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Androgen abuse epidemiology

Dominic Sagoe and Ståle Pallesen

Purpose of review

To systematically review current epidemiological literature on androgen abuse. Estimates from 32 empirical epidemiological articles were reviewed.

Recent findings

Generally, androgen abuse epidemiology and prevalence is higher in Europe, the Middle East, North America (the USA), Oceania (Australia and New Zealand), and South America (Brazil) and lower in Africa and Asia. In contrast to the general population, androgen abuse epidemiology and prevalence is higher among athletes, injection drug users, recreational sportspeople, and sexual and gender minorities.

Summary

From the 1970s, androgen abuse spread from athletes into the general population. Consistent with previous evidence, reviewed studies suggest that androgen abuse epidemiology and prevalence is higher in Western cultural contexts, the Middle East, and South America (Brazil) and lower in Africa and Asia. Evidence also corroborates indications that androgen abuse is less prevalent among women (vs. men), and in the general population in contrast to particular subpopulations consisting of athletes, injection drug users, recreational sportspeople, and sexual and gender minorities. Adolescents' androgen abuse should be of special concern. Androgen abuse in some nonsports occupations (e.g. security workers) requires further exploration. Polypharmacy and the Internet proliferation of androgens and other PIEDs require surveillance for prevention and harm reduction.

Keywords

anabolic–androgenic steroids, androgens, epidemiology, prevalence, systematic review

INTRODUCTION

Androgen abuse refers to the nonmedical usage of androgens (testosterone and its synthetic forms sometimes referred to as anabolic–androgenic steroids) for reasons such as enhanced muscle growth and strength aimed at improved sports performance or achieving a more muscular physique [1^{*}]. Long-term and supraphysiologic androgen abuse has been associated with various harmful physical and psychosocial disorders, and premature mortality [2–4]. In the 1960s, androgen abuse was primarily associated with elite athletes especially bodybuilders who were primarily motivated by the quest for superior athletic performance. Since the 1970s, androgen abuse has spread into the general population [1^{*},5^{*}]. Our meta-analysis [6] indicates a global lifetime prevalence of 3.3% (men: 6.4%, women: 1.6%). The Middle East (21.7%) had the highest geographic prevalence whereas recreational sportspeople (18.4%) had the highest prevalence whenever examined by sample/subpopulation, with athletes (13.4%) having the second highest prevalence. Several empirical investigations on

androgen abuse epidemiology have been published following the publication of our meta-analysis in 2014. The purpose of the present study is to systematically review and synthesize current (2016–2017: as determined by this journal's author guidelines) empirical literature on androgen abuse epidemiology.

METHODS

Search strategy, inclusion criteria, and study description

We conducted a systematic literature search in Google Scholar, ISI Web of Science, ProQuest, PsycNET, PubMed, relevant websites, and reference

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KEY POINTS

- Androgen abuse is higher in Western cultural contexts, the Middle East, and Brazil and lower in Africa and Asia.
- Androgen abuse is less prevalent in the general population in contrast to athletes, injection drug users, recreational sportspeople, and sexual and gender minorities.
- Adolescents' androgen abuse should be of special concern.
- Androgen abuse in some nonsports (e.g. security) occupations requires further exploration.
- Polypharmacy and the Internet proliferation of androgens and other PIEDs require surveillance for prevention and harm reduction.

lists for articles published between January 2016 and November 2017. The following keywords were used for the searches in Google Scholar, ISI Web of Science, ProQuest, and PsycNET: 'anabol* androgen* steroid* doping preval*,' 'anabol* androgen* steroid* doping epidem*,' and 'anabol* androgen* steroid* doping incidence.' For

searches in PubMed, the keywords were pragmatically adjusted: 'anabol* androgen* steroid* preval*,' 'anabol* androgen* steroid* epidem*,' 'anabol* androgen* steroid* incidence,' 'doping preval*,' 'doping epidem*,' and 'doping incidence.'

A total of 325 hits were identified from the database search and 18 additional records identified through ad hoc online and reference list searches. After removing duplicates, 219 records were available for screening. Of this pool of 219 records, 183 were removed after screening their titles and abstracts. Thus, 36 records were accessed for further evaluation. The key inclusion criteria were that the study/literature was published: (a) between January 2016 and November 2017 (as determined by this journal's author guidelines), (b) in English, (c) in a peer-reviewed journal; and (d) presented original prevalence estimate(s) of androgen abuse. After screening the 36 records for eligibility, 32 were included in the review. The search was conducted from 27th November to 10th December, 2017 and adhered to the 'PRISMA' guidelines [7]. The search and selection process is presented in Fig. 1. Of the 32 articles identified, 22 were published in 2017 [8–28,29*] and 10 in 2016 [30–39]. Study sample sizes ranged from 84 [15] to 2 098 728 [8]. Table 1 presents further characteristics of included studies.

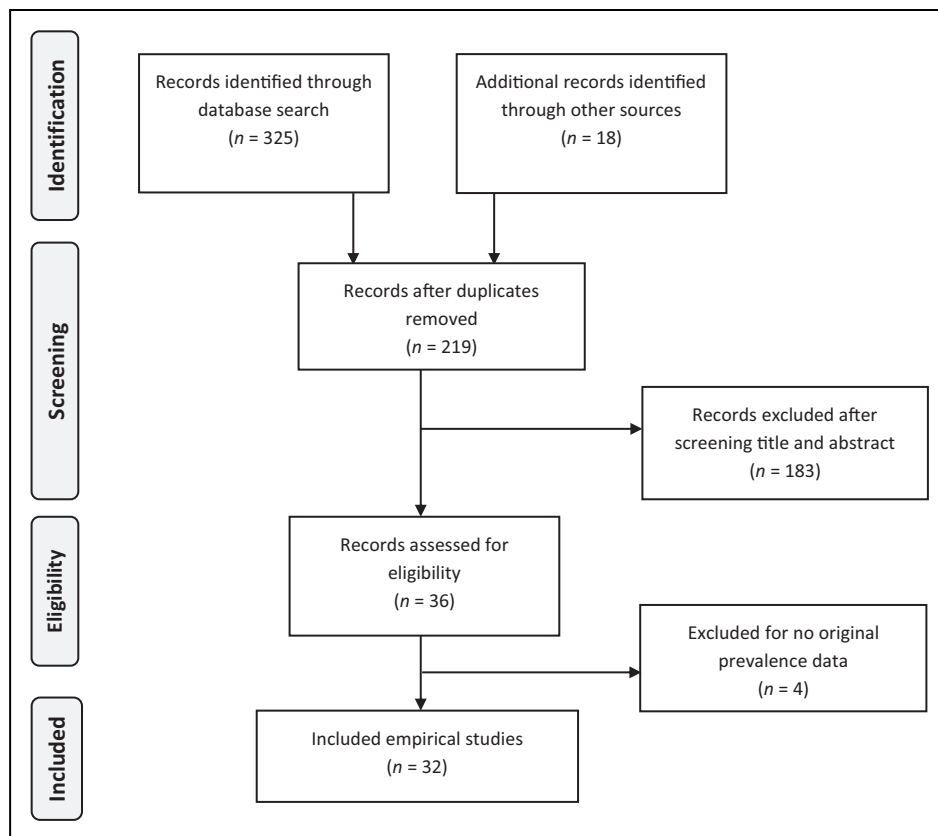


FIGURE 1. Flow diagram of systematic search for current (2016–2017) empirical epidemiological studies on androgen abuse.

Table 1. Characteristics of current (2016–2017) empirical epidemiological studies on androgen abuse

First author, year [Ref]	Country	Sample type	Assessment	Sampling	N	N (male)	N (female)	Age range, years	Age (mean)	Age (SD)	Prevalence (men, %)	Prevalence (women, %)	Prevalence (overall, %)	RR (%)
Asia														
Imanishi, 2017 [8]	Japan	Athletes	DC	NR	42 439	-	-	-	-	-	-	-	0.03 ^C	-
Europe														
Begge, 2017 [9 [¶]]	Sweden	Retired power sport athletes	Q	NR	683	683	-	39–82	57	10	20.9 [†]	-	20.9 [†]	68.6
Blank, 2017 [10]	Austria	University students	Q	NR	571	287	284	-	23.7	4.9	-	-	0.2 ^{PY}	-
Gwizdek, 2017 [11]	Poland	Gym users	Q	NR	153	83	70	18–55	F: 29.0 M: 28.2	F: 8.2 M: 7.7	30.1 [†]	7.0 [†]	19.6 [†]	-
Gwizdek, 2017 [11]	Poland	Athletes	Q	NR	267	184	83	18–66	F: 26.9 M: 26.9	F: 6.0 M: 7.7	22.8 [†]	1.0 [†]	16.1 [†]	-
Horn, 2017 [12]	United Kingdom	Sexual health patients	Q	NR	96	96	-	18–25 (55%)	-	-	4.1 ^{†, PY}	-	4.1 ^{†, PY}	-
McVeigh, 2017 [13 ^{¶¶}]	United Kingdom	NSP clients	Q	NR	-	-	-	20–29	-	-	1995: 96.5 [†] 2015: 98.6 [†]	-	1995: 17.1 [†] 2015: 54.9 [†]	-
Minutillo, 2016 [30]	Italy	Athletes	DC	NR	16 624	11 174	5450	-	27.2	10.2	1.1 ^C	0.2 ^C	0.8 ^C	-
Mooney, 2017 [14]	United Kingdom	Gym users	Q	NR	377	177	200	-	35.6	13.5	-	-	7 ^C	-
Pacifici, 2016 [31]	Italy	Urban youth	Q	NR	2621	1315	1306	14–35	-	-	1.9 [†]	0.5 [†]	1.2 [†]	100
Piacentino, 2017 [15]	Italy	Athletes	DC	NR	84	55	29	18–50	-	-	-	-	8.3 ^C	-
Sagoe, 2016 [32]	Norway	Adolescents	Q	R	1334	550	783	18	18	0	0.1 ^{PY}	0 ^{PY}	0.1 ^{PY}	64.9
Sagoe, 2017 [16]	Norway	General population	Q	NR	15 654	6399	6151	16–91	33.7	12.3	2.5 [†] , 1.2 ^C	0.3 [†] , 0.02 ^C	2.7 [†] , 0.6 ^C	-
Middle East														
Al Ghabain, 2017 [17]	Saudi Arabia	Athletes	DC	NR	4482	-	-	-	-	-	-	-	1.4 ^C	-
Al Nozha, 2017 [18]	Saudi Arabia	Gym users	Q	NR	316	316	-	18–35	-	-	11.4 ^{P6}	-	11.4 ^{P6}	92.9
Al-Hemery, 2017 [19]	Iraq	General population	Q	R	3200	2289	911	18–49 (97.9%)	39	13.4	2.5 [†]	0 [†]	1.3 [†]	91.6
Bahri, 2017 [20]	Saudi Arabia	Bodybuilders	Q	NR	465	465	-	15–34 (93.3%)	-	-	31.0 [†]	-	31.0 [†]	93.0
Haerinejad, 2016 [33]	Iran	Bodybuilders	I	NR	453	453	-	16–59	27.0	6.0	79.4 [†]	-	79.4 [†]	-
Jabari, 2016 [34]	Saudi Arabia	Gym users	Q	R	600	600	-	15–49	-	-	-	-	30.5 [†]	100
Khullar, 2016 [35]	Kuwait	Gym users	Q	NR	200	173	27	18–55	29.1	8.3	40.0 [†]	3.7 [†]	35.0 [†]	-
Rezaei, 2017 [21]	Iran	Bodybuilders	Q	R	214	-	-	20–30 (79.9%)	-	-	-	-	72.8 [†]	-
Saeidinejad, 2017 [22]	Iran	Bodybuilders	Q	NR	920	920	-	-	-	-	34.1 [†] , 11.2 ^C	-	34.1 [†] , 11.2 ^C	81.9

Table 1 (Continued)

First author, year [Ref]	Country	Sample type	Assessment	Sampling	N	N (male)	N (female)	Age range, years	Age (mean)	Age (SD)	Prevalence (men, %)	Prevalence (women, %)	Prevalence (overall, %)	RR (%)
North America														
Blashill, 2016 [36 ^M]	United States	Heterosexual adolescents	Q	R	5786	5786	-	16	16	0	2.9 ^L	-	2.9 ^L	-
Blashill, 2016 [36 ^M]	United States	Gay adolescents	Q	R	462	462	-	16	16	0	14.5 ^L	-	14.5 ^L	-
Elkins, 2017 [23]	United States	Adolescents	Q	R	38414	18424	19192	-	-	-	-	-	2.6 ^{PY}	-
Guss, 2017 [24 ^M]	United States	Cisgender youth	Q	R	2415	1117	1298	15-17 ^M	16 ^M	-	5.2 ^L	0.7 ^L	2.8 ^L	-
Guss, 2017 [24 ^M]	United States	Transgender youth	Q	R	67	-	-	15-17 ^M	16 ^M	-	-	-	38.9 ^L	-
Ip, 2017 [25 ^M]	United States	Gym users	Q	NR	293	293	-	-	-	-	9.2 ^L , gay:10.0 ^L , 6.8 ^{PY}	-	9.2 ^L , gay:10.0 ^L , 6.8 ^{PY}	-
Jampel, 2016 [37 ^M]	United States	Adolescents	Q	R	6000	6000	-	-	16	1.2	-	-	4.0 ^L (pc)	-
Parent, 2016 [38]	United States	Adolescents	Q	R	13482	6721	6761	-	-	-	4.0 ^{PM}	2.0 ^{PM}	3.0 ^{PM}	-
Sanjuan, 2016 [39]	United States	Bodybuilders, weightlifters	Q	R	122	122	-	19-57	-	-	86.9 ^L , 30.3 ^C	-	86.9 ^L , 30.3 ^C	-
Oceania														
Griffiths, 2017 [26 ^M]	Australia, New Zealand	Gays, bisexuals	Q	NR	2733	2733	-	18-78	33.9	11.9	5.2 ^L	-	5.2 ^L	-
Rowe, 2017 [27]	Australia	IPIED users	Q	NR	605	605	-	-	28.8	7.5	93.2 ^L	-	93.2 ^L	-
Yager, 2017 [28]	Australia	Undergraduates	Q	NR	589	235	354	17-58	21.1	5.1	4.4 ^{PY}	0.3 ^{PY}	1.9 ^{PY}	-
South America														
Abraham, 2017 [29 ^M]	Brazil	Gym users	Q	R	361	-	361	18-59	29.0	8.1	-	13.3 ^L , 7.7 ^{P6}	13.3 ^L , 7.7 ^{P6}	89.6
International														
Imanishi, 2017 [8]	International	Athletes	DC	NR	2098728	-	-	-	-	-	-	-	1.1 ^C	-

DC, doping control; I, interview; IPIED, injectable performance and image enhancing drugs; M, majority; NR, nonrandom; NSP, needle and syringe programme; pc, personal communication; prevalences [C: current, L: lifetime, P6: past six months, PM: past month, PY: past year]; Q: questionnaire; R: random; RR: response rate).

Data extraction and synthesis

The first author (D.S.) independently conducted the literature search and selection of articles based on the aforementioned criteria. Using a standardized data extraction form, the following data were extracted from the identified studies: author(s) and publication year, country, sample type, assessment method, sample size (total, male, and female), participants' age (range, *M* and *SD*), prevalence estimates of androgen abuse (men, women, and overall), and response rate. A final table of included studies is presented in Table 1. Due to the few studies identified, and variations in sample and prevalence types, it was not pragmatic to pool the prevalences quantitatively using a meta-analysis as we have recently done using a larger literature set on the topic [6]. Alternatively, we conducted a narrative synthesis of epidemiological estimates of identified studies. The first author read through the full-text articles several times and extracted prevalence estimates. Prevalence estimates from the included studies were then narratively synthesized and elucidated, and supplemented by other mostly current literature.

RESULTS AND DISCUSSION

OVERALL AND SEX-SPECIFIC EPIDEMIOLOGY

The overall prevalence estimates from included studies ranged from a current prevalence of 0.03% (doping control data from 42 439 Japanese athletes) [8] to a lifetime prevalence of 93.2% from a survey of 605 Australian men who inject performance and image enhancing drugs (PIEDs) [27]. The truism in the field is that prevalence is higher among men compared with women [6]. Accordingly, wherever prevalences were divided by sex, men consistently showed higher prevalences than women. Plausible explanations for the lower prevalences among women is their vulnerability to some masculinizing side-effects such as hirsutism and deepening of the voice [4,29[■],40[■]], and gender differences in body image ideals [5[■],57]. Overall, prevalence variations are explainable by differences in study characteristics (e.g. sample type) [6].

GEOGRAPHIC EPIDEMIOLOGY

The preponderance of androgen abuse epidemiology has been conducted in North America, Europe, and Oceania (Australia) with fewer studies in Africa, the Middle East, South America, and Asia [6]. This may explain Kanayama and Pope's [5[■]] opinion that:

[Androgen] abuse has now become particularly prevalent in regions such as Scandinavia, the

United States, Brazil, and British Commonwealth countries, but remains rare in countries such as China, Korea, and Japan - a pattern that reflects cultural differences in attitudes towards male muscularity (p. 1).

Europe

Of the 32 articles identified, 11 originated from Europe. In a survey of 571 Austrian university students, past year prevalence was 0.2% [10]. In a Polish survey of 153 gym users and 267 professional athletes, lifetime prevalences were 19.6 and 16.1%, respectively [11]. In Scandinavia, we estimated a past year prevalence of 0.1% from a survey of 1334 18-year-olds selected from the Norwegian national population registry [32]. Additionally, in an online-based survey of 15 654 individuals conducted in Norway, we reported a lifetime prevalence of 2.7% and a current prevalence of 0.6% [16]. Moreover, from a survey of 683 retired Swedish power sport athletes, lifetime prevalence was 20.9% [9[■]].

In Italy, doping control analysis indicated prevalences of 0.8% (16 624 athletes) [30], and 8.3% (84 athletes) [15]. In another study of 2621 Italian urban youth, the lifetime prevalence obtained was 1.2% [31]. In the United Kingdom, a survey of 96 male patients at a sexual health clinic revealed a past year prevalence of 4.1% [12], whereas a survey of 377 gym users resulted in a current prevalence of 7% [14]. Furthermore, in a comparative study of needle and syringe programme clients, the lifetime prevalence of androgen abuse increased from 17.1% in 1995 to 54.9% in 2015, with male prevalence increasing from 96.5 to 98.6% [13[■]].

The Middle East

There is growing evidence supporting a high prevalence of androgen abuse in the Middle East. Nine of the 32 articles identified were conducted in the Middle East. In a survey of a nationally representative sample of 3200 Iraqis, lifetime prevalence was 1.3% [19] whereas in the analysis of doping control data from 4482 Saudi Arabian athletes, 1.4% were androgen abusers [17]. In contrast, higher prevalences have been estimated in other studies. Past 6 months' prevalence from a study of 316 Saudi Arabian male gym users was 11.4% [18]. Still in Saudi Arabia, a survey of 465 male bodybuilders resulted in a lifetime prevalence of 31% [20] whereas a survey of 600 male gym users resulted in a lifetime prevalence of 30.5% [34]. In Iran, interviews with 453 male bodybuilders resulted in a lifetime prevalence of 79.4% [33], whereas surveys of 214 and 920 male

bodybuilders resulted in lifetime prevalences of 72.8% [21] and 34.1% [22] respectively. Additionally, a survey of 200 Kuwaiti gym users resulted in a lifetime prevalence of 35% [35].

North America (the United States)

Seven articles were identified from North America with all conducted in the United States. A past year prevalence of 2.6% was obtained from a survey of 38 414 adolescents [23], and a past month prevalence of 3% obtained from a survey of 13 482 adolescents [38]. Also, a lifetime prevalence of 4% (personal communication) was estimated from a survey of 6000 adolescent boys [37[■]]. Moreover, lifetime prevalence among 5786 heterosexual adolescents was 2.9 and 14.5% for 462 gay adolescents [36[■]]. Another study of 2415 cisgender youth presented a lifetime prevalence of 2.8% whereas lifetime prevalence was 38.9% for 67 transgender youth [24[■]]. Additionally, a survey of 293 male gym users (gays: $n = 220$) resulted in a lifetime prevalence of 9.3% [25[■]]. Furthermore, in a survey of 122 male bodybuilders and weightlifters, lifetime and current prevalences were 86.9 and 30.3% respectively [39].

Oceania (Australia and New Zealand)

Three studies originated from Oceania. In a survey of 2733 gay and bisexual men in Australia and New Zealand, lifetime prevalence was 5.2% [26[■]]. A survey of 605 male PIED injectors in Australia revealed a lifetime prevalence of 93.2% [27]. Moreover, in a survey of 589 Australian undergraduate students, past year prevalence was 1.9% [28].

South America (Brazil)

One study was identified from Brazil where a survey of 361 female gym users resulted in a lifetime prevalence of 13.3% and a past 6 months' prevalence of 7.7% [29[■]]. To our knowledge, this is the second highest ever recorded for women [41,6]. Given that androgen abuse is a predominantly male behavior, the above estimates for female gym users may indicate a high prevalence among Brazilian gym users.

Africa and Asia

As noted previously, most studies on androgen abuse prevalence and correlates have been conducted in the United States, Europe, and Australia [6]. It is, therefore, not surprising that no study was identified from Africa whereas the only study identified from Asia presented doping control data

from Japanese athletes ($N = 42\,439$, current prevalence = 0.03%) [8].

SAMPLE/SUBPOPULATION EPIDEMIOLOGY

General population

Two general population studies were identified in the present systematic review. A lifetime prevalence of 1.3% was estimated in a survey of a nationally representative sample of 3200 persons in Iraq [19]. Additionally, our online-based survey of 15 654 individuals conducted in Norway yielded a lifetime prevalence of 2.7% and a current prevalence of 0.6% [16]. As noted previously, androgen abuse spread from elite athletes especially bodybuilders into the general population in the 1970s [1[■]]. Today, tens of millions of individuals around the world abuse androgens and are at risk of experiencing serious adverse effects [5[■],6].

Athletes

Results of doping control analyses revealed estimates ranging from 0.03% in 42 439 Japanese athletes [8] to 8.3% in 84 Italian athletes [15]. Also, a survey of 267 athletes in Poland resulted in a lifetime prevalence of 16.1% [11]. A survey of 683 Swedish former power sport athletes resulted in a lifetime prevalence of 20.9% [9[■]]. The abuse of androgens by athletes has been banned in the Olympics since 1967, and is prohibited by the World Anti-Doping Agency. However, despite advances in androgen detection using mass spectrometry, the most prevalent form of doping involves androgen abuse because of its effectiveness [1[■],42].

Our meta-analysis of 48 epidemiological studies on athletes resulted in a lifetime prevalence of 13.4% [6]. It is also noteworthy that an estimated 14–39% of elite athletes are involved in doping [43] whereas the prevalence of past-year doping ('using a prohibited substance or method') based on a survey of 2167 athletes at two international competitions was 43.6% [44[■]]. Though androgens were not specified in the above reports, as noted above, it is tenable that a sizeable proportion of doping cases involve androgen abuse. Handelsman [1[■]] indicates that:

For example, among the nearly 270,000 antidoping tests conducted worldwide by WADA approved antidoping laboratories in 2013, almost 6000 (2.2%) were positive tests (adverse analytical findings) with the majority (57%) being hormones, of which > 99% were androgens (p. 24).

Recreational sportspeople

Although androgen abuse started among professional athletes, the truism in the field is that recreational sportspeople or gym users, mostly engaged in power sports, now constitute the largest subpopulation. This view is supported by evidence from our global meta-analysis where recreational sportspeople had the highest lifetime prevalence (18.4%) [6]. Of the 12 studies that sampled recreational sportspeople, estimates of abuse ranged from a current prevalence of 7% [14] to a lifetime prevalence of 86.9% [39]. In a study in Poland [11], lifetime prevalence was higher for gym users (19.6%; $n=153$) than for professional athletes (16.1%; $n=267$). In a Brazilian study that surveyed 361 female gym users, lifetime and past 6 months' prevalences were 13.3 and 7.7%, respectively, with major motivations being the need for enhanced physical appearance (about 88%) and improved sports performance (10%) [29]. Also, in an Iranian study of 920 bodybuilders, lifetime prevalence was 34.1% with the major motives for abuse being enhanced appearance (57.6%), power (21.2%), and sports performance (21.2%) [22].

Occupational (nonsports) users

Although androgen abuse is particularly associated with sports participation, especially recreational sports, there is prevalence evidence in some nonsports occupations. Handelsman [1] explains that:

Androgen abuse is a well known practice among a minority of men in security-related occupations (military, police, security, club doormen) where sculpting a fearsome, hypermasculine body image may be a prevailing esthetic or a professional advantage (p. 26).

Hoberman [45] elucidates androgen abuse among the military and police in his book. Nonsports occupational androgen abuse poses a security concern [45,46]. However, there is a lack of epidemiological research on this phenomenon.

Sexual and gender minorities

Evidence from the present review supports the perspective in the field denoting a higher prevalence among sexual minorities such as gay and bisexual men than heterosexual men. In one study, 2.9% of 5786 heterosexual adolescent boys reported a lifetime (at least once) abuse of androgens compared with 14.5% among 462 gay adolescent boys [36]. Also, a lifetime prevalence of 5.2% was estimated in a survey of 2733 gay and bisexual men, with associations

between body image as well as eating disorder symptoms and androgen abuse in this population [26]. In another study, the lifetime prevalence was 10.0% for 220 male gay gym users with 68.2% of the lifetime abusers indicating past year abuse compared with a lifetime prevalence of 6.9% among 73 male heterosexual gym users. In the same study, the major motives among gay participants were to increase muscle mass (85%), and enhance strength (71.4%), appearance (81%), and confidence (55%) [25].

Relatedly, there is a paucity of research on gender minorities such as transgender persons. One study that examined androgen abuse among youth found a lifetime prevalence of 38.9% among 67 transgender youth compared with 2.8% among 2415 cisgender youth. In the same study, the odds of lifetime abuse was 26.6 times higher among transgender men compared with cisgender men [24]. Particularly, it has been proposed that higher rates of bullying [38] and stigmatization [25,26] of sexual minorities accounts for their higher androgen abuse prevalence. Furthermore, it has been suggested that the higher prevalences among transgender youth is related to their problems with accessing androgen prescriptions from healthcare services [24].

Adolescents

Prevalences ranged from a past year estimate of 0.1% from a survey of 1334 Norwegian 18-year olds [32] to a lifetime prevalence of 14.5% from a survey of 462 United States gay adolescents [36]. Androgen abuse among adolescents is a serious concern as, in addition to other potential general harmful effects, it has been particularly associated with stunted growth, as well brain, cognition, and neurological dysfunctions that can be permanent [47–49]. In the present systematic review, in addition to being men, other factors associated with androgen abuse in adolescence include sexual minority status (e.g. being gay) [36], self-perception of being very underweight or very overweight [37], and participation in team sports [38], whereas high scores on aggression are associated with increased androgen abuse intent [32].

Drug users and polypharmacy

Androgen abusers sometimes engage in 'stacking' (the combined use of different injectable and oral androgens). Androgen abuse has also been associated with polypharmacy referring to the combined or simultaneous abuse of androgens and other licit and illicit substances in order to enhance androgen effects, deal with androgen side effects, for recreational purposes, and sexual enhancement [50].

Androgen abusers' most used substances in a survey of 361 female gym users in Brazil were alcohol (29.2%), creatine (20.8%), diuretics (18.7%), and cigarettes (10.4%) [29[■]]. Moreover, past 6 months' prevalence of polypharmacy in a survey of 316 male gym users was 82.2% [18] whereas in a survey of 571 university students, one abused androgens and also had blood transfusions [10]. Additionally, in a study of Italian urban youth, androgen abuse was associated with alcohol and energy drink consumption as well as the use of smart drugs [31]. In another study of 122 male bodybuilders and weightlifters, 20.5% were concurrent consumers of androgens and stimulants [39].

THE INTERNET AND ANDROGEN ABUSE EPIDEMIOLOGY

Conventionally, androgens were mostly obtained through direct covert encounters with dealers and smugglers operating in the underground market. With the advent of the Internet, this mode of accessing androgens has changed. Today, there is a proliferation of androgens and other PIEDs on the Internet with thousands of websites and forums dedicated to the sale and distribution of these drugs, as well as providing a sense of community and information. Hence, the Internet has been implicated in the prevalence of androgen abuse [51[■]–54[■]].

STRENGTHS AND LIMITATIONS

The present study elucidates current evidence on androgen abuse epidemiology. The systematic strategy for identifying and reporting literature on the topic is another strength. However, our exclusion of non-English language and nonpeer reviewed literature, although not uncommon, are notable limitations. Additionally, as previously explained, our presentation of the literature is descriptive because it was not pragmatic to conduct a meta-analysis as we have recently done in a more comprehensive review [6]. Moreover, epidemiological surveys of illicit or disapproved behaviors sometimes have limitations such as poor recall, low response rates and nonresponse bias, socially desirable responses, and difficulties with objective verification of responses. Particularly, androgen abuse studies sometimes have poorly-worded, unclear, and unstandardized questions (e.g. 'doping', 'hormones', PIEDs, 'steroids') making the validity of findings suspect.

IMPLICATIONS FOR POLICY AND FUTURE RESEARCH

The present review has several implications for policymakers and healthcare practice. Estimates from

the geographic epidemiological review suggest that androgen abuse is highly prevalent in Europe, the Middle East, North America, Oceania (Australia and New Zealand), and South America. Preventive and harm-reduction interventions are especially needed in these regions in order to minimize the public health impact of androgen abuse. Although there is a scarcity of empirical evidence from Africa and Asia in the present review and our previous meta-analysis [6], similar interventions in these regions may be useful in minimizing the public health impact of androgen abuse. Further research is also needed to highlight the prevalence, adverse effects, and the public health impact of androgen abuse. Researchers must adhere to recommendations [58] in order to ensure quality research.

Androgen abuse appears less prevalent in the general population [16,19] with indications of a high prevalence among certain subpopulations. Despite antidoping advances, evidence from the studies reviewed indicates high prevalence among professional athletes. Hence, more efficient antidoping efforts are needed in sports settings. Results also suggest that androgen abuse is highly prevalent among recreational sportspeople, sexual and gender minorities, and injection drug users. Thus, preventive and harm reduction interventions are needed to deal with the potential adverse effects among these subpopulations. Healthcare providers should also be educated about androgen abuse in general and may focus especially on the delineated vulnerable groups. Targeted screening during clinical evaluation may as such enhance healthcare delivery. More research is also needed to examine androgen abuse among non-sports occupations such as security work.

Relatedly, preventive and harm reduction interventions are needed to deal with the adolescent-specific harms of androgen abuse such as stunted growth and potentially permanent alteration of cardiac and brain structures [47–49]. The stigmatization of androgen abusers by the general public [55] including healthcare providers [56] as well as polypharmacy [50] can have harmful consequences, and efforts are needed to deal with this problem and its associated debilitating effects. Furthermore, efforts are needed to deal with the proliferation of androgens and other PIEDs on the Internet and potential problems and harms associated with this phenomenon.

CONCLUSION

Since the 1970s, androgen abuse has spread from athletes into the general population particularly among men. In line with anecdotal [5[■]] and empirical evidence [6], estimates from the studies included

in the present review suggest that androgen abuse epidemiology and prevalence is higher in Europe, the Middle East, North America (the United States), Oceania (Australia and New Zealand), and South America (Brazil) and lower in Africa and Asia. Evidence from the present review also corroborates indications that androgen abuse is less prevalent in the general population and highly prevalent among particular subpopulations such as athletes, injection drug users, recreational sportspeople, and sexual and gender minorities. Androgen abuse among adolescents should be of special concern because of its particularly debilitating consequences. Additionally, the abuse of androgens in some nonsports occupations such as security work requires further exploration. Targeted preventive and harm-reduction efforts are needed. Furthermore, the practice of polypharmacy among androgen abusers and the proliferation of androgens and other PIEDs on the Internet require surveillance for prevention and harm reduction benefits.

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Conflicts of interest

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