



## Original research

## Somatic effects of AAS abuse: A 30-years follow-up study of male former power sports athletes

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## ABSTRACT

**Objectives:** The aim of the present study was to investigate the association between somatic health and former abuse of AAS in former elite male athletes 30 years after the end of their active sports career.**Design:** Retrospective follow-up study.**Methods:** N=996 former elite male athletes were sent a questionnaire concerning sociodemographic variables, previous and past sport activity and lifetime prevalence of seeking professional help for health problems. N=683 (68.6%) answered the questionnaire. The lifetime prevalence of AAS-abuse was 21% (n=143), while 79% (n=540) did not admit having ever used AAS.**Results:** Former AAS-abuse was associated with tendon ruptures (p=0.01), depression (p=0.001), anxiety (p=0.01) and lower prevalence of prostate hypertrophy (p=0.01) and decreased libido (p=0.01). Former advanced AAS-abusers had higher anxiety (p=0.004) compared to the former less advanced AAS-abusers. Moreover, former advanced AAS-abusers, compared to AAS-naïves, reported more psychiatric problems (p=0.002), depression (p=0.003) and anxiety (p=0.00).**Conclusions:** A former AAS-abuse seems to be associated with some somatic and mental health problem, although a former less advanced AAS-abuse is related to lower incidence of prostate hypertrophy. The results raise the question whether some of these associations might be dose- and frequency dependent. These findings should however be seen as hypothesis generating and further studies are needed.

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## 1. Introduction

Whether AAS-abuse induces long-term somatic complications in humans is poorly investigated, probably since it is difficult to conduct well-controlled studies due to the highly individual variation of AAS abuse patterns (e.g. type of AAS compound, dosage and frequency of administration) and individual vulnerability.

Case reports and clinical studies have reported that human AAS-administration may cause several kinds of physical side effects.<sup>1–4</sup> Abuse of AAS may lead to hypercholesterolemia, platelet aggregation<sup>5,6</sup> and increased blood pressure,<sup>7</sup> all of which

constitute risk factors for heart diseases. Cases of myocardial infarction<sup>8</sup> and pulmonary embolization<sup>9</sup> have been reported among young abusers. Moreover, AAS-abuse has been shown to cause gynecomastia<sup>10</sup> and atrophy of the testes leading to gonadal dysfunction<sup>11</sup> including decreased production of both testosterone and sperm cells.<sup>12,13</sup>

It is fairly undisputed that AAS-administration causes short-term somatic side effects,<sup>1,2,14</sup> however, the evidence for persistent toxicity of AAS in other organ systems is limited. Supraphysiological doses of AAS seem to cause long-term cardiovascular effects like atherosclerosis and cardiomyopathy<sup>15</sup> and strength athletes displayed a left ventricular hypertrophy some years after discontinuation of the AAS-abuse.<sup>16</sup>

The aim of the present study was to investigate the association between somatic health and former abuse of AAS in former elite

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male athletes 30 years after the end of their active sports career. The specific research aims were to explore;

1. If a former AAS-abuse is associated with higher self-reported lifetime prevalence of somatic problems compared to non-AAS-abusers?
2. If former AAS-abusers with a more advanced AAS-abuse report higher self-reported lifetime prevalence of somatic problems compared to former AAS users with a lesser advanced AAS-abuse?

## 2. Methods

The subjects included in this study were Swedish male elite power sport athletes, on the top 10 national ranking lists, in any of the years 1960–1979 in four power sports; wrestling, Olympic lifting, power lifting and the throwing events in track and field (hammer, discus, javelin and shot put) ( $n = 1199$ ). The athletes' present contact data were identified through the Swedish Tax Agency by using the athletes' Swedish National Registration Number (NRN). Of the 1199 former elite athletes, 66 individuals were missing from the Swedish records; either due to emigration ( $n = 20$ ), or not being traceable via formal Swedish authority registers for example having "hidden identity" ( $n = 46$ ). 137 former athletes were dead in 2003. Among these deceased athletes, mortality from suicide was increased 2–4 times during the period of 30–50 years of age and mortality rate from malignancy was lower as compared with the general population of men (for further description of the deceased athletes, see<sup>17</sup>).

Thus, 996 former athletes were traceable and alive. A structured questionnaire concerning sociodemographic variables, previous and past sport activity and lifetime prevalence of seeking professional help for health problems was sent to these 996 athletes. A reminder to fill in the questionnaire was sent to those athletes who had not answered by the first letter, and finally 683 (68.6%) subjects had answered the questionnaire including the specific questions in the questionnaire concerning whether they ever had used AAS, and if when in relation to their sport career. Thus, 683 former elite athletes represent the subjects in this study.

Out of the 683 former Swedish male elite athletes, the lifetime prevalence of AAS-abuse was 21% ( $n = 143$ ), while 79% ( $n = 540$ ) did not admit having ever used AAS. All the former AAS-abusers reported having used AAS during their active sports career. The mean age of the included subjects was  $57 \pm 10$  years (39–82 years) as measured in the year 2003; the mean age of the former AAS-abusers being lower compared to the non AAS-abusers ( $53 \pm 6$  and  $58 \pm 10$  years, respectively;  $t = 6.55$ ;  $p < 0.001$ ), as thoroughly described in a previous paper.<sup>18</sup>

The former AAS-abusers ( $n = 143$ ) were divided in 'Former advanced AAS-abusers' (AAS-cycles during a minimum of two years;  $n = 53$ ) and 'Former less advanced AAS-abusers' (AAS-cycles less than two years;  $n = 89$ ). Health problems were divided into 10 main categories (bold font in Table 1), where eight of the categories were subdivided into specific diseases/problems (cursive font in Table 1).

Self-reported lifetime prevalence of seeking professional expertise for health problem, comparisons were made between 'AAS-naïves' vs 'Former AAS-abusers'; between 'Former advanced AAS-abusers' vs 'Former less advanced AAS-abusers'; and between 'AAS-naïves' vs 'Former more advanced AAS-abusers'.

The data are presented as frequencies (per cent). Differences in frequencies were assessed using Fisher's exact test. The alpha level was 0.01 due to multiple comparisons, and two-tailed levels of significance were used in all statistical analyses. The SPSS 20.0 (IBM Corp., Armonk, NY) was used for the analyses.

The present study was approved by the Regional Research Review Board in Gothenburg, Sweden. The ethical considerations are in accordance with the Declaration of Helsinki.

## 3. Results

'Former AAS-abusers', compared to 'AAS-naïves', had higher self-reported lifetime prevalence of seeking professional expertise for tendon ruptures (44.8% vs 33.4%;  $p = 0.01$ ), depression (13.3% vs 5.0%;  $p = 0.001$ ) and anxiety (13.3% vs 6.3%;  $p = 0.01$ ). 'Former AAS-abusers', compared to 'AAS-naïves', had lower prevalence of prostate hypertrophy (4.9% vs 12.4%;  $p = 0.01$ ) and decreased libido (2.8% vs 9.3%;  $p = 0.01$ ).

'Former advanced AAS-abusers', compared to 'Former less advanced AAS-abusers', had higher self-reported lifetime prevalence of seeking professional expertise for anxiety (24.5% vs 6.7%;  $p = 0.004$ ).

'Former advanced AAS-abusers', compared to 'AAS-naïves', had higher self-reported lifetime prevalence of seeking professional expertise for psychiatric problems (28.3% vs 11.9%;  $p = 0.002$ ), depression (17% vs 5.0%;  $p = 0.003$ ) and anxiety (24.5% vs 6.3%;  $p = 0.00$ ).

## 4. Discussion

The literature concerning long-term somatic effect of previous AAS-abuse is sparse.<sup>15,16</sup> The aim of the present study was therefore to investigate the relationship between lifetime prevalence of seeking professional expertise for somatic problems and former AAS-abuse, and furthermore if these somatic problems were correlated to the extent of AAS-abuse. In this 30-years follow-up study of former male elite power sport athletes, 21% ( $n = 143$ ) of the sample reported having used AAS during their active sports career (i.e. 30 years ago). This follow-up study is unique since, to our knowledge, it has the longest follow-up period.

In summary, the result showed that former AAS-abusers reported a significantly higher lifetime prevalence of seeking professional expertise for tendon rupture and psychiatric problems, specifically depression and anxiety than former athletes reported never having abused AAS. Furthermore, lower prevalence of prostate hypertrophy, and decreased libido were noted among the former AAS-abusers, as compared to AAS-naïves.

The increased prevalence of tendon ruptures is not surprising as AAS are known to cause adverse musculoskeletal effects, especially tendon rupture, attributable both to the disproportionate strength of the hypertrophied muscles and to possible deleterious effects of AAS on the architecture of the tendons themselves.<sup>19,20</sup> Furthermore, AAS-abuse in itself probably induces the athletes to try performing harder training procedures, which might render an increased risk for both muscle- and tendon ruptures.

Studies have reported a relationship between the abuse of AAS and increased frequency of suicidal thoughts and depressive symptoms<sup>11,17,19–22</sup> and anxiety.<sup>19,23</sup> Some of these studies do report that symptoms derive from the AAS abuse alone, or are an effect of other abused drugs or the co-abuse. Interestingly, the present results do not show that former AAS-abuse is associated with alcohol- or substance abuse since the former AAS-abusers did not report a higher lifetime prevalence of alcohol- and substance abuse. Thus, alcohol- or substance abuse does not seem to be a confounding variable for the association between AAS-abuse and depression and anxiety. The present results show that the association is even stronger if the former AAS-abusers have had an advanced AAS-abuse (AAS-cycles  $\geq 2$  years), as compared to a less advanced AAS-abuse (AAS-cycles  $< 2$  years). Though the present result cannot fully explain the causality for this relationship, one

**Table 1**  
Comparisons regarding self-reported lifetime prevalence of health problems were analyzed between: <sup>a</sup>Former AAS-abusers vs AAS-naïves, <sup>b</sup>Former advanced AAS-abusers (AAS-cycles  $\geq 2$  years) vs Former less advanced AAS-abusers (AAS-cycles  $< 2$  years), <sup>c</sup>Former advanced AAS-abusers (AAS-cycles  $\geq 2$  years) vs AAS-naïves. Data are presented as percentage (%).

Health problems	AAS-naïves (n = 540)	Former AAS-abusers (n = 143)	p-Value <sup>a</sup>	Former advanced AAS-abusers (n = 53)	Former less advanced AAS-abusers (n = 89)	p-Value <sup>b</sup>	p-Value <sup>c</sup>
Tumors/cancer	<b>5.6</b>	<b>2.8</b>	<b>0.20</b>	<b>3.8</b>	<b>2.2</b>	<b>0.63</b>	<b>0.76</b>
Cardiovascular	<b>32.2</b>	<b>28.7</b>	<b>0.48</b>	<b>30.2</b>	<b>28.1</b>	<b>0.85</b>	<b>0.88</b>
Arterial hypertension	17.1	13.3	0.31	11.3	14.6	0.62	0.34
Hyperlipidemia	10.0	9.9	1.00	11.5	9.1	0.78	0.64
Cardiac infarction	6.9	4.9	0.45	1.9	6.7	0.26	0.24
Heart failure	2.6	1.4	0.54	1.9	1.1	1.00	1.00
Arrhythmia	7.8	9.8	0.49	15.1	6.7	0.15	0.11
Peripheral artery disease	2.8	0	0.50	0	0	N/A	0.38
Stroke	2.2	2.8	0.76	5.7	1.1	0.15	0.14
Venous thromboembolic disease	<b>3.3</b>	<b>2.1</b>	<b>0.59</b>	<b>1.9</b>	<b>2.2</b>	<b>1.00</b>	<b>1.00</b>
Deep vein thrombosis	3.5	2.1	0.54	1.9	2.2	1.00	1.00
Pulmonary embolism	0.9	0	0.59	0	0	N/A	1.00
Pulmonary	<b>6.9</b>	<b>11.2</b>	<b>0.11</b>	<b>17.0</b>	<b>7.9</b>	<b>0.11</b>	<b>0.02</b>
Asthma	4.8	7.0	0.30	11.3	4.5	0.18	0.06
Chronic airway problems	3.7	6.3	0.17	7.5	5.6	0.73	0.26
Ortopedic	<b>69.8</b>	<b>68.5</b>	<b>0.84</b>	<b>62.3</b>	<b>71.9</b>	<b>0.27</b>	<b>0.16</b>
Fractures	35.0	31.5	0.49	30.2	31.5	1.00	0.55
Tendon ruptures	33.4	44.8	0.01	47.2	42.7	0.73	0.05
Spine problems	17.8	17.7	1.00	19.2	17.0	0.82	0.85
Rheumatic diseases	4.1	1.4	0.20	0	2.3	0.53	0.25
Arthritis	23.8	25.2	0.72	26.4	23.6	0.84	0.74
Gastrointestinal	<b>11.1</b>	<b>8.4</b>	<b>0.44</b>	<b>7.5</b>	<b>7.9</b>	<b>1.00</b>	<b>0.46</b>
Peptic ulcers	6.3	4.2	0.43	7.5	2.2	0.20	0.77
Intestinal disease	2.8	4.2	0.41	3.8	4.5	1.00	0.66
Liver disease	0.7	0.7	1.00	0	1.1	1.00	1.00
Biliary disease	3.0	0	0.03	0	0	N/A	0.38
Genitourinary/endocrine							
Prostate hypertrophy	12.4	4.9	0.01	5.8	4.5	0.71	0.18
Diabetes	6.5	2.1	0.04	1.9	2.2	1.00	0.24
Infertility	1.1	0.7	1.00	0	1.1	1.00	1.00
Decreased libido	9.3	2.8	0.01	5.7	1.1	0.15	0.61
Urology	<b>13.2</b>	<b>8.4</b>	<b>0.15</b>	<b>7.5</b>	<b>9.0</b>	<b>1.00</b>	<b>0.17</b>
Kidney disease	4.1	3.5	1.00	1.9	4.5	0.65	0.17
Urinary tract infections	9.7	5.6	0.14	5.7	5.6	1.00	0.46
Neurologic disease	<b>1.1</b>	<b>0.7</b>	<b>1.00</b>	<b>1.9</b>	<b>0</b>	<b>0.34</b>	<b>0.48</b>
Psychiatric problems	<b>11.9</b>	<b>18.2</b>	<b>0.52</b>	<b>28.3</b>	<b>12.4</b>	<b>0.02</b>	<b>0.002</b>
Depression	5.0	13.3	0.001	17.0	11.2	0.45	0.003
Mania	0.6	0	1.00	0	0	N/A	1.00
Psychosis	0.2	1.4	0.11	3.8	0	0.14	0.02
OCD	0	0.7	0.21	1.9	0	0.37	0.09
Anxiety	6.3	13.3	0.01	24.5	6.7	0.004	0.000
Alcohol/substance abuse	4.3	2.8	0.63	3.8	2.3	0.63	1.00

(Fisher's exact test).

might speculate that as the study group consisted of former elite athletes that apart from the (short) doping-period during their active career otherwise tried to have a more healthy life-style including avoidance of other drugs.

Though lifetime prevalence of seeking professional expertise for pulmonary problems did not significantly differ between former AAS-abusers and non AAS-abuser, there was a strong trend ( $p = 0.02$ ) for former AAS-abusers with advanced AAS-abuse seeking professional expertise for pulmonary problems as compared to AAS-naïves. The same results were seen for asthma, though the trend was not as strong ( $p = 0.06$ ). These findings are surprising and not readily understood. No obvious correlation between AAS-abuse and pulmonary dysfunction is described in the literature. On the contrary, AAS-administration has been tried with some success, due to its anabolic effect, to patients with longstanding chronic airway disease,<sup>24</sup> readily explained by the fact that chronic airway disease in itself is associated with low testosterone levels.<sup>25</sup> Thus, one might only speculate that those patients in the study presenting pulmonary problems do so because of relative hypogonadism secondary to previous AAS-abuse.

A former abuse of AAS seems to have a protective effect against prostate hypertrophy, especially if the former AAS-abuse had been less advanced (AAS-cycles  $< 2$  years). The result does not reflect the knowledge of AAS-effects on the prostate, where AAS instead might induce a possible risk for prostatic hypertrophy and prostatic cancer although the relationship to the AAS-abuse is poorly understood.<sup>26</sup> The lower incidence of prostate hypertrophy might be explained by an untreated relative hypogonadism, due to former AAS-abuse among these patients; a hypogonadism rendering a smaller prostate volume and thus a lower risk for prostate hypertrophy. However, these patients in turn reported a lower frequency of decreased libido, to which we have no obvious explanation. The significantly lower life time prevalence of prostate hypertrophy in AAS-abusers suggests that use of AAS may prevent testosterone-dependent prostate hypertrophy. The significantly lower life time prevalence of prostate hypertrophy in AAS-abusers supports the notion that use of AAS may prevent testosterone-dependent prostate hypertrophy also in humans as earlier argued on the basis of clinical observations and experimental data.<sup>4,27</sup>

Several studies<sup>1,2,5-8</sup> have reported a relationship between abuse of AAS and cardiovascular effects. A recent study proposes

the “higher AAS-dosage risk hypothesis”<sup>28</sup> demonstrating that the increased risk of cardiovascular events requiring hospital care among abusers of AAS is more pronounced for those having tested positively for AAS at several occasions compared to those with only one positive test. One explanation for the lack of significant results between lifetime prevalence of seeking professional expertise for cardiovascular problems and former AAS-abuse in the present study might be explained by the less expansive AAS-abuse of the former elite athletes in the present study, as compared to the more expansive AAS-abuse of in today's users. Some of the more severe somatic side effects, e.g. impaired cardiac function could thus be dose- and duration dependent.

The present data should be interpreted with caution since this association study is based on a small sample size. Since the present sample only includes former elite athletes, the results might not be generalizable to the general population of AAS-abusers. Furthermore, it must be stressed that the AAS-abuse among the studied former elite athletes probably differs greatly, both concerning the doping agents per se and the cumulative doses, to the current probably more expansive AAS-abuse in today's recreational body builders and power lifters. Also, the studied elite athletes probably administered their AAS-abuse during their active career only, which might in some patients not have rendered them long-standing side-effects, to be observed after 20–30 years, when our study was performed. Moreover, it should be pointed out that the observed prevalence of diseases in the present study may be biased by the fact that the 137 athletes (13.7%) who died were not included in this study and that this mortality rate in the 20–50 years age group was in excess of 45% compared to the general male population.<sup>17</sup> Finally, it cannot be excluded that the admitted AAS-abuse might be underestimated among the studied former elite athletes, although their total anonymity was totally guaranteed.

Thus, further studies focusing more in detail on the relationship between agents, dose and frequency of former AAS-abuse are called for in order to clarify possible long-term health effects of AAS-abuse. Such studies are of importance since, as Kanayama et al.<sup>15</sup> state, the abuse of AAS has grown into a widespread substance abuse problem over the last 20–30 years and since the power athletes today are known to have a shorter life expectancy than the general population.<sup>29</sup> If somatic long-term effects of AAS are dose- and frequency dependent, the issue is even more important now since the AAS-abusers probably have a more advanced abuse of AAS today compared to 30 years ago.

## 5. Conclusion

A former AAS-abuse does seem to have a strong association with psychiatric problem, such as depression and anxiety. This association seems to be even stronger if the abuse of AAS was advanced (AAS-cycles  $\geq 2$  years). This result raises the question whether these somatic and mental health effects of AAS-abuse are dose- and frequency dependent. However, no large differences were seen in somatic health except an association between former AAS-abuse and tendon rupture, which has been noted in previous short-term studies. Interestingly, a former AAS-abuse, especially if the abuse was not as advanced, seemed to give a lower incidence of prostate hypertrophy, which probably is explained by an AAS-induced relative hypogonadism rendering a lower prostate volume, but does not readily explain the observed decreased libido. However, these findings should be seen as hypothesis generating and further studies are needed.

## Practical implications

- The association between former AAS-abuse and depression and anxiety might be dose- and frequency dependent, which strengthens the importance of asking patients, not only active body builders, about current and former AAS-abuse in cases of depression and anxiety, since treatment may also require consultation of an endocrinologist in addition to conventional psychiatric care.
- Tendon rupture seems to be more common in elite athletes who have used AAS compared to AAS-naïve athletes, which is important knowledge that could be used as a motivating factor in secondary prevention.

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