [19]. AAS binds to the cytosolic androgen receptor by entering via cell membrane (Figure 2). The hormone-receptor complex then translocates to the nucleus, where it forms a homodimer. This homodimer binds to androgen response elements in target genes, facilitating gene transcription and ultimately leading to



**Figure 1:** Prevalence of AAS use among fitness center and gym attendees in the world.

protein synthesis [20]. These effects enhance performance and promote muscle growth, making them a significant factor in the misuse and abuse of AAS in society [21].



**Figure 2:** The mechanism of AAS action.

## 4.1. Motives for AAS use among amateur athletes

On summarizing the scientific data, it can be concluded that the main motivations for AAS use among amateur athletes in the fitness industry are:

1. Improved athletic performance: AAS use increases muscle mass, enhancing athletic performance [2, 22, 23].
2. Improved appearance: Users seek to increase muscle size and decrease body fat to improve their physical appearance [24, 25].
3. Body dysmorphia: Individuals with body dysmorphic disorder may obsess over perceived flaws in their appearance, leading them to use AAS in an attempt to achieve a more idealized physique [26].
4. Peer pressure: Some individuals are influenced by their peers or social circles to use AAS as a sporting or social norm [27, 28].
5. Psychological factors: AAS use is associated with psychological factors such as impulsivity, thrill-seeking, and risk-taking behavior [29].
6. Other motivations include the coach's approval, curiosity, family influence, the use of famous athletes portrayed in the media, and peer influence [30].

## 5. Adverse Effects of Anabolic-androgenic Steroids

AAS are a diverse group of molecules that include both endogenously produced androgens (such as testosterone) as well as synthetically manufactured derivatives. These compounds are commonly used to enhance muscle growth for aesthetic purposes and athletic performance, to minimize androgenic effects. However, it is essential to recognize that AAS use comes with a range of adverse effects that influence various organs, tissues, and bodily functions (Figure 3).

AAS abuse can lead to cardiovascular complications, including:

### 5.1. Cardiovascular system

- Increased risk of heart disease: AAS may contribute to conditions like hypertension, atherosclerosis, and myocardial infarction.
  - Alterations in lipid profiles: AAS can disrupt lipid metabolism, potentially leading to unfavorable changes in cholesterol levels.
  - Thromboembolism: AAS use has been associated with an increased risk of blood clots, which can cause serious health issues [7, 20, 31].

## 5.2. Reproductive system

- Hypogonadism: Chronic AAS use may suppress natural testosterone production, leading to hypogonadism (low testosterone levels).
  - Infertility: AAS can impair sperm production and fertility.
  - Testicular atrophy: Prolonged AAS use may shrink the testicles [7, 32, 33].

## 5.3. Neuropsychiatric effects

- The molecular and pathological mechanisms behind neuropsychiatric side effects of AAS abuse remain unclear.
  - However, some individuals using AAS have reported mood swings, aggression, and altered behavior.
  - Further research is needed to fully understand these effects [7, 34–36].

## 5.4. Liver toxicity

AAS, especially  $17\alpha$ -alkylated derivatives, can harm the liver:

- Cholestasis: AAS may disrupt bile flow, leading to cholestasis (bile accumulation).
- Peliosis hepatis: A rare condition characterized by blood-filled cysts in the liver.
- Liver adenomas and carcinomas: AAS use has been linked to the development of liver tumors [33, 37, 38].

## 5.5. Musculoskeletal injuries

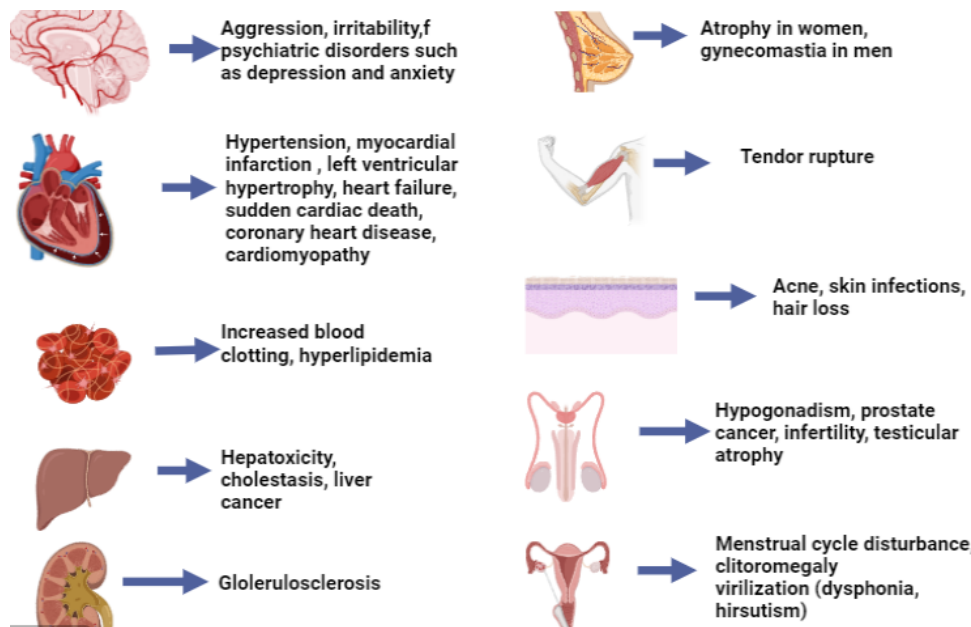
Paradoxically, while AAS enhances muscle growth, they can weaken tendons and ligaments, increasing the risk of injuries [39–41]. The effect of AAS on tendons remains the subject of ongoing research. It is still unclear exactly how AAS affects tendons [42]. However, some studies have indicated several molecular mechanisms:

- AAS stimulates rapid muscle hypertrophy, but tendons and ligaments do not adapt at the same rate. This results in an imbalance where muscles become stronger and larger, while tendons and ligaments remain relatively weaker and more prone to injury due to the disproportionate load [43, 44].
- AAS can affect the quality and quantity of collagen—the primary structural protein in tendons and ligaments. While AAS may increase collagen synthesis, they can also alter the types of collagen produced. Specifically, AAS tends to promote the formation of collagen type III over the stronger type I collagen, resulting in tendons that are less robust and more susceptible to injury [42].

## 5.6. Psychiatric disorders

- AAS use has been associated with psychiatric symptoms, including mood disturbances, anxiety, and depression [26, 37].

Thus, uncontrolled use of AAS can lead to serious consequences. Given these potential consequences, it is crucial for individuals to approach AAS use responsibly, seek medical guidance when necessary, and be aware of the risks associated with misuse.



**Figure 3:** Most common side effects of AAS.

## 6. Preventing AAS Misuse

Preventing AAS misuse in the fitness industry requires a comprehensive approach that involves education, regulation, support, and collaboration among various stakeholders. Here are some specific strategies to prevent AAS misuse in the fitness industry:

- **Education and awareness campaigns:** To develop and implement educational campaigns specifically for fitness enthusiasts, trainers, gym owners, and other industry professionals. Provide information about the risks and dangers of AAS misuse, as well as promote natural and healthy methods of achieving fitness goals [30].
- **Professional training and certification:** Ensure that fitness trainers and coaches receive proper training and certification on ethical practices, including guidelines on AAS use [45].
- **Encourage fitness professionals and enthusiasts to prioritize natural and evidence-based approaches to fitness and performance enhancement, such as proper nutrition, effective training methods, rest and recovery strategies, and legal supplements [46].**

- **Regulation and enforcement:** Work with regulatory bodies to enforce laws and regulations regarding the sale, distribution, and possession of AAS. Implement strict penalties for individuals or businesses found violating these regulations.
- **Screening and testing:** Implement regular screening and testing protocols for AAS use in fitness competitions and events. Use testing as a deterrent and a way to identify individuals who may need support or intervention [47].
- **Peer support and mentorship:** Foster a supportive environment within fitness communities where peer support and mentorship programs are encouraged. Experienced athletes and trainers can serve as positive role models and promote healthy behaviors [48, 49].
- **Access to qualified healthcare professionals:** To ensure that fitness enthusiasts have access to qualified healthcare professionals who can provide guidance on fitness, nutrition, and performance enhancement in a safe and ethical manner. Offer resources for individuals seeking information or support related to AAS use [50].

## 7. Implications for Practice and Future Research

This review focuses on public health issues related to the abuse of AAS in fitness communities. By examining the prevalence and patterns of AAS use among gym and fitness club patrons, this study provides valuable information to various stakeholders. Policymakers, health professionals, and gym management can use these findings to understand the scale of the problem and develop effective prevention strategies. In addition, this study serves as a starting point for future research, providing scientists and practitioners with an essential resource to understand and address the factors contributing to the misuse of AAS in a fitness environment.

## 8. Limitations

This study acknowledges several limitations. Firstly, relying on self-reported data may introduce bias, as participants might underreport their AAS use due to social stigma or overreport due to recall inaccuracies. Secondly, the cross-sectional design limits our ability to establish definitive cause-and-effect relationships between AAS use and associated health issues. Longitudinal studies would be more appropriate for exploring the temporal patterns of AAS usage. Finally, despite our efforts to include a diverse and inclusive sample, focusing on fitness center and gym attendees might not fully represent the demographic variations within the broader population.



## 9. Conclusion

The findings of this review study underscore a troubling trend: the widespread use of AAS extends beyond professional sports, becoming a global issue and a significant public health concern. The rapid expansion of the fitness industry, including its commercial aspects, brings positive social impacts at the same time it also raises concerns about the increasing use of performance-enhancing substances like AAS. The promotion of a healthy lifestyle can inadvertently lead some individuals to seek shortcuts, such as resorting to AAS use, in pursuit of an ideal physique. Given the limited available data on doping issues in the Republic of Kazakhstan, conducting comprehensive research on a large scale is crucial.

## Funding

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript.

## Conflicting of Interests

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## References

- [1] Kanayama G, Pope HG. History and epidemiology of anabolic androgens in athletes and non-athletes. *Mol Cell Endocrinol*. 2018 Mar 15;464:4–13.
- [2] Korkia P. Anabolic-androgenic steroids and their uses in sport and recreation. *J Subst Use*. 1997;2(3):131–135.
- [3] Henning AD, Dimeo P. The new front in the war on doping: Amateur athletes. *Int J Drug Policy* Elsevier B.V. 2018;51:128–136.
- [4] Sagoe D, Molde H, Andreassen CS, Torsheim T, Pallesen S. The global epidemiology of anabolic-androgenic steroid use: A meta-analysis and meta-regression analysis [Internet]. *Ann Epidemiol*. Elsevier Inc. 2014;24: 383–398. [cited 2021 Jan 18]. Available from: <https://pubmed.ncbi.nlm.nih.gov/24582699/>
- [5] Parkinson AB, Evans NA. Anabolic androgenic steroids: A survey of 500 users. *Med Sci Sports Exerc*. 2006 Apr;38(4):644–651. [cited 2021 Jan 24] Available from: <http://journals.lww.com/00005768-200604000-00006>
- [6] Andreasson J, Johansson T. Fitness doping. *Fitness Doping*. 2020.
- [7] Horwitz H, Andersen JT, Dalhoff KP. Health consequences of androgenic anabolic steroid use. *J Intern Med*. 2019;285(3):333–340.
- [8] Evans NA. Gym and tonic: A profile of 100 male steroid users. *Br J Sports Med*. 1997;31(1):54–58.
- [9] Sagoe D, Molde H, Andreassen CS, Torsheim T, Pallesen S. The global epidemiology of anabolic-androgenic steroid use: A meta-analysis and meta-regression analysis. *Ann Epidemiol*. Elsevier Inc. 2014;24:383–398.

- [10] Gwizdek K, Brzek A, Bak-Sosnowska M, Dittfeld A, Knapik A, Ziaja D. The use of steroids by gym athletes: An attempt to diagnose the problem scale and possible causes. *J Sports Med Phys Fitness*. 2018;58(6):880–888.
- [11] Lykhonosov MP, Babenko AY. The medical aspect of using anabolic androgenic steroids in males attending gyms of Saint Petersburg. *Probl Endokrinol (Mosk)*. 2019;65(1):19–30.
- [12] Lafta RK, Mohammad GA. Anabolic Supplements abuse among athletes in Baghdad Gyms. *Iraqi J Community Med*. 2012;2012(4):268–273.
- [13] Arora S. Knowledge, attitude and practices regarding anabolic steroids among adults. *Nurs Midwifery Res J*. 2019;15.1(June):40–48.
- [14] Tara F, Lotfalizadeh M, Moeindarbari S. Electronic Physician (ISSN: 2008-5842). *Electron Physician*. 2016;8(10):3057–3061. Available from: <http://scielo.isciii.es/pdf/albacete/v3n2/especial2.pdf>
- [15] Alsaeed I, Alabkal JR. Usage and perceptions of anabolic-androgenic steroids among male fitness centre attendees in Kuwait - A cross-sectional study. *Subst Abus Treat Prev Policy*. 2015;10(1):1–6. Available from: <http://dx.doi.org/10.1186/s13011-015-0030-5>
- [16] Sagoe D, McVeigh J, Bjørnebekk A, Essilfie MS, Andreassen CS, Pallesen S. Polypharmacy among anabolic-androgenic steroid users: A descriptive metasynthesis. *Subst Abus Treat Prev Policy*. 2015;10(1).
- [17] Bahrke MS. Performance-enhancing substance misuse in sport: Risk factors and considerations for success and failure in intervention programs. *Subst Use Misuse*. 2012;47(13–14):1505–1516.
- [18] Thiblin I, Petersson A. Pharmacoepidemiology of anabolic androgenic steroids: A review. *Fundam Clin Pharmacol*. 2005;19(1):27–44.
- [19] Wu C, Kovac JR. Novel uses for the anabolic androgenic steroids nandrolone and oxandrolone in the management of male health. *Curr Urol Rep*. 2016;17(10):1–7. Available from: <http://dx.doi.org/10.1007/s11934-016-0629-8>
- [20] Kicman AT. Pharmacology of anabolic steroids. *Br J Pharmacol*. 2008;154(3):502–521.
- [21] Melnik BC. Androgen abuse in the community. *Current Opinion in Endocrinology, Diabetes and Obesity*. 2009;16:218–223.
- [22] Baker JS, Graham MR, Davies B. Steroid and prescription medicine abuse in the health and fitness community: A regional study. *Eur J Intern Med*. 2006 Nov [cited 2021 Jan 19];17(7):479–484. Available from: <https://pubmed.ncbi.nlm.nih.gov/17098591/>
- [23] Stilger VG, Yesalis CE. Anabolic-androgenic steroid use among high school football players. *J Community Health*. 1999;24(2):131–145. [cited 2021 Jan 19] Available from: <https://pubmed.ncbi.nlm.nih.gov/10202692/>
- [24] Bonnacaze AK, O'Connor T, Aloï JA. Characteristics and attitudes of men using anabolic androgenic steroids (AAS): A survey of 2385 men. *Am J Mens Health*. 2020;14(6).
- [25] Bilard J, Ninot G, Hauw D. Motives for illicit use of doping substances among athletes calling a national antidoping phone-help service: An exploratory study. *Subst Use Misuse*. 2011;46(4):359–367.
- [26] Piacentino D, Kotzalidis G, Casale A, Aromatario M, Pomara C, Girardi P, et al. Anabolic-androgenic steroid use and psychopathology in athletes. A systematic review. *Curr Neuropharmacol*. 2014;13(1):101–121.
- [27] Kimergard A. A qualitative study of anabolic steroid use amongst gym users in the United Kingdom: Motives, beliefs and experiences. *J Subst Use*. 2015;20(4):288–294.
- [28] Harvey O, Keen S, Parrish M, Van Teijlingen E. Support for people who use anabolic androgenic steroids: A systematic scoping review into what they want and what they access. *BMC Public Health*. 2019;19(1):1–13.

- [29] Haerinejad MJ, Ostovar A, Farzaneh MR, Keshavarz M. The prevalence and characteristics of performance-enhancing drug use among bodybuilding athletes in the south of Iran, Bushehr. *Asian J Sports Med*. 2016 Sep 1;7(3).
- [30] Striegel H, Simon P, Frisch S, Roecker K, Dietz K, Dickhuth HH, et al. Anabolic ergogenic substance users in fitness-sports: A distinct group supported by the health care system. *Drug Alcohol Depend*. 2006 Jan 4;81(1):11–19.
- [31] Torrisi M, Pennisi G, Russo I, Amico F, Esposito M, Liberto A, et al. Sudden cardiac death in anabolic-androgenic steroid users: A literature review. *Med*. 2020;56(11):1–19.
- [32] Juhn MS, Tarnopolsky M. Potential side effects of oral creatine supplementation: A critical review. *Clinical Journal of Sport Medicine*. 1998;8:298–304.
- [33] Smit DL, Buijs MM, de Hon O, den Heijer M, de Ronde W. Positive and negative side effects of androgen abuse. The HAARLEM study: A one-year prospective cohort study in 100 men. *Scand J Med Sci Sport*. 2021;31(2):427–438.
- [34] Pope HG, Katz DL. Psychiatric and medical effects of anabolic-androgenic steroid use: A controlled study of 160 athletes. *Arch Gen Psychiatry*. 1994;51(5):375–382 [cited 2021 Jan 20]. Available from: <https://pubmed.ncbi.nlm.nih.gov/8179461/>
- [35] Ip EJ, Lu DH, Barnett MJ, Tenerowicz MJ, Vo JC, Perry PJ. Psychological and physical impact of anabolic-androgenic steroid dependence [Internet]. Available from: <http://caesar.sheridan.com/reprints/>
- [36] van Amsterdam J, Opperhuizen A, Hartgens F. Adverse health effects of anabolic-androgenic steroids. *Regul Toxicol Pharmacol*. 2010;57(1):117–123. Available from: <http://dx.doi.org/10.1016/j.yrtph.2010.02.001>
- [37] Pope HG, Wood RI, Rogol A, Nyberg F, Bowers L, Bhasin S. Adverse health consequences of performance-enhancing drugs: An endocrine society scientific statement. *Endocrine Reviews*. *Endocrine Society*. 2014;35:341–375. [cited 2021 Apr 18]. Available from: </pmc/articles/PMC4026349/>
- [38] Hepatotoxicity associated with illicit use of anabolic androgenic steroids in doping.
- [39] Cope MR, Ali A, Bayliss NC. Biceps rupture in bodybuilders: Three case reports of rupture of the long head of the biceps at the tendon-labrum junction. *J Shoulder Elb Surg*. 2004 Sep;13(5):580–582. [cited 2021 Jan 20]. Available from: <https://pubmed.ncbi.nlm.nih.gov/15383821/>
- [40] Kanayama G, Deluca J, Meehan WP, Hudson JI, Isaacs S, Baggish A, et al. Ruptured tendons in anabolic-androgenic steroid users. *Am J Sports Med*. 2015 Nov 1;43(11):2638–2644. [cited 2021 Apr 18]. Available from: </pmc/articles/PMC5206906/>
- [41] Sollender JL, Rayan GM, Barden GA. Triceps tendon rupture in weight lifters. *J Shoulder Elb Surg*. 1998;7(2):151–153. [cited 2021 Jan 20]. Available from: <https://pubmed.ncbi.nlm.nih.gov/9593095/>
- [42] Jones IA, Togashi R, Hatch GFR, Weber AE, Vangsness CT. Anabolic steroids and tendons: A review of their mechanical, structural, and biologic effects. *J Orthop Res*. 2018;36(11):2830–2841.
- [43] Pope HG, Wood RI, Rogol A, Nyberg F, Bowers L, Bhasin S. Adverse health consequences of performance-enhancing drugs: An endocrine society scientific statement. *Endocrine Reviews*. *Endocrine Society*. 2014;35:341–375.
- [44] Ip EJ, Lu DH, Barnett MJ, Tenerowicz MJ, Vo JC, Perry PJ. Psychological and physical impact of anabolic-androgenic steroid dependence. *Pharmacotherapy*. 2012 Oct;32(10):910–919. [cited 2021 Jan 18]. Available from: <https://pubmed.ncbi.nlm.nih.gov/23033230/>

- [45] Molero Y, Gripenberg J, Bakshi AS. Effectiveness and implementation of a community-based prevention programme targeting anabolic androgenic steroid use in gyms: Study protocol of a quasiexperimental control group study. *BMC Sports Sci Med Rehabil.* 2016 Nov 17;8(1).
- [46] Pasquarella C, Pompili M, Valeriani F, Morgado M, Milicia GM, Veronesi L, et al. The prevention of doping and the improper use of drugs and food supplements in sports and physical activities: A survey on the activity of the prevention departments of Italian local health authorities. *Ann di Ig.* 2019;31(6):533–547.
- [47] Heuberger JAAC, Cohen AF. Review of WADA prohibited substances: Limited evidence for performance-enhancing effects. *Sport Med.* 2019;49(4):525–539. Available from: <https://doi.org/10.1007/s40279-018-1014-1>
- [48] Gatterer K, Gumpfenberger M, Overbye M, Streicher B, Schobersberger W, Blank C. An evaluation of prevention initiatives by 53 national anti-doping organizations: Achievements and limitations. *J Sport Heal Sci.* 2020 May 1;9(3):228–239.
- [49] Fallace P, Aiese P, Bianco E, Bolognini I, Costa MP, Esposito R, et al. Peer education strategies for promoting prevention of doping in different populations. *Ann di Ig.* 2019;31(6):556–575.
- [50] Halliburton AE, Fritz MS. Health beliefs as a key determinant of intent to use anabolic-androgenic steroids (AAS) among high-school football players: implications for prevention. *Int J Adolesc Youth.* 2018;23(3):269–280. Available from: <http://doi.org/10.1080/02673843.2017.1344928>