The Prevalence of Anabolic-Androgenic Steroid Misuse in Iranian Athletes: A Systematic Review and Meta-Analysis

Maryam Selk-Ghaffari¹, Sakineh Shab-Bidar², *Farzin Halabchi³

¹. Sports Medicine Research Center, Neuroscience Institute, Tehran University of Medical Sciences, Tehran, Iran
². Department of Community Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Sciences, Tehran, Iran
³. Department of Sports and Exercise Medicine, Tehran University of Medical Sciences, Tehran, Iran

*Corresponding Author: Email: fhalabchi@tums.ac.ir

(Received 03 Jan 2021; accepted 20 Mar 2021)

Abstract

**Background:** Due to widespread abuse of anabolic-androgenic steroids among professional athletes and amateur sportsmen and their health-related problems, determining the prevalence and the pattern of anabolic-androgenic steroid misuse at the national level seems to be vital for designing efficient preventive and educational measures.

**Methods:** This systematic review and meta-analysis was conducted via comprehensive searches of the electronic databases including PubMed, MedLine, Scopus, Google Scholar and National Persian Databases including SID, Magiran, IranDoc (between 1980 and Dec 2019 in English and Persian languages) and also from citations in the selected papers. Overall, 39 articles met the criteria and were included in qualitative and quantitative synthesis.

**Results:** The overall prevalence rate of anabolic-androgenic steroid misuse in the Iranian athletic population was 36.2% (95% confidence interval (CI), 29-43) with significant heterogeneity between studies ($I^2=99.0\%$, $P<0.001$). Prevalence rate of anabolic-androgenic steroid misuse among elite, male and younger athletes was higher ($P<0.05$). Moreover, prevalence rate of anabolic-androgenic steroid misuse among body-building athletes (36.3%) was higher compared to other athletes (30.9%), ($P<0.001$).

**Conclusion:** Due to the higher prevalence of anabolic-androgenic steroids misuse in Iran compared to global statistics and the potential for serious adverse effects, preventive strategies and policies should be regarded as a real concern for public health.

**Keywords:** Anabolic-androgenic steroid; Athletes; Public health; Doping; Prevalence

Introduction

Anabolic-androgenic steroids (AAS) refer to testosterone and a set of its synthetic derivatives, administered in the treatment of some health problems. However, AAS are mainly used as a doping agent for aesthetic purposes to gain muscle and lose body fat, improving muscle strength, increasing athletic performance, as well as for enhancing psychological well-being (1). AAS misuse is associated with debilitating complications and increased mortality (2, 3). Unfortunately, many athletes have not proper
knowledge, attitude and behavior regarding banned drugs and their side effects (4, 5).

To minimize this major public health problem, different preventive policies and interventions have been recommended to motivate behavior change. These measures attempt to reduce the AAS misuse through targeting several behavioral risks and protective factors, such as focusing on ethics and values, harms, healthy alternatives, body image, peer expectations, drug refusal role play and social norms. They are provided in the form of educational or media programs, and expert consultations (6, 7). A study conducted in Iran showed the beneficial effects of educational programs using the theory of planned behavior in prevention and reduction of AAS misuse among young male gym users (8). Due to the widespread misuse of AAS among different athletic populations and their major health-related problems especially the young population, determining the prevalence and the pattern of misuse at the national level seems to be vital for designing of efficient preventive and educational measures (9).

Despite the sporadic studies evaluating the prevalence of AAS misuse, no quantitative meta-analysis has been conducted on this domain in Iran. A meta-analysis in this domain is of great value because it can also be used to identify moderators of the prevalence rate. Therefore, we aimed to conduct a meta-analysis on the prevalence of AAS in Iranian athletes and compare prevalence rates across different genders, sport disciplines, professional levels and regions.

**Methods**

We accomplished a systematic review and meta-analysis according to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines (10). The study was registered in PROSPERO registry (code: 165323).

**Search strategy and inclusion criteria**

Relevant articles were identified through systematic and comprehensive searches of the electronic databases including PubMed, Medline, Scopus, Google Scholar and National Persian Databases of SID, Magiran, IranDoc (between 1980 and Dec 2019 in English and Persian language) and also from citations in the selected papers. The following keywords: "Anabolic Agents"[Mesh] OR “Anabolic steroid” OR “steroid” OR “doping” were used in combination with “preval*” OR “epidem*,” OR “incidence” AND Iran AND English [Language] for the search.

Other relevant studies (including theses and conference proceedings) were identified by scanning through reference lists of selected articles and reviews.

Inclusion criteria were (a) studies including exact data on the prevalence rate of AAS misuse; (b) participants were athletes.

**Data extraction**

Two authors (F.H. & M.S.) separately extracted data applying a standardized data extraction form. Any controversies between two reviewers were discussed and more detailed evaluation of the studies were conducted until agreement was achieved.

**Assessment of methodological quality**

Risk of bias, quality and methodology of the anabolic-androgenic steroid misuse prevalence studies were assessed, applying the Joanna Briggs Institute (JBI) critical appraisal checklist (11) (Table 1).

**Level of evidence and The Strength-of-Recommendation Taxonomy (SORT)**

Studies were assessed for their level of evidence and consistency according to the Strength of Recommendations Taxonomy (SORT) by each reviewer (12). Based on SORT, I to III levels of evidence classification, and A to C classification for the recommendations will be provided.
### Table 1: Critical appraisal tool for quality assessment of the study (11)

| Question                                      |
|-----------------------------------------------|
| Q1. Was the sample frame appropriate to address the target population? |
| Q2. Were study participants sampled in an appropriate way?               |
| Q3. Was the sample size adequate?             |
| Q4. Were the study subjects and the setting described in detail?         |
| Q5. Was the data analysis conducted with sufficient coverage of the identified sample? |
| Q6. Were valid methods used for the identification of the condition?     |
| Q7. Was the condition measured in a standard, reliable way for all participants? |
| Q8. Was there appropriate statistical analysis?                           |
| Q9. Was the response rate adequate, and if not, was the low response rate managed appropriately? |

### Statistical analysis

A meta-analysis was conducted to estimate the lifetime prevalence rate of AAS consumption in Iran. We used a random-effects model (DerSimonian Liard method) was applied in the calculation of prevalence rates and corresponding 95% confidence interval (CI)s (13). Evaluation of the heterogeneity was done by calculating the Q-statistic and the I-squared tests. Subgroup analyses was conducted for all moderator variables including age range, gender, type of sport disciplines, professional level and province. Egger's test was applied to evaluate the publication bias of studies by Stata software. Egger's test results with p values less than 0.05 indicated publication bias in this study. If publication bias exists, the evaluation will be completed using trim and fill. The meta-analysis was conducted using Stata (release 12.0, College Station, Texas, USA). P-values <0.05 were considered as significant.

### Results

A systematic search was conducted for published studies. Overall, 39 articles were identified that studied prevalence of AAS misuse among 13853 athletes (Fig. 1).
Fig. 1: Flow diagram of systematic literature search on lifetime prevalence of AAS use among Iranian athletes

**Description of studies**
The study characteristics are presented in Table 2. Table 3 presents the prevalence rate of AAS misuse in overall athletic population. The prevalence rate of AAS misuse in overall athletic population was reported 36.2% (95% CI, 29-43) with significant heterogeneity between studies ($I^2=99.0\%, P<0.001$) (Fig. 2). The prevalence rate of each study is illustrated compared to the global cumulative estimate (the lower diamond).
### Table 2: Characteristics of studies on the lifetime prevalence of AAS use among Iranian athletes

| No. | Study (Reference) | Number of Participants | Gender | Age Mean±SD [Range] | Sport discipline | Professional level | Province | Lifetime prevalence (%) |
|-----|-------------------|------------------------|--------|---------------------|------------------|--------------------|----------|--------------------------|
| 1   | Aghili M (14)     | 425                    | M      | 32.3±9.95          | Bodybuilding     | Recreational       | Tehran   | 60.8                     |
| 2   | Aliabadi S (15)   | 174                    | M      | 26                 | Bodybuilding     | Recreational       | Kordestan| 11                       |
| 3   | Alidoost E (16)   | 793                    | B      | NR                 | Bodybuilding     | Recreational       | Tehran   | 27.4                     |
| 4   | Allahverdipour H (17) | 253                | M      | 22.2[15-28]        | Bodybuilding     | Recreational       | Hamedan  | 37.5                     |
| 5   | Angoorani H (18)  | 289                    | F      | 26.3±6.3 [15-52]   | Bodybuilding     | Recreational       | Tehran   | 24.2                     |
| 6   | Angoorani H (19)  | 906                    | M      | 25.7±7.1 [14-56]   | Bodybuilding     | Recreational       | Tehran   | 16.6                     |
| 7   | Arazi H (20)      | 204                    | M      | 24.5±5.1           | Bodybuilding     | Recreational       | Alborz   | 62.7                     |
| 8   | Araz H (21)       | 227                    | M      | 22.7 [15-38]       | Bodybuilding     | Recreational       | Qazvin   | 40.1                     |
| 9   | Araz H (22)       | 223                    | M      | 23.8±5.4           | Bodybuilding     | Recreational       | Gilan    | 67                       |
| 10  | Bahrami S (23)    | 389                    | M      | 27.1±5.6           | Bodybuilding     | Recreational       | Kermanshah| 32.1                     |
| 11  | Bijeh N (24)      | 282                    | M      | 24.6±5.2           | Bodybuilding     | Recreational       | Khorasan | 64                       |
| 12  | Eskandarion M (25) | 200                  | M      | 26.2±6.8 [16-46]   | Bodybuilding     | Recreational       | Razavi   | 59.5                     |
| 13  | Fakhari Rad F (26) | 148                 | B      | 25.62±6.58        | Bodybuilding     | Recreational       | Tehran   | 47.5                     |
| 14  | Fijan A (27)      | 246                    | M      | 20.1±7.8           | Bodybuilding     | Recreational       | Fars     | 39                       |
| 15  | Ghaderi H (28)    | 192                    | M      | 26.6±5.7           | Bodybuilding     | Both               | Chaharmahal| 32.8                     |
| 16  | Haerinnejad MJ (29) | 453               | M      | 27±6 [16-59]       | Bodybuilding     | Both               | Bushehr  | 41                       |
| 17  | Hazavehei MM (30) | 370                    | M      | NR                 | Bodybuilding     | Recreational       | Hamedan  | 19.2                     |
| 18  | Hoseini Kakhak AR (31) | 100               | M      | NR                 | Bodybuilding     | Elite              | NR       | 97                       |
| 19  | Jalilian F (8)    | 120                    | M      | 23.7±4.5 [15-43]   | Bodybuilding     | Recreational       | Hamedan  | 20                       |
| 20  | Khabiri A (32)    | 109                    | NR     | NR                 | Bodybuilding     | Elite              | East     | 46.8                     |
| 21  | Madani A (33)     | 277                    | M      | 27.9 [13-55]       | Bodybuilding     | Recreational       | Hamedan  | 44.4                     |
| 22  | Mahdavi M (34)    | 780                    | M      | NR                 | Bodybuilding     | Recreational       | Alborz   | 5.6                      |
| 23  | Malek M (35)      | 337                    | M      | NR                 | Bodybuilding     | Recreational       | Semnan   | 14.2                     |
| 24  | Minasian V (36)   | 169                    | F      | 22.8±4            | All sports       | Elite              | Tehran   | 15.4                     |
Table 3: Prevalence rates of AAS use among Iranian athletes, confidence intervals, and heterogeneity statistics for the overall athletic population, male athletes, and female athletes, prevalence of AAS use among Iranian athletes

| Variable | N  | Prevalence (%) | 95% CI | Q       | df (53) | F     |
|----------|----|----------------|--------|---------|---------|-------|
| Overall  | 39 | 36.2           | 29-43  | 3921.61 | 38      | 99.0% |
| Male     | 31 | 38.2           | 30-46  | 3770.92 | 30      | 99.2% |
| Female   | 2  | 19.9           | 11-28  | 5.51    | 1       | 81.8% |
| Both     | 5  | 28.1           | 19-37  | 74.25   | 4       | 94.6% |

N=number of studies; Q=heterogeneity statistic; df (53) =Q's degrees of freedom; I^2 =heterogeneity index.

According to the subgroup analysis by gender, heterogeneity in prevalence rate of AAS misuse in overall athletic population was not attributable to gender (Table 3). The prevalence rate of AAS misuse in male athletes (38.2%) was higher than in female athletes (19.9%) (P<0.001).
Fig. 2: Forest plot of prevalence rates of anabolic-androgenic steroid in overall athletic population.

ES: prevalence

According to subgroup analysis presented in Table 4, heterogeneity in prevalence rate of AAS misuse in overall athletic population was not attributable to age, sport disciplines and professional level. Prevalence rate of AAS misuse in athletes younger than 25 old (38.6%), was higher compared to athletes aged 25 and older (35.3%) (P<0.001). Moreover, prevalence rate of AAS misuse among body-building athletes (36.3%) was higher compared to other athletes, (30.9%) (P<0.001). Prevalence rate of AAS consumption among elite athletes (53.1%) was higher compared to recreational athletes (34.6%) (P<0.001) (Table 4). According to subgroup analysis, there was significant differences in prevalence rate of AAS misuse in the provinces of Iran (P<0.001).
Table 4: Prevalence rates of AAS use among Iranian athletes, 95% CIs, and heterogeneity statistics for age range, type of sport disciplines, professional level

| Variable                  | N  | Prevalence (% | 95% CI | Q    | df (53) | P    |
|---------------------------|----|---------------|--------|-------|---------|------|
| Age (yr)                  |    |               | Age (yr) |       |         |      |
| 20-24.9                   | 12 | 38.6          | 28- 49  | 445.83| 11      | 97.5 |
| 25-35                     | 16 | 35.3          | 28- 43  | 565.08| 15      | 97.3 |
| Not registered            | 11 | 34.9          | 19- 51  | 2758.09| 10      | 99.6 |
| Type of sport discipline  |    |               |         |       |         |      |
| Body-building             | 34 | 36.3          | 29- 44  | 3821.70| 33      | 99.1 |
| All sports                | 2  | 30.9          | 0.1- 62 | 32.27 | 1       | 96.9 |
| Not registered            | 3  | 38.6          | 25- 52  | 27.84 | 2       | 92.8 |
| Professional level        |    |               |         |       |         |      |
| Recreational              | 34 | 34.6          | 29- 40  | 2197.83| 33      | 98.5 |
| Elite                     | 3  | 53.1          | -5 - 110.9 | 658.09| 2       | 99.7 |
| Both                      | 2  | 37.3          | 29- 45  | 4.04  | 1       | 75.2 |

N= number of studies; Q = heterogeneity statistic; df (53) = Q’s degrees of freedom; I² = heterogeneity index.

Quality assessment, level of evidence, the strength-of-recommendation taxonomy (SORT) and publication bias

Quality assessment of the studies via the Joanna Briggs Institute (JBI) critical appraisal checklist are presented in Table 5 (11). The results of the level of evidence assessment based on SORT is illustrated in Table 6 (12). Based on Egger’s test, publication bias was reported as P-value = 0.002. Since the P-value was significant, we did further analysis to test how many small studies were there that did not publish using trim and fill. If 17 unpublished studies could exist and could reduce the prevalence rate to 20%, not desired.

Table 5: Critical appraisal of studies on prevalence rates of AAS use among Iranian athletes

| Study (Reference) | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 |
|-------------------|----|----|----|----|----|----|----|----|----|
| Aghili M (14)     | No | No | Unclear | Yes | *  | Yes | Unclear | Unclear | Unclear |
| Aliabadi S (15)   | No | No | No | Yes | *  | Yes | Unclear | No | Unclear |
| Alidoost E (16)   | No | Yes | Yes | Yes | *  | Yes | Unclear | No | Unclear |
| Allahverdipour H (17) | No | Yes | Unclear | Yes | *  | Yes | Unclear | No | Yes |
| Angoorani H (18)  | No | Yes | Yes | Yes | *  | Yes | Unclear | No | Unclear |
| Angoorani H (19)  | No | Yes | Yes | Yes | *  | Yes | Yes | No | Yes |
| Arazi H (20)      | No | Yes | Unclear | Yes | *  | Yes | Yes | No | Yes |
| Arazi H (21)      | No | Yes | Unclear | Yes | *  | Yes | Yes | No | Yes |
| Arazi H (22)      | No | Yes | Unclear | Yes | *  | Yes | Yes | No | Yes |
| Bahrami S (23)    | No | Yes | Yes | Yes | *  | Yes | Yes | No | Yes |
| Bijeh N (24)      | No | Yes | Unclear | Yes | *  | Yes | Unclear | No | Yes |

Available at:  [http://ijph.tums.ac.ir](http://ijph.tums.ac.ir)
| Name                  | 1 | 2 | 3       | 4 | 5 | 6 | 7 | 8 |
|-----------------------|---|---|---------|---|---|---|---|---|
| Eskandarion M         | No| Yes| Unclear| Yes*| Yes| Unclear| No| Unclear |
| Fakhari Rad F         | No| Yes| Unclear| Yes*| Yes| Unclear| No| Yes    |
| Fijan A (27)          | No| Yes| Yes| Yes*| Yes| Yes| No| Unclear |
| Ghaderi H (28)        | No| Yes| Unclear| Yes*| Yes| Yes| No| Unclear |
| Haerinejad MJ         | No| Yes| Unclear| Yes*| Yes| Unclear| No| Unclear |
| Hazavehei MM (30)     | No| No| Unclear| Yes*| Unclear| Unclear| No| Unclear |
| Hoseini               | No| Yes| Yes| Yes*| Yes| Unclear| Unclear| Unclear |
| Kakhak AR (31)        | No| Yes| Yes| Yes*| Yes| Unclear| Un unclear| Unclear |
| Jalilian F (8)        | No| Yes| Unclear| Yes*| Yes| Unclear| Unclear| Unclear |
| Khabiri A (32)        | Yes| Yes| Yes| Yes*| Yes| Unclear| No| Unclear |
| Madani A (33)         | No| Yes| Yes| Yes*| Yes| Unclear| No| Unclear |
| Mahdavi M (34)        | No| Yes| Yes| Yes*| Yes| Unclear| Unclear| Unclear |
| Malek M (35)          | No| Yes| Yes| Yes*| Yes| Unclear| Yes| Unclear |
| Minasian V (36)       | Yes| No| Yes| Yes*| Yes| Yes| No| Unclear |
| Nakhaee MR (37)       | No| Yes| Yes| Yes*| Yes| Yes| No| Unclear |
| Nojooomi M (38)       | No| Yes| Unclear| Yes*| Yes| Yes| No| Unclear |
| Pasharavesh L (39)    | No| Yes| Yes| Yes*| Yes| Yes| No| Unclear |
| Rahimi M (40)         | No| No| Yes| Yes*| Yes| Yes| No| Yes    |
| Rashid Lamir A (41)   | No| Yes| Unclear| Yes*| Yes| Yes| No| Yes    |
| Razavi Z (42)         | No| Yes| Yes| Yes*| Yes| Unclear| No| Unclear |
| Rezaei SMA (43)       | Yes| Yes| Yes| Yes*| Yes| Unclear| No| Unclear |
| Saeidinejat S (44)    | No| Yes| Yes| Yes*| Yes| Unclear| No| Yes    |
| Sepehri G (45)        | No| Yes| Yes| Yes*| Yes| Unclear| No| Yes    |
| Shahsavani AR (46)    | No| Yes| Unclear| Yes*| Yes| Unclear| No| Unclear |
| Sharifirad G (47)     | No| No| Unclear| Yes*| Yes| Yes| No| Unclear |
| Shojaei A (48)        | No| No| Yes| Yes*| Yes| No| No| Unclear |
| Sobhanian S (49)      | No| Yes| Yes| Yes*| Yes| Yes| No| Unclear |
| Taghavi SMR (50)      | No| Unclear| Unclear| Yes*| Yes| Unclear| No| Unclear |
| Zakeri A (51)         | No| Unclear| Unclear| Yes*| Yes| Unclear| No| Unclear |

* Not applicable
Table 6: Level of evidence and the strength-of-recommendation taxonomy (SORT) of studies on the lifetime prevalence of AAS use among Iranian athletes

| Variable                  | Strength of recommendation | Consistency across studies | Quality of Evidence |
|---------------------------|----------------------------|---------------------------|---------------------|
| Prevalence rates          | C                          | Consistent                | Level 3             |
| Gender                    | C                          | Consistent                | Level 3             |
| Age range                 | C                          | Consistent                | Level 3             |
| Type of sport disciplines | C                          | Consistent                | Level 3             |
| Professional level        | C                          | Consistent                | Level 3             |

Discussion

The results of this meta-analysis indicated that the overall prevalence rate of AAS misuse in the Iranian athletic population was as high as 36.2%. Prevalence rate of AAS misuse among elite, male and younger athletes was higher. Moreover, prevalence rate of AAS misuse among body building athletes (36.3%) was higher compared to other athletes.

Conclusive data on the prevalence of drug misuse in athletes are challenging to attain because the athletes who misuse drugs will generally deny or hide their socially and morally improper practice. However, the existing evidence indicates that the use of performance-enhancing drugs including anabolic steroids is now widespread in sportsmen.

Evidence regarding the prevalence of steroid misuse may be as diverse as statistics on positive doping tests from accredited laboratories, results of surveys of athletes on their self-reporting or perceptions of drug misuse through to anecdotal reports, and speculation by the media. These sources of evidence are widely variable, leading to estimation of prevalence with a wide range.

There have been many survey-based studies published on the prevalence of drug misuse, however, a few of them have been conducted in athletes and even fewer in elite athletes. Most of published studies are roughly divided into those that investigate the self-report of drug misuse and those that addressed for perceived use of them by other athletes. Results from the former study tend to underestimate the real prevalence, while those on perceived use usually produce overstated claims.

The overall prevalence rate of AAS misuse in the Iranian athletic population (elite and recreational) was 36.2%, according to the studies conducted in Iran. Surveys that recorded the self-report of drug misuse usually underestimate the real prevalence. Therefore, as all of our data was extracted from self-report studies, the real prevalence may be even higher. Then, due to this high prevalence and potential of serious adverse effects, it should be regarded as a real concern for public health.

The estimated prevalence in our study is much higher than what was reported in a meta-analysis on lifetime prevalence rate of AAS misuse among athletes, recreational sportspeople and general population equal to 3.3% (2). In another systematic review and meta-analysis, the overall lifetime prevalence was 2.1% among athletes, recreational sportspeople and general population in the five Nordic countries (53). In our study, prevalence rate of AAS misuse among elite athletes (53.1%) was much higher compared to recreational athletes (34.6). The overall prevalence rate of AAS misuse among recreational sportspeople and all athletes was 18.4% and 3.4%, respectively (2). Prevalence rate of AAS misuse among gymnasts was reported 24.5% in the western province of Riyadh, Saudi Arabia (54). Prevalence rate of AAS consumption was reported 5.45% among athletes in Nigeria (55). Moreover, in a study on Swedish male professional power sport athletes (wrestling, Olympic lifting, powerlifting and the throwing events in track and field), prevalence rate of 21% was reported (56). The inconsistency may be due to the strict supervision and educa-
national programs for elite athletes worldwide which highlights the need for developing preventive strategies in this domain in Iran. The prevalence rate of AAS misuse among recreational athletes in Iranian recreational athletes in our study (34.6%), is comparable to the results of a systematic review in Brazil (57). Results of this review among recreational athletes and regular physical activity practitioners indicated that prevalence rate among recreational athletes varied between 2.1% and 31.6%, based on the participants’ characteristics and the region (57). Higher prevalence rate of AAS misuse in Iran, in comparison to world and neighborhood countries, mandates major activities and policy making in this domain. According to the subgroup analysis, our study showed that prevalence rate for male athletes (38.2%) was higher than female athletes (19.9%). It is in accordance with results of global prevalence rate which reported the higher prevalence in male (6.4%) compared to female individuals (1.6%) (2). Other studies in this domain supports the gender differences in this domain (53, 58-60). The proportion of men that used non-medical AAS was significantly higher than the rate for females (2, 53).

Furthermore, the misuse rate in junior and young athletes (38.6%) was significantly higher than more experienced and senior athletes (35.3%). This finding is consistent with another study that showed a lower prevalence of AAS misuse in more experienced athletes (19). This may be explained by the higher knowledge and awareness of the experienced athletes to the adverse effects as well as their expertise to use more effective alternatives to AAS misuse. Moreover, prevalence rate was higher among body-building athletes (36.3%). This finding is compatible with the annual reports of World Anti-Doping Agency (WADA) that show the highest rate of positive doping tests for AAS in bodybuilding and powerlifting disciplines (61). This result is quite expected because the main claims for benefits of these drugs are based on their positive effects on the muscle bulk and strength that are critically important for strength and power athletes. Finally, prevalence rate among elite athletes (53.1%) was higher than recreational athletes (34.6%). Our findings are consistent with another systematic review which showed higher prevalence of AAS misuse among elite athletes (53). The higher level of competition, increased media or peer pressure and greater stress and training loads may convince the elite athletes to seek ergogenic drugs. In contrast, many recreational athletes do not take part in competitions and are more concerned regarding their health and consequently, they are more resistant to misuse.

One of the main limitations of this meta-analysis was the heterogeneous nature of included studies and the different study populations, questionnaires and sampling methods. Furthermore, we had no original studies in some provinces to assess prevalence rate of that region. Another limitation of the study was existing publication bias. On the other hand, collecting all documents including studies, conference proceedings and theses available in this field is a notable point in developing this study.

Misuse of AAS among elite and recreational athletes is a key global health issue. This study is the first systematic review and meta-analysis assessing the prevalence rate of AAS consumption in Iranian athletes. Results extracted from this study could be a valuable guide and baseline information for design of efficient strategies and developing next steps (including educational measures) for preventive policy-making and promoting awareness and knowledge about risks and complications of AAS misuse among elite and recreational athletes is mandated.

**Conclusion**

According to the higher prevalence of AAS misuse in Iranian athletic population compared to global statics and potential of serious adverse effects, preventive strategies and policies should be considered as a real concern for public health.
Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

Acknowledgements

The authors highly appreciate the cooperation of Sports Medicine Research Center and department of Sports and Exercise Medicine – Tehran University of Medical Sciences Staff who aided us for this project.

Conflict of interest

The authors declare that there is no conflict of interest.

References

1. Hartgens F, Kuipers H (2004). Effects of androgenic-anabolic steroids in athletes. Sports Med, 34(8):513-54.
2. Sagoe D, Molde H, Andreassen CS, et al (2014). The global epidemiology of anabolic-androgenic steroid use: a meta-analysis and meta-regression analysis. Ann Epidemiol, 24(5):383-98.
3. Halabchi F (2009). Doping in combat sports. In: Combat sports medicine. Eds, Kordi R, Maffuli N, Wroble RR and Wallace WA. 1st ed, Springer. London, pp. 55-72.
4. Halabchi F, Esteghamati A, Razzaghi A, Noori A (2011). How the Iranian free-style wrestlers know and think about doping? A knowledge and attitude study. IFASET, 59:209-14.
5. Seif-Barghi T, Halabchi F, Dvorak J, et al (2015). How the Iranian football coaches and players know about doping? Asian J Sports Med, 6(74):e24392
6. Bates G, Begley E, Tod D, et al (2019). A systematic review investigating the behaviour change strategies in interventions to prevent misuse of anabolic steroids. J Health Psychol, 24(11):1595-1612.
7. Mulcahey MK, Schiller JR, Hulstyn MJ (2010). Anabolic steroid use in adolescents: identification of those at risk and strategies for prevention. Phys Sportmed, 38(62):105-13.
8. Jalilian F, Allahverdipour H, Moeini B, et al (2011). Effectiveness of anabolic steroid preventative intervention among gym users: Applying theory of planned behavior. Health Promot Perspect, 1(62):32-40.
9. Halabchi F (2007). Doping in athletes. Hakim Res J, 10(62):1-12.
10. Moher D, Liberati A, Tetzlaff J, et al (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med, 6(7):e1000097.
11. Munn Z, Moola S, Lisy K, et al (2015). Methodological guidance for systematic reviews of observational epidemiological studies reporting prevalence and cumulative incidence data. Int J Evid Based Healthc, 13(62):147-53.
12. Ebell MH, Siwek J, Weiss BD, et al (2004). Strength of recommendation taxonomy (SORT): a patient-centered approach to grading evidence in the medical literature. Am Fam Physician, 69(3):548-56.
13. Borenstein M, Hedges L, Higgins J, Rothstein H. (2005) Comprehensive meta analysis. Version 2. Biostat. Englewood NJ.
14. Aghili M, Gholami M (2011). Prevalence of ergogenic substance misuse and awareness toward the side effects of doping agents in male bodybuilders of Tehran 2011: 6th scientific-students congress on physical education and sport sciences; Tehran: Ministry of Science, Research and Technology.
15. Aliabadi S, Hesami S (2014). The Relation between Awareness, Attitude and the Amount of Doping Substances and Illegal Supplements in Body Builders of Sanandaj, Iran. Arab J Business Manag Rev (Oman Chapter),4(62):73.
16. Alidoust Ghahfarrokhi E, Mokhlesi S, Shariati J (2017). An investigation of consumption and awareness of side effects of doping and weight loss drugs in non-professional athletes in Tehran fitness clubs. Sport Physiol Manag Invest, 9(74):113-126.
17. Allahverdipour H, Jalilian F, Shaghahi A (2012). Vulnerability and the intention to anabolic...
steroids use among Iranian gym users: An application of the theory of planned behavior. Subst Use Misuse, 47(62):309-17.
18. Angoorani H, Jalali M, Halabchi F (2018). Anabolic-androgenic steroids and prohibited substances misuse among Iranian recreational female bodybuilders and its associated psycho-socio-demographic factors. Addict Health, 10(4):216-222.
19. Angoorani H, Halabchi F (2015). The misuse of anabolic-androgenic steroids among Iranian recreational male body-builders and their related psycho-socio-demographic factors. Iran J Public Health, 44(12):1662-1669.
20. Arazi H, Bazyar F (2014). The prevalence of anabolic steroid misuse and the awareness about its negative effects among bodybuilders in Karaj city. Alborz Univ Med J, 3(62):48-56.
21. Arazi H, Salehi A (2013). Attitude and awareness of male bodybuilders toward adverse effects of anabolic-androgenic steroids in Qazvin, Iran. Iran J Epidemiol, 9(74): 45-53.
22. Arazi H, Hosseini R (2012). The prevalence of anabolic-androgenic steroids abuse, knowledge and attitude of their side effects, and attitude toward them among the bodybuilding athletes in Rasht. J Guilan Uni Med Sæ, 20(80):34-41.
23. Bahrami S, Yousefi B, Kaviani E, Ariapooran S (2014). The prevalence of energetic drugs use and the role of perfectionism, sensation seeking and physical self-concept in discriminating bodybuilders with positive and negative attitude toward doping. International Journal of Sport Studies, 4:174-180.
24. Bijeh N, Dehbashi M, Saghi M (2015). Studying the amount of prevalence awareness and complications of anabolic steroids among the male athletes in Mashhad city. Journal of Practical Studies at Biosciences in Sport, 2(4):78-89.
25. Eskandarion M, Kheirvarz Khezerloo J, et al (2019). Prevalence of anabolic steroids among the male bodybuilding athletes and rate of awareness to side effects in Shahroud. Sæ J Forensic Med, 25(1):1-7.
26. Fakhari rad F, Gholami M (2014). The prevalence of the use of ergogenic aids and awareness of their side effects among Iranian body builders. Int J Sport Stud, 4(7):830-5.
27. Fijan A, Effekhari MH, Dashtabi A (2018). The prevalence of anabolic androgenic steroid misuse and its associated factors among bodybuilders in Shiraz, Iran. Int J Nutr Sæ, 3(3):151-156.
28. Ghaderi H, Malekpoor Tehrani A, et al (2019). Using of anabolic steroids and its association with mental health and body image concept in men referring to sports clubs in Iran. Pak J Med Health Sæ, 13(2): 559-564.
29. Haerinejad MJ, Ostovar A, Farzaneh MR, et al (2016). The prevalence and characteristics of performance-enhancing drug use among bodybuilding athletes in the south of Iran, Bushehr. Asian J Sports Med, 7(3):e35018.
30. Hazavehei MM, Abdolmaleki MH (1999). The study of using anabolic androgenic steroid among body builders in Hamadan city in 1997. Avicenna J Clin Med, 6(2):0-0.
31. Hoseini Kakhak A. Investigating prevalence of ergogenic substances (drugs, protein and vitamin supplements) in elite bodybuilders of Tehran and Mashhad. [Master's Thesis], Tarbiat Moallem University, Iran; 2001.
32. Khabiri A. Evaluation of knowledge and prevalence of using supplements and stimulating drugs in elite athletes in the province of East Azarbaijan. [Master's Thesis], Tabriz University of Medical Sciences, Iran; 2019.
33. Madani AH, Aghamolaei T, Davoodi SH, et al (2017). Prevalence of Anabolic Steroids abuse and awareness of its effects in male athletes in Southern Iran. J Prevent Med, 4(1):27-33.
34. Mahdavi M, Shooshtarizadeh ASF, Sadri B, et al (2012). Study of prevalence of consumption and consumer awareness of doping substances and supplements side effects among male bodybuilders in Karaj. Res Pharm Sæ, 7(5):S65.
35. Malek M, Ghanaei M, Ghorbani R (2005). Survey of the frequency percentage of doping drugs among the male body building athletes and rate of knowledge to side effects. Koomesh, 6(2): 123-30.
36. Minasian V, Sarlak M (2010). Prevalence, attitude and knowledge of side effects of ergogenic substances in elite athletes of national teams and professional clubs of Tehran province. Sport Manag Stud, 4(25):119-30.
37. Nakhaei MR, Pakravan F, Nakhaei N (2013). Prevalence of use of anabolic steroids by
bodybuilders using three methods in a city of Iran. *Addict Health*, 5(3-4):77-82.
38. Noroozii M, Bahravan V (2005). Study of Anabolic Steroids and the Awareness of their Complications in Bodybuilding Athletes in Karaj (2003). *J/MS*, 11(44):1057-1063.
39. Pasharavesh I, Ramandi M, Khoshbooo S, et al (2008). Prevalence of Doping Agents' Abuse and Male Bodybuilders' Knowledge about their Side Effects in Kermanshah Gymnasiums (2004). *Journal of Kermanshah University of Medical Sciences (Bibbod)*, 11(4):418-427.
40. Rahimi MA, Siabani H, Siabani S, et al (2008). Effect of education on performance-enhancing drug abuse by bodybuilders. *Journal of Kermanshah University of Medical*, 12(1): e80106.
41. Rashid Lamir A, Dehbash M, Taghizadeh V (2014). Study the prevalence of legal and illegal supplements between athlete's men in Bodybuilders and powerlifting field. *Shomad J Manag & Physical Sport*, 2(1):1-11. [Persian]
42. Razavi Z, Moinei B, Shafiei Y, Bazmamouns H (2014). Prevalence of anabolic steroid use and associated factors among bodybuilders in Hamadan, western province of Iran. *J Res Health Sci*, 14(2):163-6.
43. Rezaei SMA (2017). Study the prevalence of anabolic steroids consumption among bodybuilding athletes in Yasuj, Iran. *Int J Nutr Sāi*, 2(2):103-108.
44. Saeidinejat S, Hooshmand E, Zahra H, et al (2017). Evaluating the pattern of anabolic androgenic steroid use and its relation with mental health of male members of bodybuilding clubs in Iran in 2015. *Asian J Sports Med*, 9(1):e00164.
45. Sepehri G, Mousavi Fard M, Sepehri E (2009). Frequency of anabolic steroids abuse in bodybuilder athletes in Kerman city. *Addict Health*, 1(1):25-9.
46. Shahsavani A (2014). Prevalence of doping drug use and awareness of their adverse effects among bodybuilding athletes in Zahedan. *Adv Environ Biol*, 8(17):1306-9.
47. Sharifirad GR, AhmadzadehSani F, Mohebi S, et al (2011). Identification of factors related to the use of doping drugs and its side effects on body building athletes in Gonabad based on health belief model. The First International & 4th National Congress on Health Education & Promotion, 16-19 May 2011, Tabriz-Iran. Health Prom Persp.
48. Shojaee Mahallati A. Frequency of Nutrition Supplements and energy enhancing drugs in bodybuilding athletes in Tehran. [M.D. Thesis], Islamic Azad University of Tehran, Iran; 1999.
49. Sobhanian S, Rajabian D, Sadeghi F, Parsayee, Manesh E (2013). Frequency of the use of anabolic drugs in bodybuilding athletes in Jahrom city. *J Jahrom Univ Med Sāi*, 11(3):30-4.
50. Taghavi SMR. Determining the awareness and usage degree of doping among body-builders in Zahedan in 2002. [M.D. Thesis] Sistan and Baluchestan University of Medical Sciences, Iran; 2003.
51. Zakeri A (2012). The frequency of infertility following anabolic steroid in bodybuilders in Tehran in 2010. *Iran J Obstet Gynecol Infertil*, 15(2): 29-34.
52. Mottram DR, Chester N (2018). *Drugs in sport*. 7th ed. Routledge Taylor & Francis, Oxfordshire, pp.:34-67.
53. Sagoe D, Torsheim Tr, Molde H, et al (2015). Anabolic-androgenic steroid use in the Nordic countries: A meta-analysis and meta-regression analysis. *Nordic Stud Alcohol Drug*, 32(1):7-20.
54. Al Bishi KA, Afiy A (2017). Prevalence and awareness of Anabolic Androgenic Steroids (AAS) among gymnasts in the western province of Riyadh, Saudi Arabia. *Electron Physician*, 9(12):6050-6057.
55. Afolayan J (2012). Knowledge and use of performance enhancing drugs among Nigeria elite athletes. *OSR Journal of Applied Chemistry*, 138-31(5).
56. Bagge AL, Rosén T, Fahilde C, et al (2017). Somatic effects of AAS abuse: a 30-years follow-up study of male former power sports athletes. *J Sci Med Sport*, 20(9):814-818.
57. Abrahami OSC, de Sousa EC, Santos AM (2014). Prevalence of the use of anabolic-androgenic steroids in Brazil: a systematic review. *Subst Use Misuse*, 49(9):1156-62.
58. Harmer PA (2010). Anabolic-androgenic steroid use among young male and female athletes: is the game to blame? *Br J Sports Med*, 44(62):26-31.

Available at: [http://ijph.tums.ac.ir](http://ijph.tums.ac.ir)
59. Bird SR, Goebel C, Burke LM, et al (2016). Doping in sport and exercise: anabolic, ergogenic, health and clinical issues. *Ann Clin Biochem*, 53(Pt 2):196-221.

60. Pope Jr HG, Kanayama G, Athey A, et al (2014). The lifetime prevalence of anabolic-androgenic steroid use and dependence in Americans: Current best estimates. *Am J Addict*, 23(4):371-7.

61. World Anti-Doping Agency (2019). 2019 Anti-doping testing figures. Montreal, Canada. https://www.wada-ama.org/sites/default/files/resources/files/2019_anti-doping_testing_figures_en.pdf