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ORIGINAL RESEARCH

Abnormalities in Blood Parameters in Athletes Taking Anabolic Androgenic Steroidal Agents; an Observational Clinical Study

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Background: Many studies indicate that high and multiple doses of anabolic-androgenic steroids (AAS) for athletic enhancement can result in serious and irreversible adverse effects. A study that includes laboratory blood testing to evaluate the direct effects of AAS agents among users has not been previously undertaken. The purpose of this study was to investigate the adverse effects of the use of AAS by athletes and to determine whether AAS use leads to changes in certain blood parameters.

Methods: This is an observational study consisting of two stages. First, the participants completed an online questionnaire assessing sociodemographic characteristics, and knowledge and attitudes towards AAS. Second, volunteers underwent laboratory blood testing. Analysis was conducted using frequency distributions and percentages of responses across various variables.

Results: Thirty-one individuals completed the online questionnaire, 18 of whom continued to stage 2, where blood samples were taken to trace any changes in blood parameters. All the participants were male, with an age range of 24–45 years. The results showed that 94% of the participants used AAS for nontherapeutic purposes. Most participants reported that they take a combination of AAS (96%), as well as in combination with other supplements (74%). The most used combination was testosterone plus growth hormone (45%), and the most used supplements were liver protectors (84%). Seventy-four percent of the participants reported side effects, and 28% had received a medical diagnosis, such as hypertension, hyperlipidemia or an infertility. High levels of testosterone, prolactin, alanine transaminase (ALT), aspartate transferase (AST) and lipid profile, and low luteinizing hormone (LH) and follicle-stimulating hormone (FSH) were observed.

Conclusion: The unsupervised use of AAS alone or in combination with other hormones and/or supplements may lead to adverse effects. Further studies with larger samples are needed to draw significant conclusions about the safety of using AAS.

Keywords: anabolic steroids, gym, male, abuse, testosterone, side effect

Introduction

Anabolic-androgenic steroids (AAS) are compounds that include testosterone derivatives as well as other derivatives of other androgens such as dihydrotestosterone (DHT). They are synthetically developed and are used to treat some medical conditions, including a number of hormone-related conditions, such as hypogonadism and delayed puberty, as well as some conditions that cause loss of muscle tissue, such as cancer, AIDS and some types of anemia.[1] AAS is safe and effective when used for medical indications and under medical supervision. However, significant adverse effects are associated with the use of AAS, such as hormonal disorder, cardiovascular dysfunction, infertility and mood disorder. Some of these side effects are considered to be minor or short-term effects, while others are considered to be more severe or long-term.[2]

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Owing to their effects on increasing muscle growth and strength, increasing bone thickness, and reducing body fat, AAS have become desirable agents for individuals seeking to improve their physical appearance and athletic performance.[2] According to estimates, the global lifetime prevalence of AAS use was 3.3% with higher rates (18.4%) reported in bodybuilders and powerlifters.[3] In a study conducted in Saudi Arabia, it was found that 22% of male gym attendees used AAS.[4] The main sources of AAS were from the coaches (55.06%), The most common oral AAS forms were oxandrolone, followed by stanozolol, and methandienone. While the most commonly used injectable AAS were metenolone enanthate, followed by Deca-Durabolin Sustanon and esterified testosterone.[4] Interestingly, 56.18% of the users recognized the harmful effects of AAS.[4]

AASs are taken in cycles consisting of 6 to 18 weeks of AAS use followed by four weeks to several months off. This cycle aims to allow the body to recover between cycles.[5] Furthermore, AAS are commonly supplemented with other hormones, referred to in AAS user circles as "steroid-accessory drugs", which may include insulin, growth hormone, or erythropoietin.[6] Additionally, athletes might choose to employ masking agents, such as diuretics, to evade androgen detection or employ what are termed "protective agents", which can include anti-estrogens, liver protectors, kidney protectors and prostate boosters, aimed at mitigating any adverse effects.[7]

In Saudi Arabia, the increasing number of gyms is testament to an escalating craving to achieve an ideal body appearance. This, along with a paucity of available information regarding the use of exogenous AAS and a lack of awareness regarding their side effects make it necessary to conduct studies highlighting the adverse side effects of AAS abuse. A study conducted in 2019 in Jeddah proposed the establishment of a national awareness programme to reduce the abuse of AAS.[8] Interestingly, this study found a strong correlation between the consumption of AAS and the consumption of energy drinks. Most participants were unaware of the side effects associated with AAS. Participants' level of knowledge was not related to the use of AAS, gender, physical exercise or energy drink consumption.[8] A 2020 study conducted in Riyadh found that the lifetime prevalence of AAS use among male gym members was high, particularly among those who are single, employed in the private sector, have a low level of education, have friends who use AAS, were offered AAS and use psychoactive medications. Hence, there is a need for health policy reforms aimed at decreasing the prevalence of AAS among young adults and improving education and awareness of the short- and long-term adverse effects of AAS use among gym attendees.[9] A study conducted in Dammam in 2021 aimed to assess the use of AAS among gym members attending gym fitness facilities in the Eastern Province and to determine whether these drugs could have potentially unfavourable effects. The results indicated that more health education and awareness programmes are needed targeting those who attend gyms, as most of the participants were unaware of the potential adverse effects of AAS use.[10]

Blood parameters in athletes, can be influenced by numerous factors, including intense physical activity which may temporarily alter liver function tests[11,12] and affect thyroid axis function and prolactin levels.[13] However, the direct impact of AAS use on these parameters remains understudied.

A study that includes laboratory blood testing to evaluate the direct effects of AAS agents among users in Saudi Arabia has not been previously undertaken. Therefore, this study aimed to measure the adverse effects of AAS in users by investigating potential changes in their blood parameters and the hormones in their blood after using exogenous AAS. This observational clinical study aimed to investigate the impact of the intake of exogenous AAS by young adults with no medical indication on their health in general and on their blood parameters in particular. To our knowledge, no previous such study has been conducted.

Materials and Methods

Participants and Methods

The study is a cross-sectional observational clinical study with two stages, as follows:

Stage 1 – A questionnaire investigating the occurrence of adverse effects in AAS abusers was designed in Google Forms and was recruited through social media, specifically WhatsApp. The questionnaire link was distributed randomly via various WhatsApp groups and direct messages. These groups included communities of athletes, fitness followers, and bodybuilding forums. This ensured that participants were likely to use or have used AAS. Clear instructions were

provided in the questionnaire to assure participants understood the study's purpose and the value of honesty. To encourage truthful reporting, anonymity was guaranteed. A small group of athletes pilot-tested the questionnaire (n=5), providing feedback on its clarity and relevance. The questionnaire was in Arabic. A condition was given in the questionnaire: an individual is requested to fill out the questionnaire if he is a male athlete who has been using AAS. There are no restrictions on which part of the country the volunteer comes from.

The questionnaire consisted of questions on the (1) sociodemographic characteristics of the participants; (2) overall knowledge, practices and patterns of AAS use (3) prevalence of side effects experienced by users (Appendix-Supplementary Figure 1).

Once the questionnaire was submitted, an announcement about participating in further laboratory tests was issued. Individuals who were willing to participate, had to contact the primary investigator via Email or phone call for further inquiries.

Definition of Adverse Effects:

In this study, adverse effects were broadly defined to include:

- Symptoms: Any abnormal physical or psychological experiences reported by the participants (eg, acne, mood changes).
- Diagnoses: Any new medical conditions diagnosed by healthcare professionals that participants reported after using AAS (eg, hypertension, infertility).
- Changes in Laboratory Parameters: Any abnormal values observed in laboratory tests conducted during the study (eg, altered hormone levels, elevated liver enzymes).

Stage 2 - Participants who met the inclusion criteria, namely healthy men with no pre-existing conditions, over the age of 18 who used AAS within the past six months, were invited to provide blood samples. Those who had used AAS for medical reasons, or who had ceased using AAS for more than six months, were excluded from the study. Once verbal consent and agreement had been obtained, participants were directed to the laboratory for blood sampling.

In order to minimize methodological or interlaboratory variability, these investigations were conducted in one standardized and validated laboratory in Makkah to ensure consistency of protocols and procedures (Appendix-Supplementary Information1). Blood samples were collected within three weeks of participants agreeing to participate in stage two of the study.

Each participant was assigned an identifiable code to maintain confidentiality, therefore avoiding the necessity of providing personal identification information to the laboratory. These investigations were conducted at no cost to the participants. As soon as the results were available, they were sent to the participants, who were given the option to review and decide whether or not to disclose their results.

Laboratory investigations included tests for testosterone, prostatic antigen, LH, FSH, prolactin, thyroid function, liver function, and complete blood count (CBC). Results of laboratory investigations were collected along with the reference standardized range for each parameter. Al Data are then transferred to an Excel document, where they were sorted, stored, analyzed, and secured.

Study Sample Size

Given the illicit nature of AASs usage and the inclination of users to conceal their usage, the study faced considerable challenges in collecting a large sample size. As a result, it was imperative to adopt a pragmatic approach and proceed with the sample size available. As part of the recruitment efforts, a multifaceted approach was implemented, taking advantage of online platforms such as social media channels as well as personal outreach to gym trainers and coaches within the community. Announcements and questionnaires were circulated persistently over a duration of three months, aiming to maximize respondent and participant involvement.

Statistical Analysis

The analysis primarily focused on frequency distributions and percentages of responses across various demographics, behaviour and outcome variables.

Ethics and Consent

Declarations

Online Consent (First Stages)

Participants in the first stage of the study provided informed consent electronically. A consent form was included at the beginning of the online questionnaire, which outlined the purpose of the study, assured confidentiality and explained the voluntary nature of precipitations (Appendix- Supplementary Information 2).

Verbal and Written Consent (Second Stage)

In the subsequent stage, participation was voluntary and required active engagement. Individuals interested in undergoing blood investigations provided verbal and written consent by directly contacting primary investigator. In this interaction, participants were informed of the study objectives, assured of data confidentiality, and assured that they can access their data or withdraw participation at any time.

Ethics Committee Approval

The Ethics Committee of Umm Al-Qura University approved the research (IRB-HAPO-02-K-012) under the Declaration of Helsinki.

Results

The online questionnaire was completed by 31 individuals, 18 of whom continued to stage 2 and were willing to provide a blood sample to measure changes in their blood parameters. All participants were males, aged 24–45 years. In terms of location of residence, 84% were resident in the Western region, while only 3% were resident in the Eastern region (Table 1).

Table 1 Sociodemographic Characteristics of the Participants

Total	**31**
The Characteristics	**Number (%)**
Age	
20s	10 (32%)
30s	13 (42%)
40s and older	8 (26%)
Gender	
Male	31 (100%)
Female	0%
Region	
Western region	26 (84%)
Central region	4 (13%)
Eastern region	1 (3%)`
The purpose of using anabolic hormones	
Therapeutic purposes	(2) 6%
Non-therapeutic purposes	(29) 94%
The hormones which were taken	
Testosterone	28 (90%)
Growth Hormone (GH)	25 (81%)
Insulin	7 (20%)
Erythropoietin	7 (20%)
Dexamethasone	1(3%)

(*Continued*)

Table 1 (Continued).

Total	**31**
The Characteristics	**Number (%)**
Use anabolic steroids in combination with other supplements	
Yes	30(96%)
No	1(3%)
Duration of taking aas	
Less than 1 month	1(3%)
1 to 3 months	20 (64%)
More than 3 months	10 (30%)

Participants' Use of AAS

The questionnaire included a question about the participants' purpose in using anabolic hormones. Approximately 94% reported that they were using AASs for nontherapeutic purposes, while only 6% were using AAS for therapeutic purposes. Therapeutic AAS use is medically prescribed and supervised to treat specific medical conditions like delayed puberty, certain types of anemia, while non-therapeutic use is the use of AAS without a valid medical prescription or legitimate medical indication, typically to enhance athletic performance, improve physical appearance (bodybuilding), or for other reasons not medically justified.

Based on our analysis, testosterone accounted for 90% of the ASS used, GHs for 81%, insulin for 20%, and erythropoietin for 20%. There are only 7 (23%) participants who took single AASs, otherwise, most of the participants (96%) took more than one type of ASSs (Table 2).

In addition, most of the participants (96%) used AAS in combination with various supplements; only one participant did not consume any supplements (see Figure 1).

Knowledge and Attitudes

The questionnaire addressed the knowledge and attitudes of the participants towards AAS by asking about their source of information, source of purchase, and whether they consulted a physician before taking AAS or when an adverse effect occurred (Figure 2).

Health Conditions and Side Effects

A majority of the participants (74%) reported some side effects, ranging from acne to changes in mood and aggressive behaviour (see Table 3), whereas only 26% denied experiencing any adverse effects.

After using AAS, seven out of 31 (28%) participants sought and received a medical diagnosis. Three were diagnosed with hypertension, three were diagnosed with hyperlipidemia, and one was diagnosed with an infertility.

Table 2 Pattern of AASs Use Among Participants

Single	**Number (%)**
Testosterone	4 (13%)
Growth Hormone	2 (6%)
Erythropoietin	1 (3%)
Combination	
Testosterone + Growth Hormone	14 (45%)
Testosterone + Growth Hormone + Insulin + Erythropoietin	3 (7%)
Testosterone + Growth Hormone + Insulin	3 (7%)
Testosterone + Growth Hormone + Erythropoietin	2 (6%)

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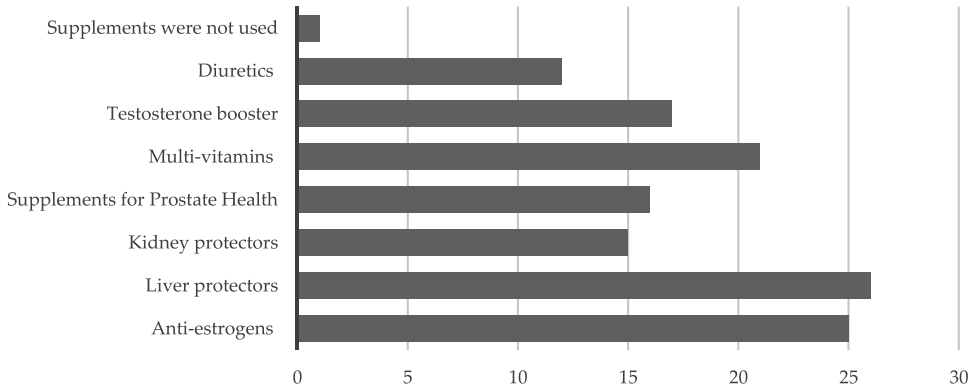

Figure 1 Supplements commonly used with AAS.

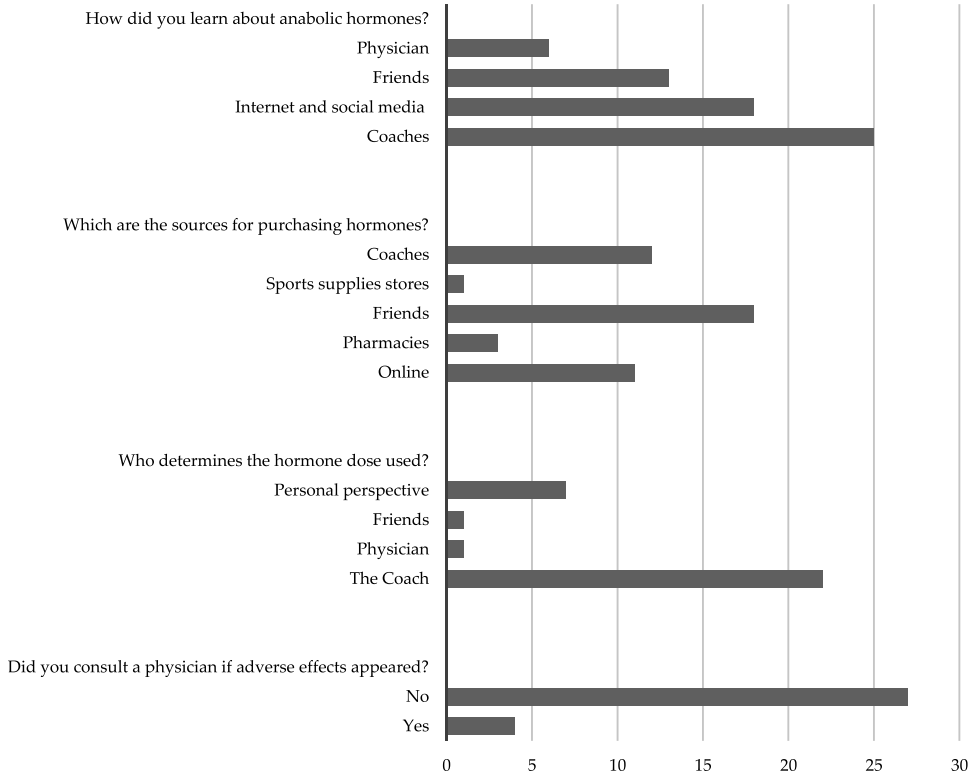

Figure 2 Knowledge and attitude of responders towards AAS use.

Changes in Blood Parameters

Blood Chemistry

Eighteen participants agreed to participate in blood laboratory testing, including hormonal, chemistry and lipid profiles. A summary of the results is provided in Table 4.

Hormonal Profiles

Testosterone levels were significantly above the normal reference range in one participant who took testosterone in combination with GH for three months. Specifically, the serum testosterone level was 15.210 ng/mL (normal reference range: 2.200–10.500 ng/mL). The same participant showed a significant high level of estradiol to 81.9 pmol/L (normal reference range: 18.4–73.4 pmol/L). In addition, estradiol levels in two participants who had been receiving testosterone with GH for four and six months were significantly high, at 471.2 pmol/L and 109.2 pmol/L, respectively.

Table 3 Adverse Effects and Medical Conditions Which Appear During or After the Use of AASs Among Participants

Symptoms	Number (%)
Acne	9 (29%)
Increased hair on the face or body	7 (23%)
Baldness or hair loss	7 (23%)
Gynecomastia	4 (13%)
Impotence	5 (16%)
Increase in sexual desire	16 (52%)
Reduction in the size of the testicles	6 (19%)
Incontinence	1 (3%)
Aggressive behaviours	11 (36%)
Depression	5 (16%)
Diagnosis	
Hypertension	2 (6%)
Hyperlipidemia	3 (10%)
Infertility (or low sperm production)	1 (3%)
None	26 (84%)

Low levels of LH and FSH were found in three participants who took testosterone in combination with GH for three months, four months, and six months. The serum level of LH was determined to be 0.22 mIU/mL, 0.74 mIU/mL and 0.40 mIU/mL, respectively (normal reference range: 1.10–25.00 mIU/mL). Furthermore, the plasma levels of FSH were 0.16 mIU/mL, 1.10 mIU/mL and 0.21 mIU/mL (reference range: 1.50–11.80 mIU/mL).

A participant who took undetermined doses of testosterone, GH, insulin and erythropoietin for six months showed a significantly high level of serum prolactin at 734.40 uIU/mL (normal reference range 54.00–340.00 uIU/mL). No significant changes were found in the prostate-specific antigen (PSA) or thyroid functions, either in TSH or T4.

Chemistry Profiles

High levels of ALT and AST were found in two participants: one participant used an unknown dose of GH for two months and showed a level of ALT of about 68 U/L (reference range: up to 42 U/L), while another participant who used testosterone in combination with GH for six months showed high levels of ALT at 87 U/L and an AST level of 58 U/L (reference range: up to 37 U/L). However, among all the participants, there were no significant changes in ALP and albumin levels.

In addition, we found that the creatinine levels of one participant (1.3 mg/dL) who had been using testosterone, GH, insulin and erythropoietin for six months were at the upper limit of the normal range (reference range: 0.6–1.2 mg/dL). However, this participant showed no significant changes in the levels of blood urine nitrogen (BUN) (Table 4).

Lipid Profiles

The lipid profile analysis showed that four participants exhibited significant elevations in their lipid profile levels. High serum cholesterol levels were reported in two participants who had used testosterone combined with GH for three months. The cholesterol level for one of the individuals was 224 mg/dL and for the other was 252 mg/dL (reference range: 140–220 mg/dL). Furthermore, one participant who took testosterone alone for three months had an elevated cholesterol level of about 286 mg/dL, a triglycerides level of 453 mg/dL (reference range: 10–190 mg/dL) and a very-low -density lipoprotein (VLDL) level of 90.6 mg/dL (reference range: 2.0–38 mg/dL). Additionally, one participant who took GH alone for two months showed a high level of serum cholesterol of about 256 mg/d. Contrary to these results, no significant changes were observed in the participants' high-density lipoprotein (HDL) or low-density lipoprotein (LDL).

No significant changes in the participants' levels of electrolytes, including sodium, potassium and calcium, were found. In addition, the participants showed no changes in fasting blood sugar neither complete blood count (CBC).

Table 4 Summary of Certain Characteristic and Blood Profile Results for the Participants

Participant	Hormone	Duration in Months	Side Effects	Changes in Blood Profiles
1	GH	2	–	↑ ALT ↑ Cholesterol
2	Testosterone+ GH	3	Hypertension ↑ sexual desire ↓Testis size Aggressive behaviour	N/A
3	Testosterone+ GH	3	Hypertension Gynecomastia ↑ sexual desire	N/A
4	Testosterone+ GH	3	Acne. Hair growth. Aggressive behaviour. ↑ sexual desire	↑ Testosterone ↑ Estradiol ↓ LH ↓ FSH
5	Testosterone+ GH+ insulin	3	Hair loss Impotence. ↑ sexual desire Aggressive behaviour	N/A
6	Testosterone+ GH	4	Acne Alopecia ↑ sexual desire ↓Testis size Aggressive behaviour	↓ LH ↓ FSH ↑ Estradiol
7	Testosterone+ GH	1	Hair growth. Acne Impotence ↑ sexual desire ↓Testis size Aggressive behaviour Depression	N/A
8	Testosterone+ GH	6	↑ Sexual desire Aggressive behaviour Depression	PT Hemoglobin Hematocrit ↑ Estradiol Platelet ↓LH ↓FSH
9	Testosterone+ GH+ insulin	8	Acne Hair loss	N/A
10	Testosterone+ insulin	3	Acne	N/A
11	Testosterone+ GH+ insulin+ Erythropoietin	6	Hair growth Hair loss	Creatinine ↑ Prolactin Lymphocyte Prolactin
12	Testosterone+ GH	6	Acne Impotence	N/A
13	Testosterone+ Erythropoietin	2		N/A

(*Continued*)

Table 4 (Continued).

Participant	Hormone	Duration in Months	Side Effects	Changes in Blood Profiles
14	Testosterone	3	Acne Hair loss Depression Impotence	RBC HG Hematocrit FBS Cholesterol Triglycerides
15	Testosterone+ GH	3	↑ Sexual desire	N/A
16	Testosterone+ GH+ insulin	3	↑ Sexual desire	N/A
17	Testosterone+ GH	3	–	N/A
18	Testosterone+ GH	6	↑ Sexual desire ↓Testis size Aggressive behaviour. Acne. Gynecomastia Hair growth Impotence	N/A

Abbreviations: GH, growth hormone; ALT, alanine aminotransferase; LH, luteinizing hormone; FSH, follicle-stimulating hormone; PT, prothrombin time; RBC, red blood cells; HG, hemoglobin; FBS, fasting blood sugar.

Discussion

The main aim of this study, in addition to investigating the adverse effects of AAS in users, was to trace any potential changes in biological parameters and hormones in the blood after the use of exogenous AAS. This study found that 74% of the participants reported some sort of side effect, ranging from acne to infertility, and 33% showed a number of changes in their blood parameters after taking AAS with and without other supplements, including higher levels of testosterone, estradiol and prolactin and decreased levels of LH and FSH.

Following the administration of AAS, there is negative feedback from the hypothalamic–pituitary axis, which is reflected in decreased levels of LH and FSH, resulting in decreased endogenous testosterone production; in turn, spermatogenesis is reduced, and atrophy of the testicles occurs.[14] Gynecomastia and breast tenderness are associated with AAS abuse due to the disturbance of the androgen–estrogen balance. Affected individuals usually take anti-estrogens, such as clomiphene, to prevent gynecomastia or to mask unwanted side effects.[15] However, we found no previous studies that evaluated the protective measures provided by these regimens. In our study, four participants reported gynecomastia as a consequence of taking AAS, with three of them taking anti-estrogens.

Athletes who use AAS tend to show increased plasma levels of liver enzymes. Brazilian researchers studied 95 bodybuilders who used AAS and found that 12.6% of them developed toxicant-related fatty liver disease.[16] Another study conducted in 2016 involving 182 bodybuilders who used AAS found that they had been affected by liver-related side effects, including hepatotoxicity.[17] In our study, above-normal ALT and AST levels were found in two participants. However, it is difficult to determine if these above-normal levels were the result of AAS consumption, whether other factors may have contributed or even whether these changes were new or not, since our study did not measure pre-AAS-consumption parameters. Indeed, heavy athletes, such as weightlifters, may experience elevated levels of these enzymes, even without taking steroids.[18] As oxidative stress is one hypothesis that explains the mechanism behind AAS-induced hepatotoxicity, most athletes who use AAS concomitantly take agents that they refer to as "liver protectors".[16,19] The milk thistle extract silymarin, has been claimed to provide several benefits, including supporting liver cell regeneration, protecting liver cells from toxins and improving the liver's detoxification capacity.[20,21] However, one participant in our study had an elevated ALT level despite taking a liver-protective drug. In light of the limited data, further investigation is needed to clarify the function of "liver protectors" and their mechanism as antioxidants capable of reducing AAS-induced liver toxicity.

The other vital organ suggested to be affected by prolonged exposure to AAS is the kidney. Prolonged use of AAS has been reported to cause the kidney to develop side effects, including kidney fibrosis and renal hypertrophy.[22] A reversible increase in serum creatinine, BUN, and uric acid may also result from AAS use.[23] In our study, it was observed that one participant had an elevated level of creatinine, although it is difficult to determine whether this was AAS-induced or not. Serum creatinine levels are influenced by factors such as age, gender, ethnicity, diet and muscle mass. In people with greater muscle mass and normal kidney function, serum creatinine levels might appear to be elevated. Hence, most studies recommend other methods rather than serum creatinine to assess renal function in healthy individuals with higher muscle mass.[24,25] Nevertheless, serious cases of acute renal failure and rhabdomyolysis have been reported after taking AAS.[26,27] One case study reports a 39-year-old athlete who presented with massive localized rhabdomyolysis of the deltoid muscle at the site of AAS injection and who showed a high level (18, 200 U/L) of serum creatinine (normal = 195 U/L).[27] As well as taking "liver protectors", athletes are known to take "kidney protectors". Astrag-Flow Kidney is a supplement containing a mix of herbal ingredients, mainly Astragalus root, which is one of the most widely used herbs in traditional Chinese medicine for treating kidney diseases.[28,29] A review that evaluated the benefits and potential harms of Astragalus for the treatment of people with CKD suggested that Astragalus may have some positive effects, such as reducing proteinuria and increasing levels of haemoglobin. However, drawing definitive conclusions about the effectiveness of Astragalus is limited by the shortcomings of the research methodologies and reporting standards.[29] In our study, one participant showed a high level of creatinine despite the use of Astrag-Flow Kidney.

In addition to taking Astragalus root as a kidney protector, surprisingly, athletes also take diuretics, mainly to mask the indications of their AAS use, both before and after competitions. Diuretics have also been used in sports where weight categories are involved and by athletes who want to maintain a low body weight, even though no evidence supports the effectiveness of diuretics in helping people lose weight quickly. Clinically, diuretics are commonly prescribed to treat hypertension and other cardiovascular disorders. Despite their clinical utility, diuretics are prohibited across all sports, although their illicit use is often detected when athletes involved in athletic competitions are tested.[30] Among our participants, 38.7% used diuretics alongside AAS.

Besides tracing potential changes in biological parameters and hormones in the blood after using exogenous AAS, our study also documented other well-known adverse effects associated with AAS use. The study found that 29% of participants reported acne, which is in line with previous studies showing that anabolic steroids can aggravate acne by increasing sebum production. This increase in sebum can be attributed to AAS' androgenic activity, which stimulates the sebaceous glands.[31] The findings of our study are consistent with findings in the broader literature, where acne is a common dermatological side effect of AAS use. Moreover, diuretics complicate the picture. While diuretics are commonly used to mask AAS use or to lose weight quickly, they can also cause skin problems. Dehydration caused by diuretics can trigger compensatory sebum production, potentially aggravating acne. Interestingly, some diuretics, such as spironolactone, exhibit anti-androgenic properties that may reduce the severity of acne symptoms.[32] In our study, three out of twelve diuretics users developed acne. However, it was not determined which type of diuretic had been used.

Depression and other mood disorders are also well-documented adverse effects of AAS. The literature confirms the prevalence of mood disorders among AAS users. For instance, a study highlighted the association between long-term AAS use and an increased risk of acute psychosis.[33] The mechanisms underlying these psychiatric effects are complex, involving alterations in neurotransmitter systems and hormonal imbalances induced by exogenous testosterone. In this study, 11 (36%) participants reported aggressive behaviour after using AAS, and 5 (16%) reported depression after using AAS.

This is the first study conducted on gym members in the Makkah region regarding AAS consumption, and it contributes to the growing body of knowledge on the adverse effects experienced by AAS users. Since our study did not use a randomized sampling method or a large-scale survey approach, it cannot provide an accurate estimate of the prevalence of any side effects or even the prevalence of AAS use in the broader athlete population. The use of WhatsApp groups for participant recruitment may have introduced selection bias, potentially overrepresenting certain demographic groups (eg, those with greater access to social media, possibly including those with lower levels of education) and limiting the generalizability of our findings to the broader population of athletes in the Makkah region. However, as AAS use is often concealed, we prioritized reaching users where they are—in online communities. Additionally, it is crucial to

interpret the findings of alternations in blood parameters in the context of other factors that may influence blood parameters. The study design did not account for variables such as the intensity and type of physical training, diet, or other health conditions, which are known to influence liver function, thyroid hormones, and lipid profiles. Future research should incorporate these factors and employ more robust methodologies, such as a controlled trial with a larger and more representative sample, to clarify the specific effects of AAS use on blood parameters in a diverse Saudi Arabian population.

Conclusions

The use of anabolic androgenic steroids(AAS) without supervision, especially when combined with other hormones and supplements, poses significant risks of adverse effects and alternation in various blood parameters. Our findings highlight the concerning lack of medical guidance for participants who chose to use AAS and subsequently experienced side effects. This underscores the critical need for healthcare professional involvement when considering AAS use. To derive significant conclusions about the safety of the use of AAS alone and in combination with other agents and supplements, future research studies with larger participant cohorts need to be conducted.

Institutional Review Board Statement

The Ethics Committee of Umm Al-Qura University approved the research (IRB-HAPO-02-K-012; approval date: September 7, 2021).

Data Sharing Statement

Data available upon request from the corresponding author.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors declare no conflicts of interest in this work.

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