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Androgenic-anabolic steroids use among bodybuilders in western Iran: application of ridge logistic regression model

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Abstract

Introduction Nowadays, the use of androgenic-anabolic steroids (AAS) by competitive and non-competitive bodybuilders and its side effects have become a major public health problem. Many studies have focused on determining the role and severity of various factors in AAS use, but the existence of collinearity between the factors leads to the non-significance of important factors. The study aimed to determine factors affecting the androgenic-anabolic steroids use in Iranian bodybuilders.

Method This descriptive-analytical study was performed on 280 male bodybuilders (142 non-competitive and 138 competitive bodybuilders) in Hamadan, west of Iran, in 2016. The participations were recruited a multistage sampling method. A self-administrated questionnaire was used, which included parts such as intrapersonal, interpersonal, and behavioral factors affecting on AAS use. To solve the consequences of collinearity was used ridge logistic regression model (RLRM) in R.3.5.1 software.

Results The mean age of bodybuilders was 25.21 years (SD = 6.31). The prevalence rate of AAS use among non-competitive and competitive bodybuilders was 27.5% and 34.1%, respectively. Factors such as age, time of starting bodybuilding, attitude, physical self-concept, behavioral intention, coach and friend use AAS, alcohol consumption, and supplement use were associated with AAS use among non-competitive and competitive bodybuilders.

Conclusion The results of the study indicated that a combination of intrapersonal, interpersonal and behavioral factors was effective on the androgenic-anabolic steroids use among Iranian bodybuilders. Adequate education about the side effects of AAS and improvement of individual skills seem to be helpful in reducing AAS use.

Keywords Bodybuilder, Steroid, Collinearity, Ridge logistic regression model

Introduction

The widespread use of muscular men in media has challenged the body image of men. Developments in bodybuilding, promotion in bodybuilding contests, and financial rewards in these contests can be very attractive for young men. Such issues have caused high interest in men toward this area, whether for fitness and gaining muscle or preparing for bodybuilding competitions. Thus, some competitive or non-competitive bodybuilders use androgenic-anabolic steroids (AAS) to speed up the muscle-building process [1–4].

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Androgenic-anabolic steroids are classified under different trade names which are synthetic derivatives of the male hormone testosterone. AAS Abuse has become an important public health concern worldwide due to its serious and dangerous side effects. The evidence indicates that infertility, hair loss, pimples, acne, thickening of the voice, heart disease, cancer, and testicular atrophy are reported as the side effects of AAS abuse [5–8]. The AAS abuse has also led to psychological problems like depression, aggression, anxiety, and sleep disorders [7, 9–11]. The results of a meta-analysis (2014) reported that the worldwide prevalence rates of AAS use by athletes and recreational athletes were estimated at 13.4% and 18.4%, respectively [12]. The prevalence rate of AAS use by Iranian bodybuilders has been estimated 32.9%. [13].

The role of intrapersonal, interpersonal, and behavioral factors affecting the androgenic-anabolic steroids use has been documented among bodybuilders [14, 15]. In previous studies, a point that has not been paid attention to is that modeling these factors may have inherent collinearity. Collinearity is defined as the relationship between predictor variables that it has some serious effects such as inflation in the variance of estimators and the non-significance of important variables. On the other hand, the contribution of each predictor variable is not separable due to collinearity [16].

Due to the non-significance of the predictor variables arising from collinearity, some researchers fit a regression model for each predictor variable. Although this seems to eliminate the collinearity, it leads to model underestimation [17]. Because of the inherent collinearity between intrapersonal, interpersonal, and behavioral factors, it is essential to control the consequences of collinearity. In this study, factors affecting the use of anabolic steroids among bodybuilders in Hamadan were determined with an appropriate model.

Methods

Study setting, population, and sampling method

This descriptive-analytical study was performed on 280 male bodybuilders in Hamadan, west of Iran, in 2016. The participations were recruited a multistage sampling method. For this, each geographical region of Hamadan city was considered as a region (three regions). Then, 12 gyms were randomly chosen from each region and from each gym, 25 bodybuilders were selected by simple sampling method. In totally, 300 bodybuilders who 280 bodybuilders completed a questionnaire (Response rate = 93.3%). Inclusion criteria were considered ages > 15 years, attending gyms at least twice a week, and no history of physical or mental disorders. Before filling out the questionnaire, an informed consent form was obtained from bodybuilders. The questionnaires

with incomplete information were excluded. In this study, a competitive and non-competitive bodybuilder were defined as a person who participates in bodybuilding competitions and a person who does not participate in any bodybuilding competition, respectively. The study was approved by the Ethics committee of Hamadan University of Medical Sciences, Iran (No. IR.UMSHA.REC.1395.356).

Measurement

A self-administrated questionnaire was used. Detailed information is provided in the Additional file 1.

Statistical methods and software

In this study the collinearity between predictor variables was examined by extracting the condition number. Because the condition number is based on the eigenvalues of the correlation matrix, it gives an accurate view of the collinearity status between the predictor variables. This index is the square root of the maximum eigenvalue divided by the minimum eigenvalue of the correlation matrix. This value was 198, which indicates severe collinearity [18]. In this survey, the response variable was AAS use (yes/no). The ridge logistic regression model (RLRM) was used to solve the consequences of collinearity, such as inflation, in the variance of estimators and non-significance of important variables [19]. Indeed, the RLRM is an extension of the ordinary logistic model. In RLRM, the variance of the estimator remarkably decreases by adding a small bias. Here, all the analyses were conducted with R.3.5.1 software at the significance level of 0.05.

Results

Totally, 142 non-competitive bodybuilders and 138 competitive bodybuilders (113 people at the regional level and 25 people at the national level) participated in this study. Characteristics of participated bodybuilders is reported in Table 1. The mean age of bodybuilders was 25.21 years (SD = 6.31).

The mean (SD) ages of non-competitive and competitive bodybuilders were 24.88(6.49) and 25.54 (6.21), respectively. The prevalence rates of AAS use in non-competitive and competitive bodybuilders were 27.5% and 34.1%, respectively. Also, the relation between AAS use and bodybuilders' status (competitive and non-competitive) were tested with chi-square ($p=0.232$).

Table 2 shows the results of affecting factors on AAS use for non-competitive bodybuilders. These results showed that people who are older are less likely to use AAS (OR = 0.881 [0.856–0.908]; $p < 0.001$). Also, subjects with more gym history are less likely to use AAS (OR = 0.902 [0.899–0.906]; $p < 0.001$). BMI and physical self-concept are other factors that have a negative

Table 1 Characteristics of participated bodybuilders (n = 280)

Variable	Non-competitive (n = 142) n (%)	Competitive (n = 138) n (%)
<i>Material status</i>		
Single	116 (81.7)	107 (77.5)
Married	26 (18.3)	31 (22.5)
<i>Education level</i>		
Under diploma	17 (12.0)	16 (11.6)
Diploma	63 (43.7)	57 (41.3)
Academic	63 (44.3)	55 (47.1)
<i>Occupation</i>		
Employed	25 (17.6)	18 (13.1)
Self-employed	81 (57.0)	82 (59.4)
Unemployed	36 (25.4)	38 (27.5)
<i>AAS use</i>		
Yes	39 (27.5)	47 (34.1)
No	103 (72.5)	91 (65.9)

relationship with AAS use. Bodybuilders with more BMI is less likely to use AAS (OR = 0.937 [0.896–0.980]; $p = 0.005$). This result is also true for physical self-concept (OR = 0.804 [0.776–0.835]; $p < 0.001$). On the other hand, the odds of AAS use increase by 16% in people who have a more positive attitude (OR = 1.164 [1.117–1.213]; $p < 0.001$).

Bodybuilders with higher behavioral intentions have 19% higher odds of taking AAS (OR = 1.190 [1.127–1.257]; $p < 0.001$). When the coach is an AAS user,

the odds of taking AAS for bodybuilders are 2 times (OR = 2.012 [1.561–2.671]; $p < 0.001$). In addition, for bodybuilders whose friends take AAS, the odds of taking AAS increase by 2.3 times (OR = 2.332 [1.815–2.998]; $p < 0.001$). Consumption of alcohol and supplements by bodybuilders increases the chance of steroid use by 82% and 70% (OR = 1.827 [1.323–2.525]; $p < 0.001$, OR = 1.702 [1.312–2.209]; $p < 0.001$). Moreover, bodybuilders who smoke are 2.1 times more likely to use steroids (OR = 2.120 [1.407–3.192]; $p < 0.001$).

Table 3 provides the results affecting factors on AAS use for competitive bodybuilders. People who are older or have longer time to start bodybuilding is higher are less likely to use AAS (OR = 0.927 [0.641–1.344]; $p < 0.001$, OR = 0.913 [0.847–1.416]; $p < 0.001$). Also, bodybuilders who have higher Physical self-concept have fewer odds to use AAS (OR = 0.798 [0.151–4.225]; $p < 0.001$). For people whose scores of attitude, behavioral intention, and desire are higher, the odds of using AAS increases by 10%, 24%, and 13%, respectively (OR = 1.108 [0.270–4.550]; $p < 0.001$, OR = 1.245 [0.216–7.180]; $p < 0.001$, OR = 1.132 [0.582–2.200]; $p < 0.001$).

The odds of using AAS is 70% higher in bodybuilders whose coach also uses AAS (OR = 1.749 [1.334–2.292]; $p < 0.001$). The odds of taking AAS is 2.8 times higher for those whose friend uses AAS (OR = 2.820 [0.983–8.129]; $p < 0.001$). Subjects who use alcohol or supplements have 2, and 2.2 times more likely AAS use (OR = 2.045 [1.789–2.336]; $p < 0.001$, OR = 2.256 [1.376–3.695]; $p < 0.001$, respectively).

Table 2 Affecting factors on AAS use for non-competitive bodybuilders

Variable	$\hat{\beta}$	SE ($\hat{\beta}$)	Odds ratio	95% CI	p-value
<i>Intrapersonal factors</i>					
Age	-0.126	0.015	0.881	(0.856, 0.908)	< 0.001
Time of starting the bodybuilding	-0.103	0.002	0.902	(0.899, 0.906)	< 0.001
Body mass index	-0.065	0.023	0.937	(0.896, 0.980)	0.005
Attitude	0.152	0.021	1.164	(1.117, 1.213)	< 0.001
Subjective norms	0.011	0.027	1.011	(0.959, 1.066)	0.684
Physical self-concept	-0.217	0.019	0.804	(0.776, 0.835)	< 0.001
Behavioral intention	0.174	0.028	1.190	(1.127, 1.257)	< 0.001
Behavioral willingness	0.033	0.033	1.034	(0.969, 1.103)	0.314
<i>Interpersonal factors</i>					
Coach use AAS	0.714	0.137	2.012	(1.561, 2.671)	< 0.001
Friend use AAS	0.847	0.128	2.332	(1.815, 2.998)	< 0.001
<i>Behavioral factors</i>					
Alcohol consumption	0.603	0.165	1.827	(1.323, 2.525)	< 0.001
Smoking	0.751	0.209	2.120	(1.407, 3.192)	< 0.001
Supplement use	0.532	0.133	1.702	(1.312, 2.209)	< 0.001

Table 3 Affecting factors on AAS use for competitive bodybuilders

Variable	$\hat{\beta}$	SE ($\hat{\beta}$)	Odds ratio	95% CI	p-value
<i>Intrapersonal factors</i>					
Age	- 0.075	0.189	0.927	(0.641, 1.344)	< 0.001
Time of starting the bodybuilding	- 0.091	0.131	0.913	(0.847, 1.416)	< 0.001
Body mass index	0.031	0.345	1.032	(0.525, 2.028)	0.194
Attitude	0.102	0.721	1.108	(0.270, 4.550)	< 0.001
Subjective norms	0.016	0.073	1.017	(0.881, 1.172)	0.546
Physical self-concept	- 0.225	0.850	0.798	(0.151, 4.225)	< 0.001
Behavioral intention	0.219	0.894	1.245	(0.216, 7.180)	< 0.001
Behavioral willingness	0.124	0.339	1.132	(0.582, 2.200)	< 0.001
<i>Interpersonal factors</i>					
Coach use AAS	0.559	0.138	1.749	(1.334, 2.292)	< 0.001
Friend use AAS	1.039	0.539	2.820	(0.983, 8.129)	< 0.001
<i>Behavioral factors</i>					
Alcohol consumption	0.715	0.068	2.045	(1.789, 2.336)	< 0.001
Smoking	0.070	0.249	1.072	(0.658, 1.747)	0.676
Supplement use	0.813	0.252	2.256	(1.376, 3.695)	< 0.001

Tables 4 and 5 show the result of RMLM for competitive bodybuilders at the national and regional levels. According to Table 4, national-level bodybuilders who are older are less likely to use AAS. Also, at this level of bodybuilders, people who smoke or take supplements are less likely to use AAS (OR = 0.307 [0.148–0.634]; $p = 0.001$, OR = 0.562 [0.328–0.964]; $p = 0.036$, respectively). By increasing BMI, the odds of steroid use increase by 14% (OR = 1.148 [1.019–1.293]; $p = 0.023$).

Based on Table 5, in competitive bodybuilders at the regional level, older subjects have less likely to use AAS (OR = 0.952 [0.918–0.988]; $p = 0.009$). Also, people who have been doing bodybuilding for a longer period of time are less likely to use AAS (OR = 0.932 [0.928–0.935]; $p < 0.001$). At this level of bodybuilders, when physical self-concept or behavioral willingness is higher, the odds of steroid use are lower (OR = 0.809 [0.771–0.848]; $p < 0.001$, OR = 0.872 [0.805–0.945]; $p = 0.001$,

Table 4 Affecting factors on AAS use for national level competitive bodybuilders

Variable	$\hat{\beta}$	SE ($\hat{\beta}$)	Odds ratio	95% CI	p-value
<i>Intrapersonal factors</i>					
Age	- 0.204	0.045	0.815	(0.746, 0.891)	< 0.001
Time of starting the bodybuilding	0.018	0.003	1.012	(1.012, 1.025)	< 0.001
Body mass index	0.138	0.061	1.148	(1.019, 1.293)	0.023
Attitude	- 0.014	0.066	0.986	(0.865, 1.123)	0.829
Subjective norms	0.139	0.115	1.149	(0.917, 1.439)	0.227
Physical self-concept	- 0.090	0.054	0.914	(0.822, 1.015)	0.093
Behavioral intention	0.040	0.110	1.041	(0.839, 1.291)	0.716
Behavioral willingness	0.010	0.080	1.010	(0.864, 1.181)	0.899
<i>Interpersonal factors</i>					
Coach use AAS	0.933	0.437	2.542	(1.080, 5.983)	0.033
Friend use AAS	0.075	0.345	1.078	(0.548, 2.120)	0.829
<i>Behavioral factors</i>					
Alcohol consumption	0.436	0.390	1.547	(0.720, 3.325)	0.264
Smoking	- 1.182	0.370	0.307	(0.148, 0.634)	0.001
Supplement use	- 0.576	0.275	0.562	(0.328, 0.964)	0.036

Table 5 Affecting factors on AAS use for regional level competitive bodybuilders

Variable	$\hat{\beta}$	SE ($\hat{\beta}$)	Odds ratio	95% CI	p-value
<i>Intrapersonal factors</i>					
Age	-0.049	0.019	0.952	(0.918,0.988)	0.009
Time of starting the bodybuilding	-0.071	0.002	0.932	(0.928,0.935)	<0.001
Body mass index	0.023	0.027	1.023	(0.970,1.079)	0.403
Attitude	0.107	0.024	1.113	(1.062,1.165)	<0.001
Subjective norms	-0.020	0.032	0.980	(0.921,1.043)	0.523
Physical self-concept	-0.212	0.024	0.809	(0.771,0.848)	<0.001
Behavioral intention	0.224	0.039	1.250	(1.159,1.349)	<0.001
Behavioral willingness	-0.136	0.041	0.872	(0.805,0.945)	0.001
<i>Interpersonal factors</i>					
Coach use AAS	0.332	0.140	1.394	(1.059,1.835)	0.018
Friend use AAS	1.045	0.143	2.842	(2.147,3.762)	<0.001
<i>Behavioral factors</i>					
Alcohol consumption	0.622	0.241	1.862	(1.162,2.985)	0.010
Smoking	0.041	0.185	1.041	(0.725,1.496)	0.826
Supplement use	0.969	0.162	2.636	(1.919,3.621)	<0.001

respectively). People who have a higher score in attitude and behavioral intention increase the odds of using AAS by 11% and 25% (OR = 1.113 [1.062–1.165]; $p < 0.001$, OR = 1.250 [1.159–1.349]; $p < 0.001$, respectively).

The coach's use of steroids and alcohol consumption for these bodybuilders increase the odds of using AAS by 39% and 86% (OR = 1.394 [1.059–1.835]; $p = 0.018$, OR = 1.862 [1.162–2.985]; $p = 0.010$, respectively). When a bodybuilder's friend uses AAS or the bodybuilder takes supplements, the odds of using AAS increases by 2.8, and 2.6 times (OR = 2.842 [2.147–3.762]; $p < 0.001$, OR = 2.636 [1.919–3.621]; $p < 0.001$, respectively).

Discussion

This study investigated the factors affecting AAS use in non-competitive and competitive bodybuilders. The prevalence rate of AAS use among non-competitive and competitive bodybuilders was 27.5% and 34.1%, respectively,

although the relationship between AAS use and the bodybuilders' status (competitive and non-competitive) was not significant. In the available evidence, more AAS use is seen in both competitive bodybuilders [20] and non-competitive bodybuilders [21]. In our study, about one-third of competitive and non-competitive bodybuilders used AAS. It seems that only competitive goals can't justify the use of AAS. Adolescents' and young adults' attention to body shape and body image through increasing muscle mass has been documented, so that some of these people believe that boys/men with bigger muscles are more attractive [22]. The evidence indicates

that the reasons for the use of AAS could be the pressure of the press to compete and win, positive attitude towards doping to achieve success, people's unrealistic expectations from competitions, the pressure of coaches, the lack of monitoring of consumption, the competitive personality of the bodybuilder, attracting the attention of the spectators of sports competitions, the heavy schedule of a bodybuilder's competitions, increasing strength, muscle mass, and endurance pointed out [23–25].

The ridge logistic regression was applied with respect to severe collinearity between predictors. This study showed that younger bodybuilders and those with less experience in the gym were more likely to use steroids in both groups of bodybuilders, which was consistent with Wichstrom [26]. The possible reason for this result could be that with increasing age and more experience using the gym, the intensity of emotions decreases and the person understands the facts more than in the past.

An inverse relationship was found between BMI and AAS use in non-competitive bodybuilders, which confirms the results of the study by Mattila et al. [27]. It is possible that non-competitive bodybuilders attend the gym to build muscles and may use AAS to speed up the process.

The present study revealed a positive association between AAS use with intention and attitude toward AAS use in both groups. Also, AAS use was associated with a lower physical self-concept in both groups. This finding supports in the other studies [28–31]. Positive intention and attitude towards an issue usually lead to doing that behavior, and a negative physical self-concept

may cause a person haste in muscle building. For competitive bodybuilders, there was a relationship between behavioral willingness and AAS use. It may be because using steroids is not banned for bodybuilders in competitions hence, they easily show a desire to use.

The use of AAS by coaches and friends has a positive effect on bodybuilders' AAS use. This association was observed in both competitive and non-competitive bodybuilders. These results support previous research findings [32, 33] and can be attributed to the fact that the coach usually gives the bodybuilding exercise program and consultation, and may also sell these steroids. On the other hand, compliments are common in Iranian culture and a bodybuilder may be tempted to receive it by a close friend. Additionally, a friend has the role of a training opponent who is to be beaten by the bodybuilder.

Among behavioral factors, alcohol and supplement use were positively associated with AAS use. This relationship was seen in both groups of bodybuilders. In accordance with the present results, previous studies have demonstrated a positive relationship between alcohol and supplement consumption and AAS use [34–37]. Smoking had a positive effect on steroid use among bodybuilders which the previous study has reported such results [38].

Limitations

The results of the current study should be interpreted in light of some limitations. First limitation was related to cross-sectional design and observed associations did not show the causality. Another limitation of our study was that data was obtained using self-reported data that may be associated with social desirability bias and due to the risky nature of the behavior of using androgenic-anabolic steroids, some bodybuilders may refuse to tell the truth. Finally, the study was conducted only among male bodybuilders. So, the generalizability of the results is limited because our sample consisted of men.

Conclusions

The results of the study indicated that a combination of intrapersonal, interpersonal and behavioral factors was effective on the androgenic-anabolic steroids use among Iranian bodybuilders. Adequate education about the side effects of AAS and improvement of individual skills seem to be helpful in reducing AAS use.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s13102-023-00616-4>.

Additional file 1: Measurement details.

Acknowledgements

The authors are grateful to all of the bodybuilders who participated in this study.

Author contributions

Study design: SK, JF, HM, Data acquisition, analysis and interpretation: SK, SK, MB, JF, Writing of the first draft: SK, SK, and JF. Revising first draft for important intellectual content: SK, SK, MB, HM and JF. All the authors have read and approved the final version of the manuscript.

Funding

This study was supported by the Vice Chancellor for Research and Technology of Hamadan University of Medical Sciences financially (No. 9804253413).

Availability of data and materials

The analyzed dataset in this study is available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study was approved by the Ethics committee of Hamadan University of Medical Sciences, Iran (No. IR.UMSHA.REC.1395.356). The informed consent form was obtained from all bodybuilders. All methods were carried out in accordance with the Declaration of Helsinki and relevant regulations.

Consent for publication

Not applicable.

Competing interests

The author declares that they have no competing interests.

Received: 5 October 2022 Accepted: 9 January 2023

Published online: 11 January 2023

References

- Bateman O, Žeželj D. Steroid solidarity: the culture of juicing at the Mr. Olympia competition. *Va Q Rev.* 2017;93(3):60–72.
- Pereira E, Moyses SJ, Ignácio SA, Mendes DK, Silva DSDA, Carneiro E, et al. Prevalence and profile of users and non-users of anabolic steroids among resistance training practitioners. *BMC Public Health.* 2019;19(1):1650.
- Perry PJ, Lund BC, Deninger MJ, Kutscher EC, Schneider J. Anabolic steroid use in weightlifters and bodybuilders: an internet survey of drug utilization. *Clin J Sport Med.* 2005;15(5):326–30.
- Zahnow R, McVeigh J, Bates G, Hope V, Kean J, Campbell J, et al. Identifying a typology of men who use anabolic androgenic steroids (AAS). *Int J Drug Policy.* 2018;55:105–12.
- Sekuła MJ, Świerczyńska B, Smoluchowski K, Undziakiewicz A, Pieciewicz-Szczęśna H. Hepatotoxicity of anabolic androgenic steroids in sport. *J Educ Health Sport.* 2020;10(9):349–56.
- Torrisi M, Pennisi G, Russo I, Amico F, Esposito M, Liberto A, et al. Sudden cardiac death in anabolic-androgenic steroid users: a literature review. *Medicina.* 2020;56(11):587.
- van Amsterdam J, Opperhuizen A, Hartgens F. Adverse health effects of anabolic-androgenic steroids. *Regul Toxicol Pharmacol.* 2010;57(1):117–23.
- Vorona E, Nieschlag E. Adverse effects of doping with anabolic androgenic steroids in competitive athletics, recreational sports and bodybuilding. *Minerva Endocrinol.* 2018;43(4):476–88.
- Angoorani H, Halabchi F. The misuse of anabolic-androgenic steroids among Iranian recreational male body-builders and their related psychosocio-demographic factors. *Iran J Public Health.* 2015;44(12):1662.
- Börjesson A, Möller C, Hagelin A, Vicente V, Rane A, Lehtihet M, et al. Male anabolic androgenic steroid users with personality disorders report more aggressive feelings, suicidal thoughts, and criminality. *Medicina.* 2020;56(6):265.

11. Havnes IA, Jørstad ML, Wisløff C. Anabolic-androgenic steroid users receiving health-related information; health problems, motivations to quit and treatment desires. *Subst Abuse Treat Prev Policy*. 2019;14(1):1–12.
12. Sagoe D, Molde H, Andreassen CS, Torsheim T, Pallesen S. The global epidemiology of anabolic-androgenic steroid use: a meta-analysis and meta-regression analysis. *Ann Epidemiol*. 2014;24(5):383–98.
13. Safari Tekyeh S, Yousefi B, Astinchap A. Anabolic steroids consumption prevalence and awareness of their side effects among male bodybuilders in Iran: a meta-analysis. *J Appl Health Stud Sport Physiol*. 2018;5(2):1–12.
14. Saeidinejat S, Hooshmand E, Zahra H, Najari AV. Evaluating the pattern of anabolic androgenic steroid use and its relation with mental health of male members of bodybuilding Clubs of Iran, in 2015. *Asian J Sports Med*. 2018;9(1):e60164.
15. Uddin Z, Iqbal Q, Haider S, Saleem F. Usage and perceptions of anabolic-androgenic steroids among male gym attendees in Quetta city, Pakistan—a descriptive analysis. *Res Pharmacy Health Sci*. 2019;5(2):152–7.
16. Dormann CF, Elith J, Bacher S, Buchmann C, Carl G, Carré G, et al. Collinearity: a review of methods to deal with it and a simulation study evaluating their performance. *Ecography*. 2013;36(1):27–46.
17. Hoerl AE, Kennard RW. Ridge regression: biased estimation for non-orthogonal problems. *Technometrics*. 1970;12(1):55–67.
18. Midi H, Sarkar SK, Rana S. Collinearity diagnostics of binary logistic regression model. *J Interdiscip Math*. 2010;13(3):253–67.
19. Schaefer RL. Alternative estimators in logistic regression when the data are collinear. *J Stat Comput Simul*. 1986;25(1–2):75–91.
20. Steele I, Pope H, Ip EJ, Barnett MJ, Kanayama G. Is competitive bodybuilding pathological? Survey of 984 male strength trainers. *BMJ Open Sport Exerc Med*. 2020;6(1):e000708.
21. Evans NA. Gym and tonic: a profile of 100 male steroid users. *Br J Sports Med*. 1997;31(1):54–8.
22. Nilsson S, Baigi A, Marklund B, Fridlund B. The prevalence of androgenic-anabolic steroids by adolescent in country of Sweden. *Eur J Public Health*. 2001;11:195–7.
23. Arazi H, Salehi A. Attitude and awareness of male bodybuilders toward adverse effects of anabolic-androgenic steroids in Qazvin, Iran. *Iran J Epidemiol*. 2014;9(3):45–53.
24. Halabchi F. Doping in athletes. *Hakim*. 2007;10(1):1–12.
25. Parkinson AB, Evans NA. Anabolic androgenic steroids: a survey of 500 users. *Med Sci Sports Exerc*. 2006;38(4):644–51.
26. Wichstrøm L. Predictors of future anabolic androgenic steroid use. *Med Sci Sports Exerc*. 2006;38(9):1578–83.
27. Mattila V, Rimpelä A, Jormanainen V, Sahi T, Pihlajamäki H. Anabolic-androgenic steroid use among young Finnish males. *Scand J Med Sci Sports*. 2010;20(2):330–5.
28. Al-Falasi O, Al-Dahmani K, Al-Eisaei K, Al-Ameri S, Al-Maskari F, Nagelkerke N, et al. Knowledge, attitude and practice of anabolic steroids use among gym users in Al-Ain district, United Arab Emirates. *Open Sports Med J*. 2008;2:75–81.
29. Bahrke MS, Yesalis CE, Kopstein AN, Stephens JA. Risk factors associated with anabolic-androgenic steroid use among adolescents. *Sports Med*. 2000;29(6):397–405.
30. Goulet C, Valois P, Buist A, Côté M. Predictors of the use of performance-enhancing substances by young athletes. *Clin J Sport Med*. 2010;20(4):243–8.
31. Shahhosseini M, Noury GR. Comparing body image, self-esteem and gender roles in the bodybuilder anabolic-androgenic steroid (AAS) users and nonusers. *Sports Psychol*. 2016;1(1):19–29.
32. Chng CL, Moore A. A study of steroid use among athletes: knowledge, attitude and use. *Health Educ*. 1990;21(6):12–7.
33. Sepehri G, Fard MM, Sepehri E. Frequency of anabolic steroids abuse in bodybuilder athletes in Kerman city. *Addict Health*. 2009;1(1):25.
34. Brower KJ. Anabolic steroid abuse and dependence. *Curr Psychiatry Rep*. 2002;4(5):377–87.
35. Hildebrandt T, Harty S, Langenbucher JW. Fitness supplements as a gateway substance for anabolic-androgenic steroid use. *Psychol Addict Behav*. 2012;26(4):955.
36. Ip EJ, Trinh K, Tenerowicz MJ, Pal J, Lindfelt TA, Perry PJ. Characteristics and behaviors of older male anabolic steroid users. *J Pharm Pract*. 2015;28(5):450–6.
37. Wright S, Grogan S, Hunter G. Motivations for anabolic steroid use among bodybuilders. *J Health Psychol*. 2000;5(4):566–71.
38. Nakhaee MR, Pakravan F, Nakhaee N. Prevalence of use of anabolic steroids by bodybuilders using three methods in a city of Iran. *Addict Health*. 2013;5(3–4):77–82.

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