

Prevalence and Characteristics of Adverse Analytical Findings Among Athletes in Kuwait: A National Cross-Sectional Study of the Kuwait Anti-Doping Program (2022–2023)

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Article

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Abstract

Background

Doping remains a major threat to athlete health and the integrity of competitive sport. Reliable national surveillance data are essential for evaluating anti-doping programs and guiding evidence-based prevention strategies. This study aimed to determine the prevalence of adverse analytical findings (AAFs) among athletes tested in Kuwait during 2022–2023, describe the demographic and sport-related characteristics associated with AAFs, and identify the prohibited substances detected according to the World Anti-Doping Agency (WADA) Prohibited List.

Methods

A national cross-sectional study was conducted using data extracted from the WADA Anti-Doping Administration and Management System (ADAMS). The study included all doping control samples collected from athletes registered with Kuwaiti sports clubs and national federations between 1 January 2022 and 31 December 2023. Descriptive statistics were used to summarize demographic characteristics and AAF prevalence. Associations between athlete characteristics and AAF status were assessed using the chi-square test, with statistical significance defined as $p < 0.05$.

Results

Among 667 analyzed samples, 23 (3.4%) demonstrated adverse analytical findings, while 644 (96.6%) produced negative results. Most athletes were male (90.2%), Kuwaiti nationals (91.2%), and aged 16–29 years (69.4%). No statistically significant associations were observed between AAF prevalence and age, sex, nationality, competition setting, sample type, or sport category (all $p > 0.05$). Anabolic androgenic steroids (WADA class S1.1) represented the most frequently detected prohibited substances, followed by other anabolic agents, peptide hormones, cannabinoids, and glucocorticoids.

Conclusions

This first national study provides baseline epidemiological evidence on adverse analytical findings among athletes tested in Kuwait. Although the overall prevalence of AAFs was relatively low, anabolic agents accounted for the majority of detected prohibited substances. These findings support strengthening athlete education, expanding targeted testing strategies, enhancing anti-doping surveillance, and promoting collaborative national initiatives to further improve the effectiveness of Kuwait's anti-doping program.

Introduction

Doping remains one of the greatest challenges to modern sport because it threatens athlete health, compromises fair competition, and undermines the integrity of sporting events. To harmonize anti-doping efforts worldwide, the World Anti-Doping Agency (WADA) was established in 1999 and introduced the World Anti-Doping Code in 2003. The Code, together with the International Standards, provides a unified framework for preventing, detecting, and sanctioning doping in sport while safeguarding athletes' right to compete in a doping-free environment. A substance or method is included on the WADA Prohibited List when it fulfills at least two of the following criteria: the potential to enhance sport performance, the potential to pose a health risk to athletes, or violation of the spirit of sport. The Prohibited List is reviewed and updated annually to reflect scientific advances and emerging doping practices.¹²

Monitoring the prevalence of doping is essential for evaluating the effectiveness of national anti-doping programs and guiding evidence-based prevention strategies. WADA's Anti-Doping Testing Figures demonstrated a gradual increase in the proportion of adverse analytical findings (AAFs), from approximately 0.65% of analyzed samples in 2021 to 0.77% in 2022, highlighting the continued global challenge of prohibited substance use despite extensive testing programs.³ However, AAFs represent only detected violations and may underestimate the true prevalence of doping because detection depends on testing frequency, analytical sensitivity, athlete selection, and the pharmacokinetic characteristics of prohibited substances.⁴

Although several countries have reported national data on AAF prevalence, evidence from the Middle East remains limited. Previous studies from Saudi Arabia, France, Italy, and the United States have described variations in the prevalence and distribution of prohibited substances among athletes, reflecting differences in sports culture, testing strategies, and anti-doping policies.^{4,7-9} These findings emphasize the importance of generating country-specific epidemiological data to support the development of targeted anti-doping interventions.

Kuwait formally committed to the international anti-doping movement by signing the Copenhagen Declaration and ratifying the UNESCO International Convention against Doping in Sport in 2007. Subsequently, the Kuwait Anti-Doping Agency (KADA) was established under Law No. 82 of 2018 as the independent National Anti-Doping Organization responsible for implementing the World Anti-Doping Code in Kuwait. KADA is responsible for planning, implementing, monitoring, and continuously improving the national anti-doping program, including doping control, results management, education, and prevention activities.^{5,6}

Despite these developments, no published national study has described the prevalence of adverse analytical findings among athletes tested in Kuwait. The absence of such data limits the ability to evaluate the effectiveness of the national anti-doping program and identify priorities for future educational and testing strategies.

Therefore, this study aimed to determine the prevalence of adverse analytical findings among athletes tested in Kuwait between 2022 and 2023 using data extracted from the WADA Anti-Doping

Administration and Management System (ADAMS). The secondary objectives were to examine the distribution of AAFs according to demographic and sport-related characteristics, identify the prohibited substances detected according to the WADA Prohibited List, and provide evidence-based recommendations to strengthen the national anti-doping program.

Method

Study Design

This cross-sectional study analyzed doping control data extracted from the World Anti-Doping Agency (WADA) Anti-Doping Administration and Management System (ADAMS). The study included all doping control samples collected through Kuwait's national anti-doping program between 1 January 2022 and 31 December 2023. Ethical approval for this study was obtained from the Kuwait Anti-Doping Agency (KADA). The study utilized retrospectively collected, de-identified administrative data extracted from the WADA ADAMS database. As no identifiable participant information was collected and the study involved secondary analysis of existing data, the requirement for individual informed consent was waived in accordance with the approval granted by KADA. All methods were carried out in accordance with the World Anti-Doping Code, the International Standard for Testing and Investigations (ISTI), and all relevant guidelines and regulations. Furthermore, this study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement

Study Population and Eligibility Criteria

The study included all doping control samples collected from athletes aged 16 years or older who were registered with recognized Kuwaiti sports clubs, national sports federations, or enrolled in either the Registered Testing Pool (RTP) or Testing Pool (TP) of the Kuwait Anti-Doping Agency during the study period. Kuwait's national anti-doping program encompasses athletes participating in both individual and team sports. Individual sports included aquatics, athletics, boxing, bowling, canoeing, cycling, fencing, electronic sports, judo, karate, kickboxing, powerlifting, rowing, sailing, shooting, squash, taekwondo, table tennis, tennis, weightlifting, and wrestling, whereas team sports included basketball, football, handball, ice hockey, padel, and volleyball. Only athletes with complete laboratory results available in ADAMS were included in the analysis. Samples reported as Atypical Findings (ATFs) and other Anti-Doping Rule Violations (ADRVs) that were not classified as Adverse Analytical Findings (AAFs) were excluded from the study.

Data Collection

Data were extracted from the WADA ADAMS platform following institutional approval from the Kuwait Anti-Doping Agency. The extracted variables included athletes' demographic characteristics (age, sex, and nationality), sport category and discipline, competition setting (in-competition or out-of-

competition), sample type, Therapeutic Use Exemption (TUE) status, and laboratory test results. For samples with adverse analytical findings, additional information regarding the detected prohibited substance(s), their metabolites, and their classification according to the WADA Prohibited List applicable at the time of sample collection was also extracted. During the study period, 55 certified Doping Control Officers (DCOs) conducted 492 official doping control missions, and all collected samples were analyzed by the Qatar Anti-Doping Laboratory (QADL), a World Anti-Doping Agency-accredited laboratory, under an international agreement between the Kuwait Anti-Doping Agency and the Qatar Anti-Doping Laboratory. To ensure participant confidentiality, all data extracted from ADAMS were anonymized and de-identified before statistical analysis, and no personally identifiable information was accessed or reported.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize participants' demographic characteristics, testing characteristics, and laboratory findings, with categorical variables presented as frequencies and percentages. The primary outcome was the prevalence of Adverse Analytical Findings (AAFs) among all analyzed doping control samples. Secondary outcomes included the distribution of AAFs according to demographic characteristics, sport category, sport discipline, competition setting, and prohibited substance class. Athletes were categorized into three predefined age groups (16 to < 30 years, 30 to < 40 years, and ≥ 40 years) for comparative analyses. Differences between athletes with negative results (NR) and those with AAFs were assessed using the Pearson chi-square test, and all statistical tests were two-sided. A p-value < 0.05 was considered statistically significant.

Result

General Characteristics of the Study Population

A total of 667 doping control samples collected between January 2022 and December 2023 were included in the analysis. Overall, 644 samples (96.6%) yielded negative results (NR), whereas 23 samples (3.4%) demonstrated Adverse Analytical Findings (AAFs). Most samples were collected from athletes aged 16 to < 30 years (69.4%), followed by those aged 30 to < 40 years (29.2%). Male athletes accounted for 90.2% of the study population, while 91.2% were Kuwaiti nationals. Most samples were collected during in-competition testing (60.4%), and urine was the predominant sample type (94.3%). The distribution of samples between individual and team sports was relatively balanced, with 54.3% originating from individual sports and 45.7% from team sports (Table 1)

Prevalence of Adverse Analytical Findings

Among the 667 samples analyzed, the overall prevalence of Adverse Analytical Findings (AAFs) was 3.4% (23/667), whereas 96.6% (644/667) of samples produced negative results. All AAFs resulted from the detection of prohibited substances, and no prohibited methods were identified during the study

period. Although most AAFs occurred among athletes aged 16 to < 30 years (69.6%), males (95.7%), Kuwaiti nationals (87.0%), and participants in individual sports (65.2%), no statistically significant associations were observed between AAF prevalence and age group, sex, nationality, competition setting, sample type, or sport category (all $p > 0.05$) (Table 2).

Distribution of Adverse Analytical Findings by Sport

The distribution of AAFs varied across sports disciplines. Among individual sports, athletics accounted for the highest proportion of AAFs (11 of 23; 47.8%), followed by weightlifting (2 of 23; 8.7%), while boxing and canoeing each contributed one AAF (4.3%). No AAFs were detected in the remaining individual sports during the study period. Among team sports, volleyball demonstrated the highest proportion of AAFs (3 of 23; 13.0%), followed by basketball and handball (each 2 of 23; 8.7%) and football (1 of 23; 4.3%). No AAFs were identified in ice hockey or padel. The distribution of AAFs across individual and team sport disciplines is illustrated in Figs. 1 and 2, while detailed frequencies are presented in Table 3.

Distribution of Detected Prohibited Substances

Among the 23 Adverse Analytical Findings (AAFs), a total of 38 prohibited substances were identified, indicating that several samples contained more than one prohibited substance. Anabolic agents (WADA class S1) were the predominant substance class, accounting for 60.6% (23/38) of all detected prohibited substances. Within this category, anabolic androgenic steroids (S1.1) represented the majority (47.4%, 18/38), while other anabolic agents (S1.2) accounted for 13.2% (5/38).

The most frequently detected individual prohibited substances included metenolone, drostanolone, boldenone, nandrolone, oxandrolone, metandienone, and 1-testosterone. Other prohibited substance classes identified were peptide hormones and growth factors (S2), beta-2 agonists (S3), hormone and metabolic modulators (S4), diuretics and masking agents (S5), stimulants (S6), cannabinoids (S8), and glucocorticoids (S9). The complete distribution of detected prohibited substances according to the WADA Prohibited List is presented in Table 4, while the proportional distribution of substance classes is illustrated in Fig. 3.

Discussion

This study represents the first national epidemiological assessment of Adverse Analytical Findings (AAFs) among athletes tested through the Kuwait Anti-Doping Agency (KADA) using data extracted from the World Anti-Doping Agency (WADA) Anti-Doping Administration and Management System (ADAMS). Among 667 analyzed doping control samples collected between 2022 and 2023, the overall prevalence of AAFs was 3.4%. Although AAFs were identified across several sports disciplines, anabolic agents accounted for the majority of detected prohibited substances, with anabolic androgenic steroids representing the most frequently identified class. Furthermore, no statistically significant associations

were observed between AAF prevalence and athletes' demographic characteristics, competition setting, sample type, or sport category. These findings provide the first comprehensive national baseline describing the epidemiology of adverse analytical findings in Kuwait and establish an important benchmark for evaluating future anti-doping strategies and surveillance programs.

The prevalence of AAFs observed in the present study was higher than the overall prevalence reported in the WADA global Testing Figures, where adverse analytical findings represented approximately 0.65% of analyzed samples in 2021 and 0.77% in 2022. However, direct comparison between national and international data should be interpreted with caution. The prevalence of AAFs is influenced by multiple factors, including the characteristics of the tested athlete population, sport-specific risk profiles, testing distribution plans, the proportion of in-competition and out-of-competition testing, intelligence-led target testing, and laboratory analytical capabilities. Similar variability has been reported among national anti-doping programs worldwide, reflecting differences in testing strategies, available resources, and implementation of anti-doping policies. Accordingly, the findings of the present study should be interpreted as the prevalence of adverse analytical findings among tested athletes rather than the true prevalence of doping among the entire athletic population in Kuwait.

Anabolic agents constituted the predominant class of prohibited substances detected in this study, with anabolic androgenic steroids accounting for nearly half of all identified prohibited substances. This observation is consistent with findings reported in successive WADA annual testing reports and previous epidemiological studies, which have consistently demonstrated that anabolic steroids remain among the most frequently detected prohibited substances in competitive sport. Their predominance is biologically plausible given their well-established ability to increase skeletal muscle mass, strength, recovery, and overall athletic performance, particularly in sports requiring power and explosive performance. The frequent detection of substances such as metenolone, drostanolone, boldenone, nandrolone, oxandrolone, metandienone, and 1-testosterone in the present study generally reflects international patterns of prohibited substance detection. Nevertheless, the current study was based exclusively on laboratory-confirmed adverse analytical findings and did not investigate athletes' motivations, routes of exposure, supplement use, prescribing practices, or intentionality. Therefore, no conclusions can be drawn regarding the underlying behavioral factors contributing to these findings.

The distribution of AAFs differed among sports disciplines, with athletics contributing the largest proportion of adverse analytical findings, followed by volleyball, weightlifting, basketball, and handball. These findings should be interpreted carefully because the observed distribution may reflect differences in testing intensity rather than differences in the actual prevalence of prohibited substance use among athletes competing in these sports. National anti-doping organizations commonly implement risk-based testing distribution plans, prioritizing sports perceived to have a greater risk of doping based on physiological demands, historical evidence, and intelligence information. Consequently, athletes participating in higher-risk sports are frequently tested more often, increasing the likelihood of detecting adverse analytical findings. Therefore, the observed sport-specific distribution should not be interpreted

as evidence that athletes in these sports necessarily engage in prohibited substance use more frequently than athletes participating in other disciplines.

The present findings have important implications for anti-doping practice and public health in Kuwait. The predominance of anabolic agents highlights the continued need for targeted educational initiatives focusing on the health consequences, ethical implications, and regulatory consequences associated with anabolic steroid use. Furthermore, these findings support the continued implementation of intelligence-led testing strategies while reinforcing preventive educational programs across both individual and team sports. The results may also assist the Kuwait Anti-Doping Agency in refining future testing distribution plans, identifying emerging trends in prohibited substance use, prioritizing educational interventions, and allocating available resources more efficiently. Establishing reliable national epidemiological data is essential for evaluating the effectiveness of anti-doping policies and monitoring changes in prohibited substance use over time.

This study possesses several important strengths. To our knowledge, it is the first published national study evaluating adverse analytical findings among athletes in Kuwait using official data extracted from the WADA ADAMS database. The study included all eligible doping control samples collected through Kuwait's national anti-doping program during the study period, thereby providing comprehensive national coverage. In addition, all biological samples were analyzed by a WADA-accredited laboratory using internationally standardized analytical procedures, enhancing the validity, reliability, and comparability of the laboratory findings with those reported by other anti-doping organizations worldwide. The use of standardized international reporting systems further strengthens the reproducibility and external credibility of the study.

Despite these strengths, several limitations should be acknowledged. First, the retrospective cross-sectional design precludes the establishment of causal relationships between athlete characteristics and adverse analytical findings. Second, the relatively small number of AAFs limited the statistical power to detect significant associations between demographic variables and laboratory outcomes. Third, because anti-doping testing is based on risk assessment and intelligence-led testing strategies rather than random sampling of all athletes, the reported prevalence cannot be generalized to the entire athletic population in Kuwait. Finally, the ADAMS database does not contain detailed information regarding athletes' motivations, intentional or unintentional exposure, dietary supplement use, therapeutic indications, socioeconomic factors, or other behavioral determinants that may contribute to adverse analytical findings. These factors should be explored in future research using complementary study designs.

Future longitudinal and multicenter studies involving extended surveillance periods and larger athlete populations are warranted to better characterize temporal trends in adverse analytical findings within Kuwait and neighboring Gulf countries. Integrating additional information, including Athlete Biological Passport (ABP) data, Therapeutic Use Exemptions (TUEs), educational interventions, and intelligence-led testing strategies, may further enhance understanding of prohibited substance use and facilitate

evaluation of the long-term effectiveness of national anti-doping programs. Collectively, the findings of this study provide the first national epidemiological baseline for monitoring adverse analytical findings in Kuwait and contribute valuable evidence to the limited body of anti-doping research from the Gulf region. This evidence may also support future policy development, optimize testing distribution strategies, and strengthen regional collaboration in promoting clean sport.

Conclusion

This study represents the first national epidemiological evaluation of Adverse Analytical Findings (AAFs) among athletes tested through the Kuwait Anti-Doping Agency (KADA) using official WADA ADAMS data. The findings demonstrated an overall AAF prevalence of 3.4% among analyzed doping control samples collected between 2022 and 2023, with anabolic agents—particularly anabolic androgenic steroids—constituting the predominant class of detected prohibited substances. No significant associations were identified between AAF prevalence and demographic characteristics, competition setting, sample type, or sport category. These findings provide the first comprehensive national epidemiological baseline for understanding adverse analytical findings in Kuwait and contribute valuable evidence to the limited body of anti-doping literature from the Gulf region. Beyond describing the current pattern of prohibited substance detection, this study offers practical information that may support evidence-based testing distribution, targeted educational initiatives, and strategic policy development within Kuwait's national anti-doping program. Continued surveillance using standardized international methodologies, combined with longitudinal research and regional collaboration, will be important for monitoring evolving trends in adverse analytical findings, evaluating the effectiveness of anti-doping interventions, and strengthening efforts to protect athlete health and promote fair competition.

Abbreviations

AAF	adverse analytical findings
AAS	anabolic androgenic steroids
ABP	athlete blood passport
ADAMS	The Administration and Management System Platform
ADRV	Anti-Doping Rule Violation
ANOVA	one-way analysis of variance
ATF	atypical finding results
CNS	

central nervous system
COPD
Chronic obstructive pulmonary disease
DCOs
doping control officers
EPO
Erythropoietin
FDA
Food and Drug Administration
KADA
Kuwait Anti-Doping Agency
NR
Negative Result
QADL
Qatar Anti-Doping Laboratory
RTP
registered testing pool
THC
tetrahydrocannabinol
TP
testing pool
TUE
Therapeutic Use Exemption
WADA
World Anti-Doping Agency
UNESCO
The United Nations Educational, Scientific, and Cultural Organization

Declarations

Acknowledgments

The authors express gratitude to KADA for acceptance of using the test results obtained from doping controls performed in Kuwait.

Ethics approval

Ethical approval was taken from the head of KADA administration and ethical committee to use athletes' data for research purposes under their regulations.

Conflicts of Interest

The authors declare no conflict of interest.

Funding

The authors declare that they have not received funding for conducting this study.

Data availability

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

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Tables

Tables 1 to 4 are available in the supplementary files section

Figures

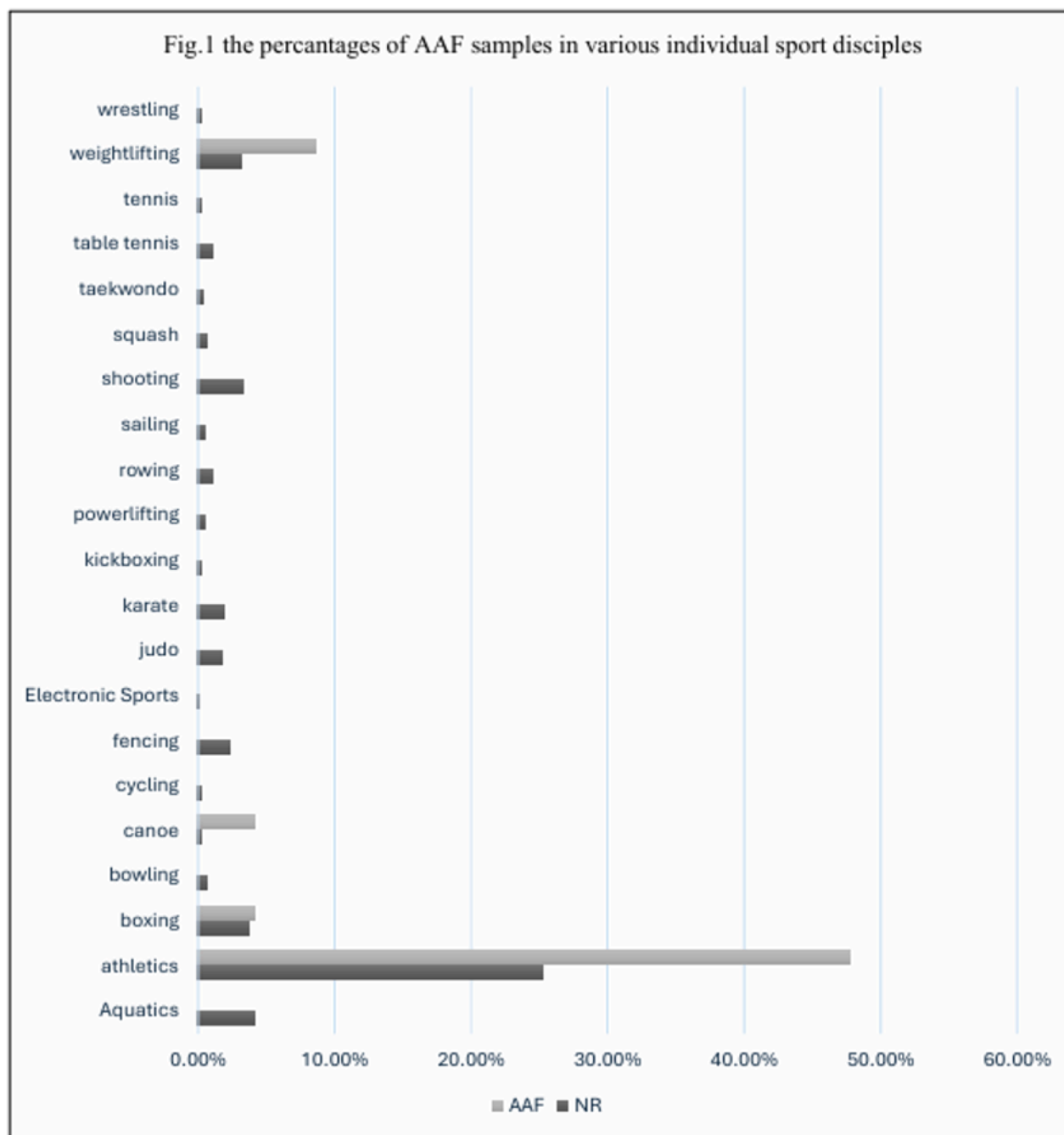


Figure 1

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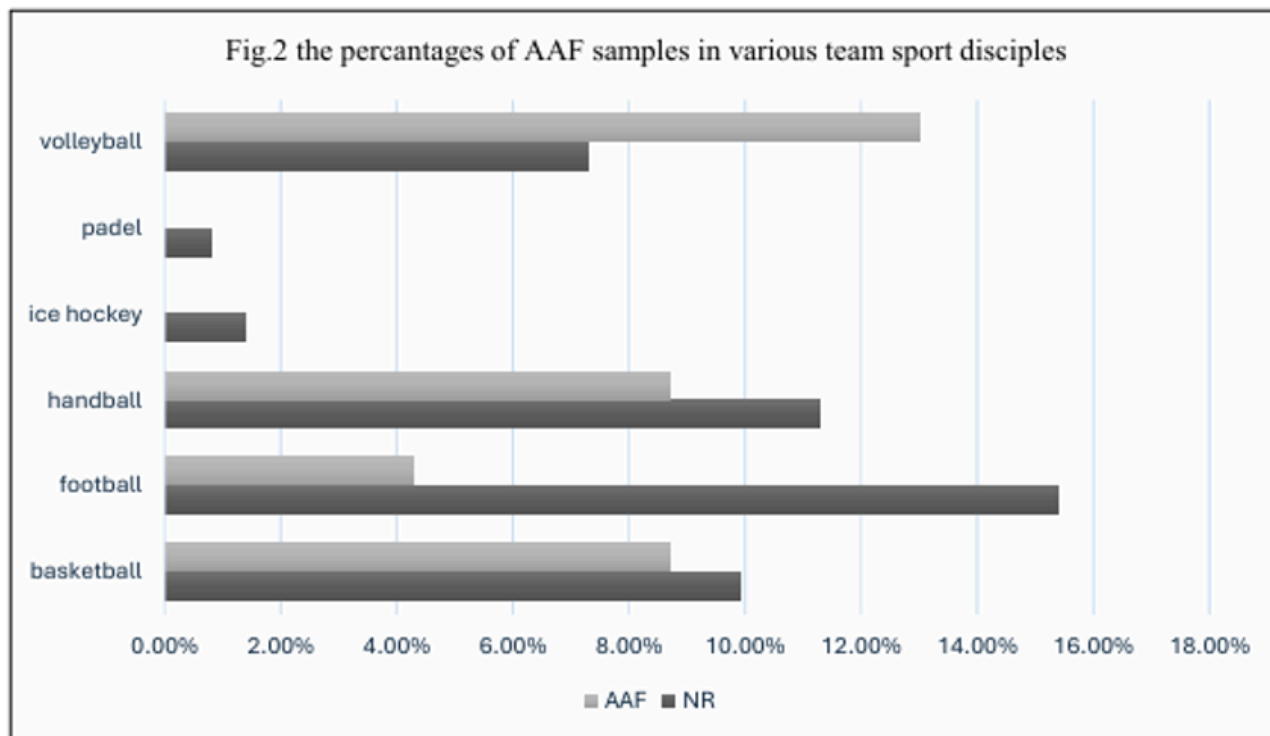


Figure 2

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Fig.3 the percentages of prohibited substances classifications detected in AAF samples according the WADA prohibited list

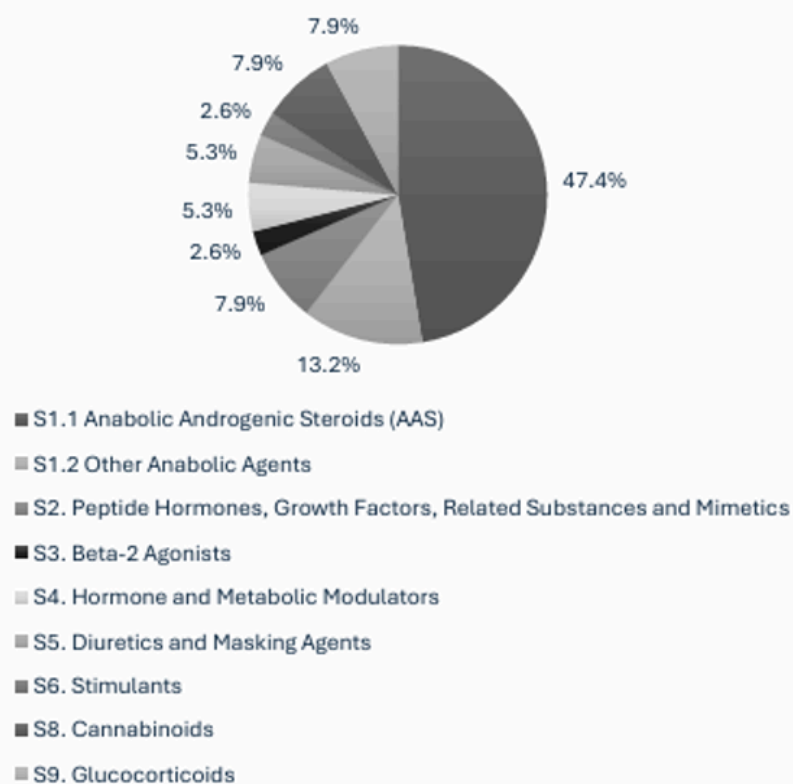


Figure 3

See image above for figure legend.

Supplementary Files

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