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The Influence of Doping on the Skin: Dermatological Manifestations of Anabolic-Androgenic Steroid Use in Sport - A Narrative Review

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Abstract

Background: Anabolic-androgenic steroids (AAS) are used by competitive and recreational athletes. The latter are not subject to anti-doping testing. Cutaneous manifestations are common, may appear early and can be overlooked.

Aim: To synthesise evidence on dermatological manifestations of AAS use in sport and their implications for early recognition.

Material and methods: The narrative review included 28 publications from 2000-2026 identified through PubMed, ScienceDirect, SpringerLink, Quality in Sport archive and reference lists. Searches were restricted to full texts in English or Polish language and human subjects. Evidence was synthesised thematically.

Results: Supraphysiological AAS exposure may promote sebaceous gland hypertrophy and sebum secretion via the androgen receptor. Acne is the most commonly reported visible adverse effect, ranging from exacerbation of lesions to acne fulminans. Other effects include androgenetic alopecia in men, hirsutism as part of virilisation in women, striae and keloids. Injections may cause abscesses, granulomas, pyomyositis and non-tuberculous mycobacterial infections.

Conclusions: These manifestations may suggest AAS use but are not diagnostic. They should prompt enquiry, particularly in individuals who train intensively, covering supplements and injections. Some may persist after cessation, highlighting the importance of early detection, counselling and education. Risk information alone may not discourage use.

Key words: Anabolic Androgenic Steroids; Doping in Sports; Skin Diseases; Drug-Related Side Effects and Adverse Reactions; Acne Vulgaris; Alopecia; Injections.

1. Introduction

Anabolic-androgenic steroids (AAS) are synthetic derivatives of testosterone [1,2]. Although testosterone is used therapeutically, including for testosterone replacement therapy in male hypogonadism, non-medical AAS use involves doses substantially exceeding therapeutic levels to promote muscle growth and increase strength [3]. The use of AAS for doping is prohibited by anti-doping organisations, including the World Anti-Doping Agency (WADA) [4].

As reported by Bond et al., global estimates of lifetime AAS use are 3.3% overall, with 6.4% among males and 1.6% among females [3]. Athletes engaged in bodybuilding, fitness and strength sports use AAS to increase muscle mass and improve their physique [4]. Exposure to idealised physiques promoted in social media has been associated with body dissatisfaction and AAS use [1]. As most AAS users are recreational athletes [5], not subject to anti-doping testing, clinical encounters may be particularly important for identifying exposure to AAS and addressing its health outcomes. Furthermore, some adverse effects may escape users' awareness and can be detected only through medical examination [2].

The health complications of AAS use extend across multiple organ systems. Cardiovascular, hepatic and endocrine disturbances, including hypertension, dyslipidaemia, hepatotoxicity and gynaecomastia, occur alongside dermatological adverse effects [3]. Complications have been reported not only during AAS use, but also after withdrawal [2]. Among the dermatological manifestations, acne has been reported in approximately 50% of AAS users and clinically may indicate exposure [6]. Nevertheless, the dermatological adverse effects encompassing acne, alopecia, striae, hirsutism and injection-site furuncles are often overlooked [1].

Cutaneous manifestations may develop early during AAS exposure, making dermatologists well placed to recognise potential AAS misuse [7]. Severe presentations, particularly acne fulminans, may leave permanent scars and be accompanied by anxiety and depression [1]. These potential consequences underscore the clinical relevance of recognising exposure promptly. Case reports reviewed by Hartgens and Kuipers suggest that some athletes accept the risk of serious health consequences and are not deterred from AAS use by their adverse effects [2],

which makes the role of the physician as an educator particularly important. Dermatological assessment may provide an opportunity to discuss AAS use, address dependence and support efforts to improve patient outcomes [1].

This narrative review aims to synthesise evidence on the dermatological manifestations of AAS use in competitive and recreational sport, their underlying mechanisms and complications related to the route of administration, with particular emphasis on early recognition and the roles of dermatologists.

2. Research materials and methods

2.1 Review design

This narrative review examined dermatological manifestations of non-medical AAS use in competitive and recreational sport. The aim was to synthesise available data concerning underlying mechanisms, clinical manifestations, and cutaneous complications related to the route of administration, rather than to comprehensively identify all relevant publications.

2.2 Evidence identification

A literature search was performed through databases: PubMed, ScienceDirect, SpringerLink, and the Quality in Sport archive search in October 2026. Search query included “anabolic steroids”, “performance-enhancing drugs”, “image and performance enhancing drugs”, “dermatolog*”, “skin”, “cutaneous”, “acne”, “alopecia”, “striae”, “hirsutism”, “injection site”, and “abscess” combined using Boolean operators and adapted to each platform. The main search scope included publications from 2000-2026. Searches were restricted to English or Polish language and human subjects. No animal studies were included. Only articles with full text available were considered. After automatic deduplication, 58 records were identified from the electronic databases. Authors’ manual screening narrowed the sources to 27.

Additional literature sources were obtained by reviewing references of obtained articles. Reference lists of selected publications were screened between 3 and 4 October 2026 to identify additional relevant sources (n=1).

2.3 Study selection

Eligible publications comprised cohort studies, reviews, surveys, case reports and case series regarding non-medical AAS use and manifestations affecting the skin or its appendages, including injection-related complications. Publications were excluded if they were irrelevant to the scope. Other appearance-enhancing substances were excluded.

2.4 Evidence synthesis

Titles and abstracts were screened before full-text assessment. References were managed using Zotero and an extraction sheet was created to collect data regarding included papers. Search tasks were distributed among the authors, and inclusion decisions were made jointly. All cited sources were read by the authors, and findings obtained through secondary sources were identified as such. Evidence was synthesised thematically, proceeding from mechanisms to direct androgen-related manifestations, indirect effects, complications related to the route of

administration and clinical implications. Neither a meta-analysis nor a formal quality appraisal was performed owing to the heterogeneity of the included studies. As this study is a narrative review, the selection of literature was intentional and selection bias cannot be ruled out.

3. Research results

3.1 Mechanisms

AAS are synthetic compounds derived from testosterone. Their administration may lead to supraphysiological androgen concentrations in the body [1]. The mechanism of action of individual derivatives depends on their chemical structure, which influences their affinity for the androgen receptor as well as their interactions with steroid-metabolising enzymes and transport proteins, including sex hormone-binding globulin (SHBG) [6].

Unliganded androgen receptors reside in the cytoplasm of target cells. They are activated by free testosterone or 5α-dihydrotestosterone (DHT), which is generated from testosterone via the enzyme 5α-reductase. Receptor activation induces the release of associated heat shock proteins: HSP90, HSP70 and HSP40. The receptor subsequently translocates to the nucleus, where dimerisation occurs. The activated receptor then regulates target gene transcription through androgen response elements (AREs) [5].

Androgen receptors are found in sebocytes and follicular keratinocytes [6]. Androgens play a vital role in sebum production [3]. Studies cited by Bond et al. reported that testosterone administration increased sebum production in both adult women and men [3]. AAS directly increase sebum synthesis by binding to androgen receptors in sebocytes, and indirectly by inducing a nuclear receptor belonging to the peroxisome proliferator-activated receptors (PPAR) family. PPARs participate in sebocyte development, proliferation and differentiation and induce lipogenesis [6]. AAS use is associated with sebaceous gland hypertrophy and increased sebum secretion [6]. As reported by Melnik et al., the analysis of sebaceous glands in athletes receiving AAS during a four-week training period demonstrated an 89.2% increase in gland size. A significant rise in the number of sebocytes was also observed in both differentiating and undifferentiated cell populations [6]. In a separate study cited by Melnik et al., a significant increase in the sebum secretion rate was observed during 12 weeks of strength training combined with AAS administration [6]. Sebaceous gland changes were also accompanied by an increase in skin surface lipids and higher proportions of cholesterol and free fatty acids within their composition [7].

Increased sebum production, together with abnormal follicular keratinisation, is thought to contribute to comedone formation [7]. Furthermore, elevated sebum production also fosters an environment conducive to the proliferation of Cutibacterium acnes [1]. The aforementioned enhanced androgen activity, increased sebum production and bacterial expansion are associated with a risk of developing acne [1,6]. Beyond acne-related effects, AAS use is associated with androgenetic alopecia [7]. AAS also contribute to striae development by stimulating protein synthesis in skeletal muscle cells causing accelerated muscle hypertrophy that exceeds the capacity of the overlying skin to expand [7].

3.2 Acne

Acne is among the most commonly reported adverse effects of AAS use [3]. As reported by Melnik et al., estimates suggest that it affects approximately 50% of users, and it has been ranked as the most common clinically visible adverse effect [6]. Acne vulgaris may develop following either oral or intramuscular administration [7].

The HAARLEM study illustrates how estimates vary according to the method of assessment [8]. The prevalence of self-reported acne increased from 10% at the start of an AAS cycle to 52% at its end, whereas examination by a physician showed an increase from 13% to 29% [8]. These figures describe the proportion of participants with acne rather than changes in lesion severity. The discrepancy also highlights the limitations of relying on self-reported outcomes [3]. In the cohort study by Heerfordt et al., 23% of AAS users were prescribed at least one dermatological medication, compared with 14% of controls [9]. These percentages concern dermatological medication overall, although AAS users also received more topical and systemic acne treatments [9]. Separately, in the Danish cohort study by Horwitz et al., 27.3% of AAS users had filled at least one prescription for acne treatment [10].

The clinical presentation ranges from increased seborrhoea and exacerbation of pre-existing acne to acne conglobata and acne fulminans [6,11]. Severe forms may occur even in athletes with no previous history of acne [7,11]. The characteristic distribution of AAS-associated "bodybuilding acne" includes the face, shoulders, chest and back [7].

Onset as early as three weeks after starting AAS has been documented in an individual case study cited by Walker and Adams. In that bodybuilder, acne vulgaris progressed to acne fulminans during a further three months of continued AAS use [7]. This case illustrates possible progression with continued exposure rather than an established timeline. AAS-associated lesions do not always respond to routine acne treatment and may persist even for months after cessation. Even when active lesions resolve following withdrawal and treatment, scarring may remain [7].

Acne fulminans is rare and considered the most severe form of acne [1]. Its development has been linked to a proposed immune response to Cutibacterium acnes, which may become more intense as the bacterial population increases, connecting this presentation with the mechanisms outlined earlier [7]. Clinical features may include painful, haemorrhagic lesions and tender ulcerative nodules affecting the face, chest, shoulders and back. Fever, fatigue, lymphadenopathy and musculoskeletal pain may accompany the skin lesions, together with leukocytosis and an elevated erythrocyte sedimentation rate [1]. In sports where physical appearance is central, severe acne and permanent scarring may carry a particular psychological burden, including low self-esteem, anxiety and depression [1].

Bond et al. note that treatments commonly used in clinical practice, including benzoyl peroxide and topical retinoids, are less frequently used by AAS users. They suggest that some users may favour isotretinoin as an effective oral agent that is readily available on the black market, although only a small proportion of AAS users report taking it [3]. Isotretinoin carries potential dermatological, ophthalmological and psychiatric adverse effects and is a potent teratogen [3]. A case report by Voelcker et al. described marked worsening of AAS-associated acne during isotretinoin treatment, with an acne fulminans-like presentation but no systemic symptoms [11]. This individual observation does not establish the frequency or causation of such exacerbations. These concerns underline the importance of medical supervision, while appropriate acne treatment may help prevent permanent

scarring [3]. Recognition of “bodybuilding acne” may therefore provide an opportunity to enquire early about AAS misuse and discuss its wider health effects [1,6].

3.3 Hair

The hair follicle is an androgen-responsive structure, with testosterone and DHT acting through the androgen receptor signalling pathway outlined earlier. Androgenetic alopecia has been described in both male and female athletes using AAS [7].

In the HAARLEM study, the proportion of male participants reporting alopecia increased from 2% at baseline to 12% in the last week of the AAS cycle [8]. However, the absence of an objective assessment prevents a distinction between a true increase in alopecia and an increase in perceived hair loss. Concurrent use of other drugs, including thyroid hormones with the potential to promote hair loss, further complicates attribution to AAS [3].

In women, hair changes form part of a broader pattern of virilisation. Hirsutism and androgenetic alopecia may accompany voice deepening and clitoral enlargement [3]. Historical reports from the systematic doping programme in the German Democratic Republic between 1965 and 1989 illustrate these effects in female athletes exposed to high doses of AAS. Hirsutism was among the adverse effects that led some athletes to discontinue AAS and withdraw from certain events [12].

Under a therapeutic regimen of 150 mg testosterone enanthate every four weeks, mild hirsutism occurred in approximately one in five women, as reported by Bond et al. The same review, drawing on studies of testosterone treatment in postmenopausal women, describes an onset after approximately four to six months. These observations cannot be directly extrapolated to doping: higher doses may produce an earlier onset and increase the likelihood of hirsutism [3].

The therapeutic data summarised by Bond et al., and subsequently cited by Dutka et al., describe resolution of mild hirsutism after treatment cessation; they do not represent independent confirmations of reversibility [3,5]. Walker and Adams, however, state that alopecia and hirsutism may persist after AAS withdrawal [7]. Evidence of resolution under therapeutic exposure does not establish reversibility under doping conditions, while the general statement about persistence does not establish its frequency or duration. This uncertainty has implications for counselling, as considered further in the Discussion.

3.4 Striae and other cutaneous manifestations

Increased muscle mass is one of the intended effects of AAS use, but the resulting tissue growth may be accompanied by striae distensae, linear marks of cutaneous stretch atrophy. These changes have been described in areas of pronounced muscle hypertrophy, including the neck, chest, shoulders and upper arms [7]. Dutka et al. relate the greater muscular response in the arms, neck and chest to a higher number of androgen receptors in these regions [5]. Striae arise from the mismatch between muscle growth and expansion of the overlying skin [7]. A secondary effect of AAS on collagen, with reduced skin elasticity, has been proposed as an additional mechanism

[13]. Withdrawal does not necessarily reverse these changes: muscle size returns towards normal after AAS cessation, whereas the striae remain [7].

Alterations in collagen metabolism, proposed as a contributing factor in striae formation, have also been implicated in keloid formation. The review by Walker and Adams describes extensive linear keloids in bodybuilders and a hockey player using oral and intramuscular AAS, none of whom reported a previous history of keloids. Existing lesions persisted after withdrawal, although no new lesions developed. The same review cites a study suggesting that supraphysiological AAS doses increase type I collagen synthesis and reduce its degradation. This offers a possible explanation for the reported keloids, without establishing their mechanism or frequency among AAS users [7].

Beyond acne, stimulation of sebaceous glands by AAS has been linked to seborrhoeic dermatitis, rosacea, epidermoid cysts, and oily skin and hair. Sebaceous gland overactivity has also been proposed to contribute to secondary infections, including furunculosis and folliculitis. These are discussed here as possible consequences of sebaceous gland activity, distinct from the injection-site lesions addressed in the following section. A further source cited in the same review suggests an increased prevalence of pityriasis versicolor in athletes using AAS, with increased sebum production providing conditions favourable to the growth of Malassezia furfur [7]. These associations should be interpreted cautiously, as the cited material does not establish their frequency or confirm that AAS are an independent cause.

Most of the evidence summarised in this section, including the account of striae, comes from the 2009 review by Walker and Adams, which draws on earlier reports and proposed mechanisms rather than providing prospective estimates of incidence or risk. The persistence of striae and keloids after AAS withdrawal has implications for patient counselling, considered further in the Discussion. The following section examines complications related to AAS injection.

3.5 Complications after injections

Alongside their direct cutaneous effects, AAS use may be accompanied by complications related to non-sterile injection practices [7]. AAS were the most commonly injected image- and performance-enhancing drugs (IPEDs) in the study by Van de Ven et al., with use reported by 83% of participants [14]. In a survey of 366 male IPED injectors, 6.8% reported ever having an abscess, sore or open wound at an injection site, while 42% reported ever experiencing redness, tenderness and swelling [15]. These symptoms were self-reported and do not necessarily indicate infection [15]. Registry-based evidence provides a broader perspective: in the Danish cohort studied by Heerfordt et al., 2.7% of AAS users had a recorded diagnosis of one or more skin conditions during follow-up, compared with 0.8% of controls. The excess was mainly attributable to hospital-diagnosed skin infections [9]. This estimate concerns skin conditions overall, however, and does not establish whether the infections were related to injections.

Local complications include injection-site furuncles, bacterial abscesses and sterile abscesses [1,7]. Repeated injections into the same site may also cause inflammation and oil-induced granuloma formation [7]. Deeper

infection was documented in a series of five bodybuilders with pyomyositis, whose local signs included erythema, warmth and fluctuance, potentially resembling a superficial abscess. Cultures yielded Staphylococcus aureus in four patients and viridans group streptococci in one. Where the interval was reported, patients presented three to sixteen days after their most recent AAS injection. Two patients developed an additional focus of infection, involving the contralateral arm in one and the gluteal muscles in the other. Muscle necrosis was observed during surgery in the latter patient [16].

Pai et al. described recurrent axillary abscesses caused by Mycobacterium fortuitum in an otherwise immunocompetent man who had previously injected anabolic steroids into his pectoral muscles. The abscesses recurred after drainage, and routine bacterial cultures initially showed no growth; the organism was subsequently isolated from a tissue sample [17]. This case suggests that recurrent abscesses with negative routine cultures may warrant consideration of non-tuberculous mycobacteria and tissue sampling for mycobacterial culture. The authors proposed direct inoculation during injection and AAS-related immune modulation as possible contributing mechanisms, but neither was established as the cause of infection [17].

The available evidence includes self-reported survey data, registry-based observations and case reports or series. Each has different limitations: the survey was restricted to heterosexual men and concerned IPED injection rather than AAS alone; the registry findings do not establish an injection-related origin; and the case reports cannot determine the frequency of specific complications [9,15–17]. Injection history nevertheless remains relevant to the assessment of these complications. One patient in the pyomyositis series did not initially disclose AAS use, illustrating a potential obstacle to recognising an injection-related cause [16]. The implications for history-taking and diagnostic assessment are considered further in the Discussion.

4. Discussion

4.1 Main findings and strength of evidence

This review indicates that AAS use is associated with a broad range of cutaneous manifestations. Direct androgen effects on the pilosebaceous unit contribute to acne and changes in hair growth, while striae, keloids and injection-related complications involve additional mechanisms [7,18]. Population-based observations support the clinical relevance of these findings. Horwitz et al. reported a higher incidence of prescription-based acne treatment among AAS users than controls: 10.8 versus 4.7 per 1,000 person-years, with a hazard ratio of 2.3. This is an indirect measure of treated acne, rather than an estimate based on dermatological examination. Their exploratory analysis also identified more hospital contacts for cutaneous abscesses, furuncles, carbuncles and urticaria, but yielded no new statistically significant findings after correction for multiple comparisons. These observations should therefore be treated as exploratory signals and do not establish a link with AAS injections [10]. In the study by O'Sullivan et al., 43% of users reported acne during AAS use [19]. Together, these observations suggest a substantial dermatological burden, although differences in outcome assessment prevent direct comparison between studies.

The evidence remains uneven. Much of the literature consists of case reports, small series and observational studies, which can identify clinically important presentations but provide limited estimates of their frequency or risk [20]. Concurrent use of several substances, incomplete disclosure and reliance on self-reported outcomes further complicate interpretation [19–21]. The associations described in this review therefore vary in certainty, and findings from selected clinical populations should not be assumed to represent all athletes using AAS.

4.2 Recognition of AAS use

AAS are recognised causes of drug-induced acne. Their use may aggravate pre-existing acne vulgaris, and severe presentations, including acne conglobata and acne fulminans, have been reported. Accompanying hirsutism or male pattern hair loss may provide further evidence of androgen exposure. Sudden onset, an unusual age at presentation and resistance to conventional treatment are general clues to drug-induced acne, rather than features specific to AAS. Malassezia folliculitis should also be considered in the differential diagnosis of an acne-like eruption, particularly when the apparent acne does not respond to treatment [22]. Acne itself is common and cannot establish AAS use. Suspicion may be strengthened by a combination of findings, such as injection marks over large muscles, pronounced muscular hypertrophy, hair loss in men, hirsutism in women, oedema or gynaecomastia [23]. These signs should prompt direct enquiry about AAS use, rather than be treated as diagnostic proof [24].

4.3 Challenges in identifying AAS exposure

Obtaining an accurate exposure history can be difficult [22,25]. Richardson et al. describe reluctance among participants to discuss AAS use with family members, partners and health professionals, as well as limited medical help-seeking when problems arise [25]. Disclosure may also be incomplete. In the Finnish study by Vauhkonen et al., two patients acknowledged previous use while denying current use despite clinical findings suggesting ongoing exposure [21]. Other patients may not recognise their exposure if products sold as nutritional supplements contain anabolic substances [20]. Questions should therefore cover supplements and products intended for muscle building, including those purchased online or in gyms, as well as substances explicitly described as steroids [20,26]. Concurrent use of other performance-enhancing agents and ancillary drugs adds further uncertainty [20,26]. Rochoy et al., for example, describe the use of selective oestrogen receptor modulators during “post-cycle therapy”, with the stated intention of restoring hypothalamic-pituitary function. These accounts describe users’ intentions rather than demonstrating treatment efficacy [26]. This broader exposure history matters because accompanying drugs may contribute to adverse effects and make attribution to AAS alone difficult [20,26].

4.4 Gynaecomastia as a clinical indicator of AAS use

Although gynaecomastia is not a primary skin disorder, it is a visible finding relevant to the assessment of suspected AAS use [23]. Horwitz et al. reported an approximately 13-fold higher hazard (HR 13.3; 95% CI 8.3-21.4) of a new gynaecomastia diagnosis among AAS users than among controls [10]. Conversion of some AAS to oestrogens provides a mechanism for breast gland enlargement [23]. Clinical examination can identify the condition, and surgical treatment may be required in some patients; O’Sullivan et al. reported bilateral excision in five participants [19]. Attempts to manage this complication independently with tamoxifen or letrozole illustrate how concern about visible adverse effects can lead to additional drug exposure [19,26]. Such use should not be

taken as evidence of efficacy or safety [26]. Recorded diagnoses may also underestimate the burden, since embarrassment and reluctance to seek medical care can prevent cases from reaching official health records [10].

4.5 AAS use in women

In women, AAS exposure may be accompanied by hirsutism, scalp hair loss, voice deepening, clitoral enlargement and reduced breast volume [20,23,27]. The Finnish retrospective study included 39 women with documented doping use, 34 of whom had used AAS. Five women, representing 12.8% of the full sample, had reported AAS-related signs of virilisation to their doctor, while objective signs were documented in four additional patients. The figure of 12.8% therefore describes patient-reported findings in a selected clinical sample, rather than the prevalence of virilisation among female AAS users [21]. Reversibility also differs between manifestations. Acne, menstrual disturbances and associated infertility may improve after withdrawal [20]. In contrast, virilising changes, including marked hirsutism, voice deepening, clitoral enlargement, breast atrophy and male pattern hair loss, may persist or be irreversible, depending on the dose and duration of AAS exposure [20,27]. This does not imply that all androgen-related changes are permanent: mild hirsutism occurring at therapeutic doses may resolve after withdrawal [3]. These differences make early recognition important, while also requiring caution when discussing the likely outcome for an individual patient [27].

4.6 Clinical management and harm reduction

Clinical assessment should combine physical examination and appropriate investigations with a detailed history of the substances used, their doses, routes of administration and duration of exposure [21,22]. For acne, the timing of onset or worsening in relation to AAS use is particularly relevant. The reviewed literature supports advising cessation of AAS and treating acne according to its severity [22]. Early assessment of hair loss is also important, although evidence for finasteride and minoxidil specifically in AAS users is lacking. This gap does not demonstrate that these treatments are ineffective; it limits confidence that results from other populations apply during continued AAS exposure [24]. Injection history has a separate diagnostic role. Weinreb et al. describe reactive masses at sites of repeated AAS injections that resembled soft tissue neoplasms clinically, radiologically or histologically. Knowledge of local injections can help interpret imaging and histopathology and may prevent unnecessarily aggressive surgery, but it does not replace adequate investigation of a suspicious lesion [28].

Patient counselling should address both visible changes and the wider consequences of AAS use [7]. Scarring, striae and keloids may remain after withdrawal, and some virilising effects in women may be irreversible, depending on the dose and duration of exposure [7,20]. Cessation can also be complicated by dependence. Depression, akathisia, loss of appetite, insomnia and chronic fatigue have been described among withdrawal symptoms, rather than as defining features of dependence itself. Patients experiencing these problems may require psychological or addiction care; cognitive behavioural therapy and counselling have been proposed in the reviewed literature, although their effectiveness was not established by those reports [23]. Finally, the infections described in this review support discussing injection practices openly. Sharing or reusing needles, syringes and drug containers can expose users to blood-borne infections and skin or soft tissue infections. Education about adverse effects should therefore be accompanied by advice on safer injection practices, avoidance of shared or reused equipment and access to needle and syringe services [18]. Dermatological care offers an opportunity to recognise

AAS-related harm and initiate a wider conversation about health, continued exposure and support for cessation [7,20].

4.7 The role of physicians in the management of a patient using AAS

Physicians should remain alert to possible AAS use in patients who train intensively, whether competitively or recreationally [20]. In the context of alopecia in female athletes using AAS, multidisciplinary care involving dermatologists, endocrinologists, psychologists and sports medicine specialists has been recommended to support cessation [27]. Education about AAS-related adverse effects for athletes and coaches may contribute to prevention and earlier recognition of complications [27].

Dermatological complications, such as acne and hair loss, may adversely affect self-confidence and self-esteem [24,25]. Given that the motivation for using AAS is physique enhancement [24], discussing with the patient the potential adverse effects of AAS use on appearance may provide particularly persuasive arguments. However, in the study by O'Sullivan et al., the majority of participants who were aware of the potential for complications still planned to continue using AAS [19]. Information about health risk alone may be insufficient to discourage AAS use and change the behavioural pattern, because potential health damage is sometimes accepted [2].

4.8 Limitations

This study is a narrative review; thus, the selection of publications was purposive, which introduces a risk of selection bias. The literature search was conducted exclusively on PubMed, ScienceDirect, SpringerLink and the Quality in Sport archive; therefore, relevant studies indexed in other databases may have been missed. We only included publications in English or Polish for which full text was available; hence, studies published in other languages and those for which full text was unavailable were excluded, potentially affecting the scope. Only studies involving humans were included; therefore, potentially significant information supported at this time only by animal models may have been omitted. Various types of publications were included; however, as their results were not standardised, direct quantitative comparison was not possible. Certain findings, especially those concerning infrequent dermatological complications of AAS use, were derived from secondary sources. Additionally, title and abstract screening was targeted at predefined thematic areas rather than an exhaustive review of the entire set of retrieved records.

4.9 Future research directions

Literature regarding dermatological complications associated with AAS use remains limited. The discrepancy between self-reported acne and physician-assessed findings in the HAARLEM study reflects the importance of combining patient reports with objective assessment [3,8].

Further research should examine how individual AAS compounds, doses, cumulative doses and duration of exposure influence dermatological outcomes, including androgenetic alopecia in men using high doses of AAS [2,3,24]. Other priorities include estimating the frequency of less commonly reported complications not requiring hospitalisation, such as striae, and assessing the long-term consequences of AAS use [2,9]. Greater inclusion of

women is needed across these areas, alongside objective classification of alopecia and evaluation of its management in female athletes [21,27].

Building on existing research into users' perception of adverse effects [25,27], further exploration of how the development of visible skin complications of AAS use affects body image and self-esteem and the decision to continue using AAS is needed.

5. Conclusions

AAS affect the skin and its appendages through androgen receptor signalling in the pilosebaceous unit. Other cutaneous changes are related to rapid muscle growth, possible alterations in collagen metabolism or the route of administration.

Acne is the most commonly reported visible adverse effect, ranging from exacerbation of existing acne to acne fulminans. Additional manifestations include androgenetic alopecia in men and hirsutism as part of virilisation in women, alongside less well-documented striae, keloids and sebum-related changes. Injections may cause abscesses and deeper or atypical infections. Reversibility varies, and some changes may persist after withdrawal.

Cutaneous findings may suggest AAS use but do not establish it, warranting direct enquiry about AAS, supplements and injection practices. Physicians assessing people who train intensively may recognise harm early and help patients access multidisciplinary care. Counselling should address potentially persistent changes and safer injection practices, although information about risks alone may not discourage continued use.

Given the reliance on case reports and self-reported outcomes, further research should clarify relationships with dose and duration of exposure, establish the frequency of less commonly reported manifestations and include more women.

Disclosure

Supplementary Materials

Not applicable.

Author Contributions

Conceptualisation: [MW], [RD], [AB], [JM], [MD], [AK], [MP], [AS], [JP], [NK]
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Conflicts of Interest

All authors deny any financial or personal relationships with other people or organisations that could inappropriately bias their work.

Declaration of the Use of Generative AI and AI-Assisted Technologies in the Writing

Claude (Anthropic; Opus 5.5 model) was used to assist with formulating database queries, organising the manuscript structure, translating some fragments of author-written text from Polish into English, and improving grammar, style and clarity. It is important to emphasise that AI was used strictly as an assistive instrument under human supervision. The manuscript's substantive content was written by the authors, who reviewed and verified all AI-assisted revisions and checked source-based information against the original publications. The authors retained full responsibility for the interpretation of findings, conclusions, and the final manuscript.

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