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Anabolic-androgenic steroid use in the Nordic countries: A meta-analysis and meta-regression analysis

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ABSTRACT

AIMS – To investigate the lifetime prevalence and moderators of non-medical AAS use in the five Nordic countries. METHODS – We conducted a meta-analysis and meta-regression using studies gathered from searches in PsycINFO, PubMed, ISI Web of Science, Google Scholar, and reference checks. Included were 32 studies that provided original data on 48 lifetime prevalence rates based on a total of 233,475 inhabitants of the Nordic countries. RESULTS – The overall lifetime prevalence obtained was 2.1% [95% confidence interval (CI): 1.3-3.4, I^2 = 99.5, $P < 0.001$]. The prevalence for males, 2.9% (95% CI: 1.7-4.8, I^2 = 99.2, $P < 0.001$), was significantly higher (Q_{bet} = 40.5, P < 0.001) than the rate for females, 0.2% (95% CI: 0.1-0.4, I^2 = 90.5, P < 0.001). Sweden has the highest prevalence of AAS use: 4.4%, followed by Norway: 2.4%, Finland: 0.8%, Iceland: 0.7%, and Denmark: 0.5%. Country, sample type, and male sample percentage significantly predicted AAS use prevalence in a meta-regression analysis. No indication of publication bias was found. CONCLUSION – Though subject to some limitations, our findings suggest that non-medical AAS use should be regarded as a serious public health problem in the Nordic countries.

KEYWORDS – anabolic steroids, Nordic countries, Scandinavia, prevalence, meta-analysis, meta-regression

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Introduction

Anabolic–androgenic steroids (AAS) are a group of hormones including testosterone and its synthetic derivatives. These hormones are used clinically to treat conditions such as reproductive system dysfunction, breast cancer, and anemia. Increasingly, some healthy individuals have been using AAS for non-medical purposes (Boyadjiev, Georgieva, Massaldjieva, & Gueorguiev, 2000; Sagoe, Molde, Andreassen, Torsheim, & Pallesen, 2014a). Non-medical AAS use was mainly restricted to elite athletes and bodybuilders in the 1960s and 1970s as a means to enhance strength and athletic performance (Yesalis & Bahrke, 1995). Non-medical AAS use has however spread into the general population in the last few decades (Kanayama, Hudson, & Pope, 2008) mainly driven by a desire for boosting physical strength and improving appearance (Kanayama, Hudson, & Pope, 2010; Parkinson & Evans, 2006; Tanner, Miller, & Alongi, 1995). Indeed, results from a recent global epidemiological investigation indicates that recreational sportspeople constitute the largest group of AAS users (Sagoe et al., 2014a).

There is extensive evidence connecting

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long-term AAS use to criminality (Lood, Eklund, Garle, & Ahlner, 2012; Lundholm, Haggård, Möller, Hallqvist, & Thiblin, 2013) and several debilitating physical and psychological disorders as well as mortality (Bahrke & Yesalis, 2004; Dodge & Hoagland, 2011; Hoffman & Ratamess, 2006; Kanayama et al., 2008; Pallesen, Jøsendal, Johnesen, Larsen, & Molde, 2006; Pope, & Kanayama, 2012; Pope, Kanayama, & Hudson, 2012; Urhausen et al., 2004). Despite such evidence of the harmful consequences of non-medical use, AAS seem to be among the least studied of the world's major abused drugs (Pope et al., 2013). Hence, Degenhardt and Hall (2012) did not investigate the prevalence of AAS use in their study of the global prevalence of illicit drug use and dependence because of the scarcity of information regarding the AAS use epidemiology compared to drugs such as cocaine and cannabis.

Kanayama, Hudson, and Pope (2012) suggest that the prevalence of AAS use is higher in the Nordic countries compared to most other parts of the world. Several epidemiological investigations of AAS use have been conducted in the Nordic countries. However, to our knowledge, there has never been a pan-Nordic meta-analytic investigation of the prevalence of AAS use. Thus, we conducted a meta-analysis on the lifetime prevalence of non-medical AAS use in the Nordic countries. We calculated overall prevalence estimates across the Nordic countries, gender, publication year, sample type, and sampling method. We further investigated the predictive effect of the above study variables on the overall lifetime prevalence rate using a meta-regression analysis.

Methods

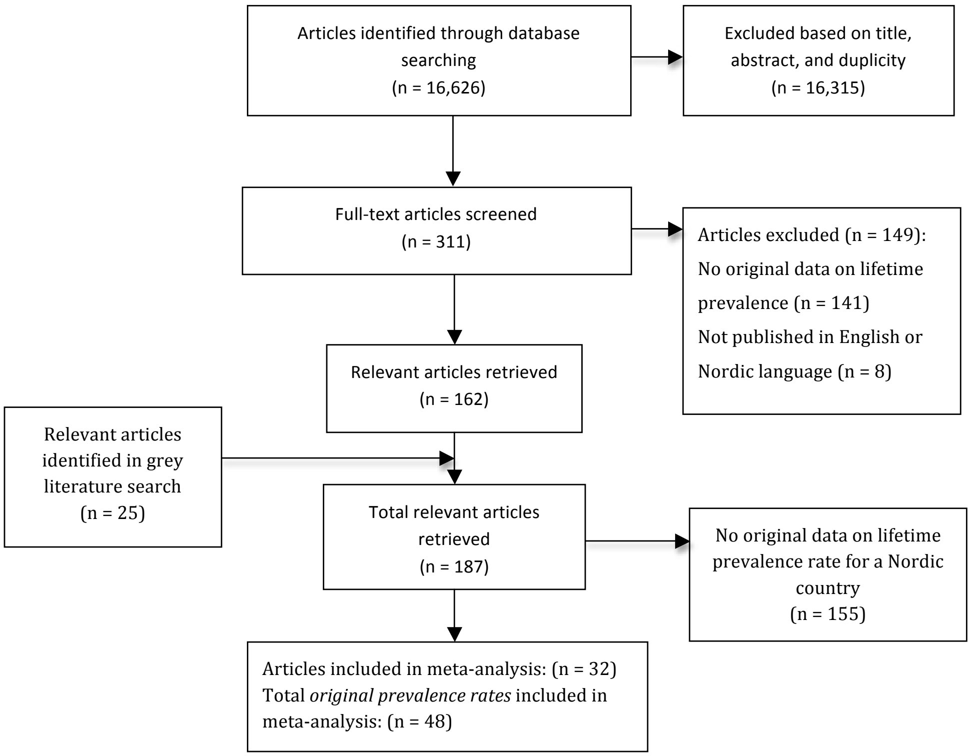
Literature search strategy and inclusion criteria

We conducted a systematic and comprehensive literature search in PsycINFO, PubMed, ISI Web of Science, and Google Scholar for articles published between 1970 and July 2013. The following keywords: 'anabol*', 'steroid*', 'doping' were each used in combination with 'preval*', 'epidem*', and 'incidence' for the search. Studies were included if they satisfied the following criteria: (a) they were published between 1970 and July 2013 (b) they presented original data on the lifetime prevalence rate of AAS use, and (c) they were published in English or a Nordic language. From an initial pool of 16,626 hits, 311 full-text papers were retrieved for further evaluation. After screening the 311 full-text papers for eligibility, 162 met the inclusion criteria.

In addition, we checked the references of identified studies in search of potential unidentified studies conducted for any Nordic country or countries. We also searched online databases and websites for data on lifetime prevalence rates of AAS use in general population or household surveys, school surveys, government reports, and regional reports for any Nordic country or countries. Twenty-five (25) new articles were identified through this grey literature search. Thus, we screened a total of 187 studies for eligibility. After screening the 187 articles, 32 articles presented original data on lifetime prevalence of AAS use for the Nordic countries (Denmark, Finland, Iceland, Norway, and Sweden) and were consequently included in the present study.

In the search for grey literature, we ad-

Figure 1. Flow diagram of systematic literature search.



hered to Calabria et al.'s (2009) strategy that if data from a representative national study existed for a country, data from a study with similar a methodology and target age group was not included in order to prevent duplicates. Thus, for adolescents, we relied on the European School Survey Project on Alcohol and Other Drugs (ESPAD). ESPAD is a survey of European adolescents (of about 35 countries) conducted every fourth year since 1995 (Hibell et al., 2000, 2004, 2007, 2009, 2012). The literature search was in line with the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Moher, Liberati, Tetzlaff, & Altman, 2009) and the Meta-analysis of Observational Studies in Epidemiology (MOOSE) group (Stroup et al., 2000). Figure 1 presents the literature search and selection process.

Description of studies

Five articles (Hibell et al., 2000, 2004, 2009, 2012; Nilsson, Baigi, Marklund, & Fridlund, 2001a) out of the 32 articles identified presented prevalence rates of AAS use for multiple studies totaling up to 16 separate studies. Thus, a total of 48 separate studies were identified which provided original data on lifetime prevalence rates of AAS use for the Nordic countries. A total of 233,475 inhabitants [61,329 females, 85,313 males – some studies do not present a sample breakdown in terms of gender] of the Nordic countries participated in these studies. The year of publication of the studies ranged from 1974 (Haug & Ingvaldsen, 1974; Solberg, 1974) to 2013 (Nøkleby, 2013; Singhammer, 2013; Lindqvist et al., 2013). Most studies were conducted in Sweden (n = 20), followed by Norway (n = 13), Finland (n = 7), Iceland (n = 5), and Denmark (n = 3). The study characteristics are presented in Table 1.

Data extraction

Studies were scrutinized and selected based on their titles, abstracts, and subject matter by the first author. We developed a standardized data extraction form. Using this form, the first author and another reviewer independently extracted data from the identified studies. The following data were extracted from the included studies: author name and publication year, country, and region of research, type of sample (prisoners and arrestees, recreational sportspeople, drug users, athletes, non-athletes, and high school), assessment method (questionnaires or interview), sampling method (random or non-random), sample size (total, male, and female), age of participants (range, mean, and standard deviation), response rate, and lifetime prevalence rate of AAS use reported (male, female, and overall). The inter-reviewer reliability for the reviewers for 162 studies identified in the first part of the search was found to be Kappa = 0.854 ($P < 0.001$) indicating an almost perfect agreement between the two reviewers (Viera & Garrett, 2005). Consensus was reached on discrepant extractions between the two reviewers through further review and discussion of the articles. A final table of all studies is presented in Table 1.

Publication bias

We assessed publication bias visually by funnel plot and statistically by the trim and fill procedure (Duval & Tweedie, 2000) in Comprehensive Meta-Analysis version 3.0 (Biostat Inc., 2014). The point estimate and 95 percent confidence interval (95% CI) for the combined studies under the random-effects model was 2.1% (95% CI: 1.3-3.4). These values were unchanged when the trim and fill function was applied indicating the absence of publication bias. The absence of publication bias was further confirmed as inspection of the funnel plot showed a symmetrical distribution of studies in terms of prevalences.

Statistical analysis

We conducted a meta-analysis and meta-regression analysis to estimate the lifetime prevalence, as well as predictors of lifetime AAS use prevalence, in the Nordic countries. The meta-analysis and meta-regression analysis were conducted using Comprehensive Meta-Analysis, version 3.0 (Biostat Inc., 2014). In calculating overall prevalence figures, relevant study characteristics (see Table 1) were coded for each study in Comprehensive Meta-Analysis, version 3.0. Thus, we were able to calculate pooled prevalence figures for relevant study characteristics based on the coded data for each study.

The calculation of prevalence rates and 95% CI was done using a random-effects model because it is most useful when the studies included in the meta-analysis may not be representative of the entirety of studies on the topic. Thus, results generated from the use of the random-effects model have more external validity than results generated from the use of the fixed-

Table 1. Characteristics of studies on the lifetime prevalence of AAS use in the Nordic countries.

First author, year	Country	Sample type	Assessment method	Sampling method	*N*	Sample size (male)	Sample size (female)	Age range (y)	Age mean	Age SD	Prevalence (male) %	Prevalence (female) %	Prevalence (overall) %	Response rate %
Gårevik 2010	Sweden	Arrested drug users	I	NR	56	-	-	-	30[†]	7.4[†]	-	-	81	-
Hakansson 2012	Sweden	General	Q	R	21211	14160	7051	15-64	29	-	1.7	0.3	1.7	32
Haug 1974	Norway	Weightlifters	Q	NR	15	15	-	-	-	-	87	-	87	38
Hibell 1997	Sweden	High school	Q	R	3472	1746	1725	15-16	-	-	2	0	1	86
Hibell 2000	Denmark	High school	Q	R	1790	875	915	15-16	-	-	1	0	1	92
Hibell 2000	Finland	High school	Q	R	3286	1646	1640	15-16	-	-	1	0	1	90
Hibell 2000	Iceland	High school	Q	R	3524	1758	1766	15-16	-	-	1	0	1	89
Hibell 2000	Norway	High school	Q	R	3918	1980	1811	15-16	-	-	2	0	1	90
Hibell 2000	Sweden	High school	Q	R	3455	1715	1730	15-16	-	-	2	0	1	87
Hibell 2004	Denmark	High school	Q	R	2978	1504	1474	15-16	-	-	2	1	1	89
Hibell 2004	Finland	High school	Q	R	3543	1739	1804	15-16	-	-	1	0	1	91
Hibell 2004	Iceland	High school	Q	R	3348	1728	1604	15-16	-	-	1	1	1	81
Hibell 2004	Norway	High school	Q	R	3833	1945	1888	15-16	-	-	2	0	1	87
Hibell 2004	Sweden	High school	Q	R	3232	1592	1640	15-16	-	-	1	0	1	87
Hibell 2007	Sweden	High school	Q	R	4245	1960	2285	15-16	-	-	1	0	1	84
Hibell 2009	Finland	High school	Q	R	4988	2297	2691	15-16	-	-	1	0	1	91
Hibell 2009	Iceland	High school	Q	R	3510	1797	1713	15-16	-	-	1	0	1	81
Hibell 2009	Norway	High school	Q	R	3482	1778	1704	15-16	-	-	2	0	1	89
Hibell 2009	Sweden	High school	Q	R	3179	1550	1629	15-16	-	-	2	0	1	84
Hibell 2012	Denmark	High school	Q	R	2181	979	1202	15-16	-	-	0	1	1	89
Hibell 2012	Finland	High school	Q	R	3744	1815	1929	15-16	-	-	1	0	1	90
Hibell 2012	Iceland	High school	Q	R	3333	1717	1616	15-16	-	-	1	0	1	81
Hibell 2012	Norway	High school	Q	R	2938	1498	1440	15-16	-	-	1	0	1	88
Hibell 2012	Sweden	High school	Q	R	2569	1311	1258	15-16	-	-	1	0	1	85
Kindlundh 1998	Sweden	Adolescents	Q	R	2742	1353	1364	16-19	-	-	1.7	0.1	0.9	80.8
Klötz 2010	Sweden	Prisoners	I	NR	59	59	-	21-52[†]	30.1[†]	6.5[†]	55.9	-	55.9	50
Korte 1998	Finland	Prisoners	Q	R	354	354	-	18-76	32	10	9.6	-	9.6	82.5
Leifman 2011	Sweden	Gym users	Q	R	1752	1183	563	16 – 49[*]	33	-	3.9	0.2	2.05	91.1
Lindqvist 2013	Sweden	Former athletes	Q	NR	683	683	-	39-82	57	-	21	-	21	68.6
Lindström 1990	Sweden	Bodybuilders	Q	NR	171	138	33	15+	25	-	38.4	9.09	32.7	90
Ljungqvist 1975	Sweden	Athletes	Q	NR	99	-	-	-	-	-	-	-	31	69
Lundholm 2010	Sweden	Prisoners	I	NR	3597	3201	396	-	-	-	28.1	5	26	-
Mattila 2009	Finland	Adolescents	Q	R	22519	-	-	12-18	-	-	0.5	0.2	0.3	74
Mattila 2010	Finland	Military conscripts	Q	NR	10396	10396	-	18-29	-	-	0.9	-	0.9	96
Nilsson 1995	Sweden	High school	Q	R	1383	688	695	14-19	-	-	5.8	1.0	3.4	96
Nilsson 2001a	Sweden	Adolescents	Q	R	345	345	-	16-17	-	-	8.7	-	8.7	96
Nilsson 2001a	Sweden	Adolescents	Q	R	451	451	-	16-17	-		5.76	-	5.76	-
Nilsson 2001b	Sweden	Adolescents	Q	R	5827	-	-	16-17	-	-	2.9	0	1.4	95
Nilsson 2005	Sweden	Adolescents	Q	R	4049	4049	-	14-18	-	-	1.2	-	1.2	92.7
Nøkleby 2013	Norway	Drug users	Q	NR	109	79	30	17-50	-	-	40.5	20	35	85
Pallesen 2006	Norway	Adolescents	Q	R	1351	703	642	-	17.5	2.2	3.6	0.6	2.1	69.8
Sagoe 2014b	Norway	Adolescents	Q	R	2055	963	1088	17	17	0	0.52	0.09	0.30	70.4
Singhammer 2013	Denmark	Recreational sportspeople	Q	R	5010	2006	3004	15-60	-	-	-	-	1.8	-
SNIPH 2009	Sweden	General	Q	R	58000	-	-	15-64	-	-	1	0	1	-
Solberg 1974	Norway	Weightlifters	Q	NR	25	25	-	-	-	-	24	-	24	68
Thorlindsson 2010	Iceland	High school	Q	R	10918	5195	5585	15-24	17.7	1.84	1.6	0.2	0.9	-
Wichstrøm 2001	Norway	Adolescents	Q	R	8508	3931	4577	14-25	17.33	2.18	1.2	0.6	0.8	78
Wichstrøm 2006	Norway	High school	Q	R	2924	1277	1647	15-24	22.1	1.9	-	-	1.9	68

I: Interview; Q: Questionnaire; NR: Non-random sampling; R: Random sampling; SNIPH: Swedish National Institute of Public Health: [†]: AAS users; [*]: Majority of participants

Table 2. Prevalence rates, confidence intervals, and heterogeneity statistics.

	N	p%	95% CI	*Q*	df(Q)	I^2
Overall	48	2.1	1.3–3.4	8724.4*	47	99.5
Gender						
Male	41	2.9	1.7–4.8	5107.5*	40	99.2
Female	32	0.2	0.1–0.4	326.8*	31	90.5
Country						
Sweden	20	4.4	2.0–9.4	6209.4*	19	99.7
Norway	13	2.4	1.2–4.7	519.6*	12	97.7
Finland	7	0.8	0.3–1.8	284.5*	6	97.9
Iceland	5	0.7	0.5-0.9	13.3**	4	69.9
Denmark	3	0.5	0.4–0.6	0.1 ns	2	0
Sample type						
Drug users	2	59.2	16.5-91.4	26.9	1	96.3
Athletes	5	32.3	22.0–44.7	28.8*	4	86.1
Prisoners and arrestees	3	26.2	11.5–49.3	67.5*	2	97.0
Recreational sportspeople	1	2.1	1.5–2.8	0 ns	0	0
Non-athletes	3	1.2	0.8–1.7	71.7*	2	97.2
High school	34	0.9	0.7–1.1	611.8*	33	94.6
Sampling method						
Non-random	12	18.7	6.0–45.5	5857.6*	11	99.8
Random	36	1.0	0.8–1.3	707.0*	35	95.0
Publication year						
1970–1989	3	44.8	18.5–74.4	12.5**	2	84.1
1990–1999	7	3.8	1.3–11.1	800.4*	6	99.3
2000–2013	38	1.4	0.8–2.6	7195.7*	37	99.5

* $p < 0.001$, ** $p < 0.01$, *ns* = not significant.
N: number of studies included in the analysis. p%: prevalence (%). 95% CI: 95% confidence interval. *Q*: heterogeneity statistic. df(*Q*): *Q*'s degrees of freedom. I^2: heterogeneity index.

effect model (Borenstein, Hedges, Higgins, & Rothstein, 2009).The *Q* statistic and the I^2 index were used to assess the heterogeneity of the prevalences.

Furthermore, in order to identify moderator variables that could explain the variance in the overall prevalence rate, a meta-regression analysis was performed under a random-effects model. The moderator variables included in the meta-regression analysis were: country (Sweden, Norway, Finland, Iceland, and Denmark), sample type (drug users, athletes, prisoners and arrestees, recreational sportspeople, non-athletes, and high school), sampling method (non-random and random), publication year (1970–1989, 1990–1999, and 2000–2013), and the percentage of males in the sample [lower than or equal to fifty percent (≤ 50%), greater than seventy-five percent (> 75%), greater than fifty percent but lower than or equal to seventy-five percent (> 50% to ≤ 75%), and percentage not provided]. The category with the highest number of studies was used as a contrast for each moderator variable.

Results

Prevalence rates and heterogeneity testing

Table 2 presents the total number of studies, the prevalence rates and confidence limits as well as the heterogeneity statistics (*Q* and I^2) for the overall population of the five Nordic countries, males, females, countries, sample type, sampling method, and publication year.

From Table 2, the overall prevalence rate obtained from 48 studies was 2.1% (95% CI : 1.3-3.4%, $I^2 = 99.5$, $P < 0.001$). In addition, the prevalence rate for males, 2.3%, was significantly higher ($Q_{bet} = 40.5$, $df =$

Table 3. Meta-regression analysis of the predictors of AAS use prevalence.

	B	SE	95% CI		*Z*	*P*
Country						
Sweden†						
Norway	-.14	.29	-.70	.43	-.48	.633
Finland	-1.05	.29	-1.62	-.50	-3.68	.000
Iceland	-.48	.36	-1.18	.23	-1.33	.184
Denmark	-.75	.43	-1.60	.09	-1.75	.080
Sample type						
High school†						
Drug users	4.93	.64	3.68	6.17	7.76	.000
Athletes	2.34	.69	.99	3.68	3.41	.000
Prisoners and arrestees	2.65	.53	1.60	3.69	4.97	.000
Recreational sportspeople	.61	.67	-.70	1.93	.92	.360
Non-athletes	-.06	.47	-.97	.85	-.13	.899
Sampling method						
Non-random†						
Random	-.19	.48	-1.13	.75	-.40	.691
Publication year						
2000–2013†						
1970–1989	1.29	.67	-.02	2.61	1.93	.054
1990–1999	.28	.29	-.28	.84	.99	.325
Percentage of males in sample						
≤ 50%†						
> 75%	1.29	.36	.59	1.99	3.60	.000
> 50% to 75%	.13	.25	-.36	.62	.53	.59
% not provided	.39	.44	-.47	1.25	.89	.372

R^2 = 89.0%.
† = Reference category.

1, $P < 0.001$) than the prevalence rate for females, 0.2%.

When prevalence was investigated by country, Sweden had the highest overall prevalence rate of AAS use: 4.4%, followed by Norway: 2.4%, Finland: 0.8%, Iceland: 0.7%, and Denmark: 0.5%. In addition, apart from Denmark, the heterogeneity statistic (*Q*) for the overall prevalence rates reached statistical significance ($P < 0.001$).

With reference to sample type, drug users had the highest overall prevalence rate: 59.2%, followed by athletes: 32.3%, prisoners and arrestees: 26.2%, and recreational sportspeople 2.1%. Moreover, prevalence rate for non-athletes was 1.2% while high school students had the lowest prevalence rate: 0.9%. With the exception of recreational sportspeople, the heterogeneity statistic (*Q)* for the overall prevalence rates for all sample types reached statistical significance ($P < 0.001$).

In addition, studies that used non-random sampling methods had a higher overall prevalence rate, 18.7%, than studies that used random sampling methods, 1.0%.

Furthermore, publication years 1970 to 1989 had the highest overall prevalence rate: 44.8%, followed by 1990 to 1999: 3.8%, and 2000 to 2013: 1.4%. The heterogeneity statistic for the prevalence rates, *Q*, also reached statistical significance ($P < 0.001$) for all publication years.

Meta-regression analysis

We performed a meta-regression analysis to evaluate the effect of country, sample type, sampling method, publication year, and the percentage of males in the sample on the overall prevalence of AAS use.

Of these variables, country, sample type (athletes, drug users, and prisoners and arrestees), and percentage of males in the sample [greater than seventy-five percent (> 75%)] significantly predicted AAS use prevalence. Together, they accounted for 89.0% of the variance in the overall AAS use prevalence rate. The results are presented in Table 3.

Discussion

This paper presents, to our knowledge, the first-ever meta-analysis and meta-regression analysis of the lifetime prevalence of AAS use specifically for the Nordic countries. The lifetime prevalence rate across all studies was 2.1%. Moreover, the overall lifetime prevalence rate for males, 2.3%, was significantly higher than the overall lifetime prevalence rate for females, 0.2% confirming the preponderance of available evidence (Andrade et al., 2012; Johnson, Jay, Shoup, & Rickert, 1989; Kindlundh, Isacson, Berglund, & Nyberg, 1998; Sagoe et al., 2014a).

We found further support for this result in the finding that percentage of males in samples significantly predicted prevalence in the meta-regression analysis consistent with results from a worldwide prevalence study (Sagoe et al., 2014a). In addition, we found that Sweden has the highest prevalence rate of AAS use: 4.4%, followed by Norway: 2.4%, Finland: 0.8%, Iceland: 0.7%, and Denmark: 0.5%. In corroboration of this finding, country was a significant predictor of prevalence in the meta-regression analysis. Moreover, the prevalence for Finland was significantly lower than prevalence for Sweden in the meta-regression analysis.

Our finding that outside the arena of competitive athletics, prevalence of AAS use is highest among drug users and prisoners and arrestees is further consistent with a recent study that found a very high incidence rate of AAS and polydrug use in a laboratory testing of the urine samples of Swedish prisoners (Lood et al., 2012). Similarly, consistent with Striegel et al. (2006) who found that athletic involvement has a significant positive correlation with AAS use, we found that athletes and recreational sportspeople have higher prevalence of AAS use than non-athletes. This result corroborates evidence suggesting that the odds of AAS use increases by about 91% with participation in at least one sport (Dodge & Jaccard, 2006; Lorang et al., 2011). Moreover, consistent with results from a global investigation of AAS use prevalence (Sagoe et al., 2014a), sample type significantly predicted prevalence in the meta-regression analysis.

The finding that studies using non-random sampling methods report a higher prevalence rate than studies based on random sampling methods seems to be related to the fact that the predominance of non-randomly selected samples comprised athletes, prisoners, arrestees, and drug users among whom AAS use prevalence is relatively higher compared to high school students and non-athletes, as previously found (Baker, Thomas, Davies, & Graham, 2008; Bojsen-Møller & Christiansen, 2010; Grace, Baker, & Davies, 2001; Lood et al., 2012). However, sampling method was insignificant in the meta-regression analysis indicating that other moderators better accounted for the heterogeneity in prevalence.

Study strengths and limitations

This study, to our knowledge, is the first to have systematically examined the lifetime prevalence rate of non-medical AAS use specifically in the Nordic countries by a quantitative meta-analytic approach. Thus, the prevalence estimates in the present study constitute the best currently available basis for policymaking and planning in the Nordic countries. The systematic nature of this research, the large number of included studies and participants, and the analysis of the data using meta-analysis and meta-regression analysis are also notable assets.

The present meta-analysis, however, has some limitations worth noting in the interpretation of findings. First, the prevalence rates reported in the studies included in our meta-analysis may have exaggerated our final prevalence estimates. Kanayama et al. (2007) suggest that prevalence rates of AAS use are sometimes exaggerated because some respondents answer that they have used AAS when in fact they have used some non-AAS supplement they believed was an AAS. This problem has exacerbated with the proliferation of supplements since the 1990s as it has become more difficult to determine whether a person is using AAS or some non-AAS substance. It is important to note, however, that this problem with false-positive responses may be minimal in the Nordic countries where most questionnaires are administered in Nordic languages rather than English. This is because questionnaires administered in non-English languages may be better at differentiating substances containing AAS from non-AAS substances (Kanayama et al., 2007). In addition, the overall prevalence figures reported in the present study may have been influenced by the inclusion of studies on some groups/populations noted for AAS use such as athletes, offenders, and drug users (Sagoe et al., 2014a). Still, we break down the estimates for these different groups/populations in order to present nuanced information about the prevalence estimates.

Furthermore, the present study investigated the lifetime prevalence of AAS use which, expectedly, should be higher than current prevalence because lifetime prevalence estimates due to their retrospective nature and wider period of coverage are more vulnerable to recall bias compared to current prevalence which cover a shorter period of use (Gmel & Daeppen, 2007). Moreover, in contrast to current prevalences, lifetime prevalence estimates cannot be validated against objective measures such as urine testing (Pagonis et al., 2006).

Although subject to the limitations noted above, our prevalence estimates suggest that non-medical AAS use should be considered a major public health problem in the Nordic countries and must require the attention of policy makers and researchers. In this regard, efforts need to be made in all the Nordic countries not only to deal with this problem, but also to monitor trends in the incidence and prevalence of AAS use. This research provides a strong foundation that can be built upon with the emergence of more evidence on AAS use in the Nordic countries.

Declaration of interest None.

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