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Research Paper

A decade of doping control in the South American football confederation (CONMEBOL) (2014 to 2024): comparative analysis by discipline and player sex

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ABSTRACT

Doping control is vital for ensuring fairness and protecting athlete health in football. Recent studies in elite European leagues show low rates of adverse findings, but data on South American competitions are limited. We aimed to analyse the number and distribution of doping control tests, as well as the number and types of banned substances reported as adverse analytical findings, in the football disciplines governed by the South American Football Confederation (CONMEBOL). The analysis was performed by using the data provided by the CONMEBOL Medical Commission and Anti-doping Unit from 2014 to 2024. During this period, 24,726 doping control tests were analysed with 89 adverse analytical findings (0.42% ± 0.27%). The most commonly detected groups of banned substances were anabolic agents (36), diuretics and masking agents (26) and glucocorticoids (19). The proportion of cannabinoids was unusually in futsal ($p < 0.05$) with no differences in the remaining groups of prohibited substances between football disciplines. From the total number of adverse analytical findings, 78 were detected in men and only 11 in women, with a significantly different distribution between sexes ($p = 0.016$): men showed higher proportions of anabolic agents ($p < 0.05$), while women exhibited higher proportions of diuretics and masking agents ($p < 0.05$). These findings reflect the outcomes of current anti-doping detection strategies in South American football. Although detection rates were low, discipline- and sex-specific differences observed in substance categories may help inform future research and the development of more targeted testing and education approaches.

1. Introduction

Football (soccer) has been the world's most popular sport throughout the last century, dominating global viewership, participation, and commercial revenue within the sports industry (Pifer et al., 2018). This widespread popularity has fostered a highly competitive environment, where success is often measured by marginal gains and continuous performance improvement (Ntoumanis et al., 2014; Petróczi & Aidman, 2008). As a result, athletes are frequently exposed to intense pressure to meet high expectations from clubs, sponsors, and fans, which can contribute to the seeking of performance-enhancing methods (Barkoukis et al., 2013; Ntoumanis et al., 2014). The increasing professionalization of football, combined with the pursuit of marginal advantages to achieve peak physical performance, has created a potentially fertile ground for the emergence of doping practices (Dvorak et al., 2006). Despite this high-pressure environment, existing research suggests that reported adverse analytical finding rates in professional football are low compared to some other high-performance sports (Aguilar-Navarro et al., 2020a). However, this perception may be influenced by the limited number of investigations on doping detection in football, particularly outside of the major European competitions (Moscovici et al., 2024) or in less-studied formats beyond the traditional 11-a-side

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discipline (hereafter referred to as 'football').

Football, futsal and beach football are disciplines currently governed by the Fédération Internationale de Football Association (FIFA). The physical and tactical demands of the different football disciplines may influence the types of substances footballers might seek to enhance performance. Traditional football is played with 11 players per team over two 45-min halves on a large pitch (around 100 m in length and 64–75 m in width). The game permits only a limited number of substitutions (generally up to 5), which requires most players to sustain continuous physical performance over 90 min. As a result, football play combines high-intensity efforts such as sprints, tackles, and aerial duels interspersed with periods of lower intensity (Ferrandis et al., 2023), demanding a unique combination of characteristics such as agility, endurance, speed, and strength (Sarmento et al., 2018). In contrast, futsal is played indoors on a much smaller pitch (40 × 20 meters) with five players per team and allows unlimited substitutions. The game consists of two 20-min halves, but with frequent stoppages and a faster pace than traditional football, demanding explosive power, quick decision-making, and rapid changes of direction (Barbero-Alvarez et al., 2008). Last, beach football, played on sand, presents a unique physiological challenge due to the unstable surface, which increases energy expenditure and muscle activation during movements. Matches are shorter, typically consisting of three 12-min periods, and also permit frequent substitutions, encouraging repeated high-intensity efforts (Leite, 2016). All these disciplines share similarities in their technical movements and exhibit some common physiological demands, as all of them are intermittent high-intensity team sports. However, due to the distinct characteristics of each type, such as the playing surface, size of the field, number of players, game duration, and substitution rules, these disciplines appear to diverge from one another. These structural and contextual differences shape the physical, technical, and metabolic demands of each discipline and may influence the types of performance-enhancing substances that athletes might be tempted to use (Handelsman, 2015); however, this hypothesis has yet to be substantiated with concrete and objective data.

Additionally, practices and behaviours toward doping may differ between male and female football players (Aguilar-Navarro et al., 2020b). Research has shown that male athletes are more frequently associated with the use of anabolic agents, while female athletes exhibit higher rates of diuretics and masking agents, potentially linked to weight control concerns and body image pressures (Aguilar-Navarro et al., 2020b; Hernández-Mendo et al., 2021). Beyond football, studies in other sports have similarly reported sex-related differences in doping intentions, substance preferences, and motivational drivers, reflecting distinct physiological, psychological, and socio-cultural influences (Barkoukis et al., 2013; Ntoumanis et al., 2014). These differences may have important implications for the design of targeted anti-doping education programmes, testing strategies, and prevention policies.

Since 1966, FIFA has been concerned with ethical aspects, physical and mental health and equality between competitors, while being attentive to the problem of doping (Dvorak et al., 2006). The prevalence of doping in football has been a phenomenon that has attracted the attention of sports organizations, governmental authorities and researchers in recent decades. According to the results of doping control tests published by the World Anti-Doping Agency (WADA), it has been revealed that the percentage of samples containing banned substances in football has remained relatively stable at approximately 1.2% in last years (Aguilar-Navarro et al., 2020a). Overall, anabolic agents represent the most commonly found adverse drug finding, followed by stimulants and glucocorticoids (Aguilar-Navarro et al., 2020b). At a global level, football is the sport with the highest number of samples analysed per year and with the highest proportion of samples obtained in competition. However, despite extensive anti-doping testing, football consistently exhibits a relatively low proportion of adverse analytical findings compared with some other sports, a pattern that likely reflects sport-specific detection processes rather than underlying differences in doping prevalence (Aguilar-Navarro et al., 2020a).

Currently, there is a lack of studies comparing the prevalence of doping between countries in the context of football (Moscovici et al., 2024). Overall, recent studies have shown low rates of adverse analytical findings in elite-level competitions ruled by FIFA or UEFA (FIFA, 2023; UEFA, 2023). Yet limited data exist on the prevalence and distribution of adverse analytical findings within South American football competitions. Consequently, there remains a dearth of comprehensive studies examining the frequency and distribution of adverse analytical findings within the South American Football Confederation (CONMEBOL). It is important to note that adverse analytical findings do not necessarily equate to confirmed anti-doping rule violations. An adverse analytical finding refers to the detection of a prohibited substance or its metabolites in an athlete's sample, as identified by a WADA-accredited laboratory. However, this finding may later be explained by factors such as a therapeutic use exemption, unintentional exposure, or other procedural considerations. In this context, an anti-doping rule violation is only established after the formal results management process has been completed. Therefore, adverse analytical findings should be interpreted as analytical detection outcomes rather than confirmed doping offences. Thus, the objective of this investigation was to describe and analyse the number and distribution of doping control tests, as well as the number and types of banned substances reported as adverse analytical findings, in the football disciplines governed by CONMEBOL. This analysis was conducted using a descriptive and exploratory approach, aimed at identifying detection patterns rather than inferring doping prevalence or causal relationships.

2. Materials and methods

The current investigation presents an *ad hoc* analysis of the number of doping tests conducted and of the number of adverse analytical findings per drug class in the CONMEBOL from 2014 to 2024. For this aim, this study includes data of the CONMEBOL Medical Commission and Anti-doping Unit reports made available annually on their webpage (CONMEBOL, 2025a). These reports provide data from WADA-accredited laboratories on the number of samples analysed and the corresponding adverse analytical findings by drug class, limited to those tests requested by CONMEBOL as the testing authority. Accordingly, the reports include data from 11-a-side football (traditional format), futsal, and beach football, disaggregated by age group and competition level. For instance, at the senior level, they encompass doping control tests from competitions such as the Copa Libertadores, Copa América, and Pre-Olympic qualifiers. Additionally, data are included from youth tournaments across all under-20 categories. Throughout this study, adverse analytical finding rates are interpreted as indicators of detection under current anti-doping testing systems, rather than as direct measures of the true prevalence of doping behaviour among athletes. Analysing these detection patterns is valuable as it enables the identification of trends across football disciplines and athlete groups, which may help inform the optimisation of anti-doping testing strategies and education programmes, even in the absence of direct measures of true doping prevalence.

To date, 2024 is the last public available report and the current study present then data of a total of 11 annual reports. Since 2016, CONMEBOL Medical Commission and Anti-doping Unit published information on the number of analysed samples and adverse analytical findings per football discipline for the first time. So, the analysis of these variables is available in the last nine annual reports. In these reports, each adverse analytical finding is categorised by the group of substances, as per the WADA List of Banned Substances (World Anti-Doping Agency, 2025b). Specifically, the reported substance groups include anabolic agents, peptide hormones and growth factors, beta-2 agonists, hormone and metabolic modulators, and diuretics and masking agents, which are prohibited at all times (i.e., both in- and out-of-competition); as well as stimulants, narcotics, cannabinoids, and glucocorticoids, which are

prohibited only during football competition. According to the WADA Code (World Anti-Doping Agency, 2021) and the FIFA Anti-Doping Regulations, in-competition is defined as the period commencing at 11:59 p.m. on the day before a competition in which the athlete is scheduled to participate, through to the end of the competition and the sample collection process related to the competition. So, this implies that the in-competition doping test period lasts less than 24 h for matches of national leagues but it can reach up to several weeks for international tournaments of national teams. This analysis has followed a similar pattern to previous publications in the frequency of adverse analytical and atypical findings in athletics and swimming (Aguilar-Navarro et al., 2021b; Lara et al., 2021).

2.1. Statistical analysis

The data were electronically extracted from the Medical Commission and Anti-doping Unit report (available in .pdf format) and entered into a database designed for the purposes of this research. The data were extracted by one author using a spreadsheet (Excel 2021, Microsoft Office, WA, USA). A second author independently verified the extracted data by cross-checking the entries against the original CONMEBOL reports, and any discrepancies were discussed and resolved by consensus. The percentage of adverse analytical findings per year was calculated by dividing the number of adverse analytical findings by the number of samples within each annual report. The proportion of analytical findings per drug class within the 2014-2024 period was calculated by dividing the number of adverse findings in each drug category by the total number of adverse findings during this period. The differences in the distribution of adverse analytical findings per drug class between football disciplines (football, futsal and beach football) and sex (men and women) were tested with crosstabs and Chi square tests, including adjusted standardised residuals. Given the low frequency of some categories, particularly when stratifying by sex and football discipline, some cells included expected counts below five; therefore, Chi-square analyses were conducted for exploratory purposes and results were interpreted with caution. A discipline or sex was considered to have an atypical distribution of adverse findings per drug class when the proportion of any drug class was below or above the critical value of Z (i.e.,

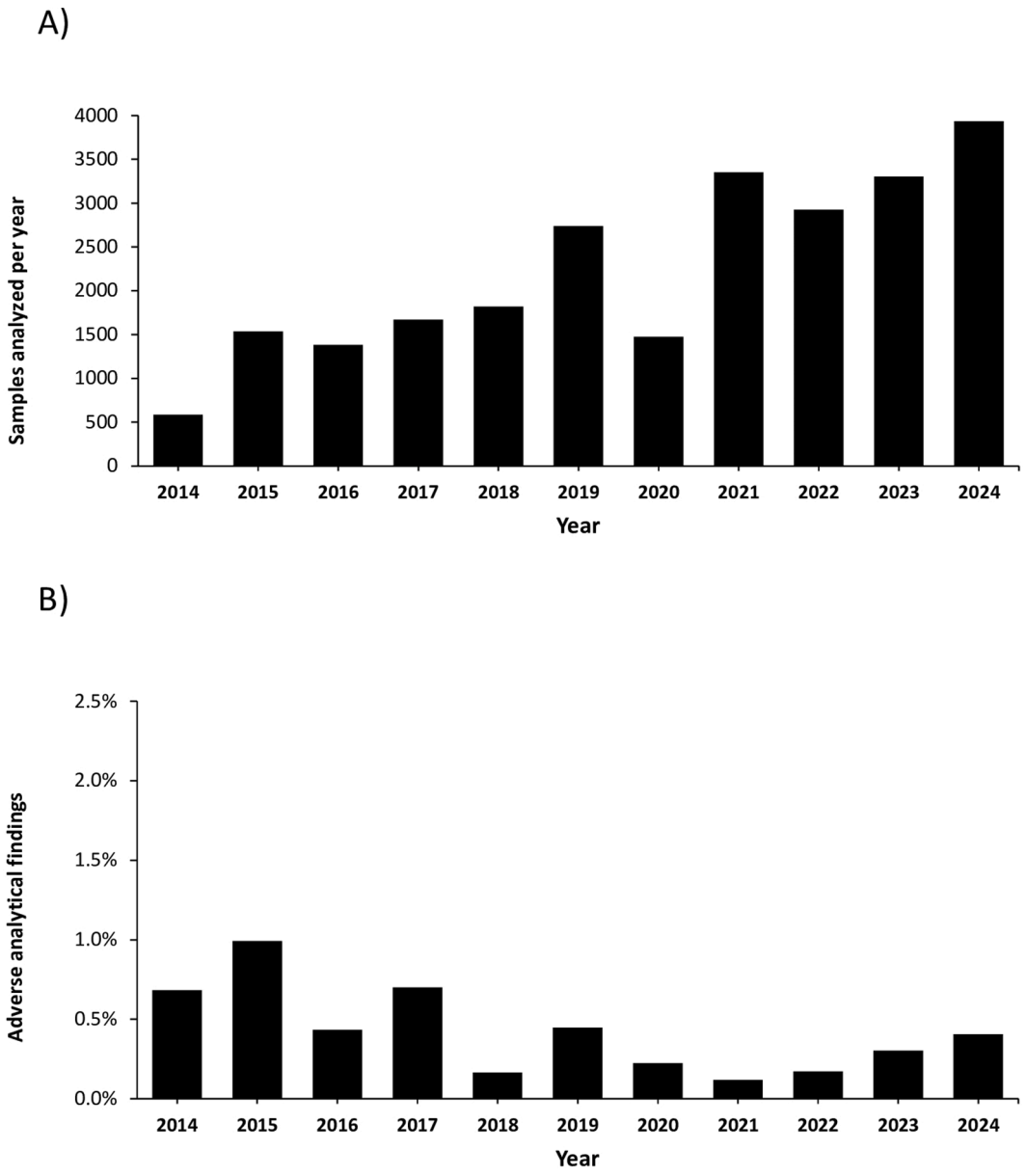

Fig. 1. (A) Number of samples analysed and (B) percentage of adverse analytical findings in South American Football Confederation from 2014 to 2024.

1.96). The data were analysed with the statistical package SPSS v 27.0 (SPSS Inc., Chicago, IL). The significance level was set at $p < 0.050$.

3. Results

Fig. 1 contains data about the number of samples analysed (Fig. 1A) and the frequency of adverse analytical findings per year (Fig. 1B). A total of 24,726 doping control tests were obtained and analysed from 2014 to 2024. Doping control tests ranged from 586 in 2014 to 3935 in 2024. Within this period, there were 89 adverse analytical findings reported for an overall frequency of adverse analytical findings of 0.42% ± 0.27%. Frequency of adverse analytical findings ranged from 0.68 in 2014 to 0.41% in 2025. A total of 19,105 samples (81.9%) were in-competition and 5,621 samples (18.1%) were out-of-competition analysis. In this case, there were 82 adverse analytical findings in samples obtained in in-competition samples (95.6%) while 7 adverse analytical findings were reported in out of competition samples (4.4%).

A detailed analysis of the number of adverse findings per drug class is presented in Table 1. Among the 89 adverse analytical findings reported between 2014 and 2024, a total of 97 banned substances were detected. This discrepancy is explained by the fact that in 82 cases, only one prohibited substance was identified, whereas in the remaining seven cases, two to three banned substances were detected within the same sample. Overall, the most frequently detected substances prohibited at-all-times by WADA were boldenone and clenbuterol (anabolic agents), along with hydrochlorothiazide, furosemide and acetazolamide (diuretics and masking agents). Additionally, the most commonly detected substances in in-competition samples were betamethasone and dexamethasone (glucocorticoids), cocaine and sibutramine (stimulants), and higenamine (a beta-2 agonist). Within the samples with more than one banned substance, the combination of furosemide and acetazolamide was the most common compound.

Fig. 2 contains the frequency of adverse analytical findings per drug category in each football discipline. Football was the discipline with the highest number of adverse analytical findings, 72 in total (31 anabolic agents, 17 glucocorticoids, 12 diuretics and masking agents, 8 stimulants, 3 beta-2 agonists and 1 cannabinoids). Futsal ranked second with 9 adverse analytical findings (1 anabolic agents, 2 glucocorticoids, 4 diuretics and masking agents and 2 cannabinoids). However, in beach football only 8 adverse analytical findings were detected in the period under investigation (4 anabolic agents, 2 diuretics and masking agents, 1 stimulant and 1 beta-2 agonist). Interestingly, the proportion of cannabinoids was higher than expected in futsal ($p < 0.05$) with no differences in the remaining groups of prohibited substances.

Fig. 3 contains the frequency of adverse analytical findings per drug category in each sex. As the number of samples collected by sex was not available in the CONMEBOL reports, these results represent absolute counts of detected substances rather than sex-specific prevalence estimates. Men was the sex with the highest number of adverse analytical findings, 78 in total (35 anabolic agents, 15 glucocorticoids, 12 diuretics and masking agents, 9 stimulants, 4 beta-2 agonists and 3 cannabinoids), while in women only 11 adverse analytical findings were detected between 2014 and 2024 (1 anabolic agents, 4 glucocorticoids and 6 diuretics and masking agents). The distribution of adverse analytical findings per drug category was different between male and women ($p = 0.016$). Male presented abnormally high proportions of adverse analytical findings within the group of anabolic agents ($p < 0.05$) and women presented atypically high proportions of banned diuretics and masking agents ($p < 0.05$).

Table 1
Substances identified as adverse analytical findings per drug class category in the reports of the CONMEBOL Medical Commission and Anti-doping Unit from 2014 to 2024.

Substance Group	Total	Substance	Occurrences
Anabolic Agents	36	Boldenone	16
		Clenbuterol	11
		Stanozolol	3
		Enobosarm (Ostarine)	3
		Nandrolone	2
		Methandienone	1
Beta-2 Agonist	4	Higenamine	4
Diuretics and Other Masking Agents	26	Hydrochlorothiazide	7
		Furosemide	6
		Acetazolamide	4
		Dorzolamide	2
		Chlorothiazide	2
		Canrenone	2
		Thiazides	1
		Spironolactone	1
		Chlorthalidone	1
Stimulants	9	Cocaine	4
		Sibutramine	3
		Amphetamine	1
		Octopamine	1
Cannabinoids	3	Carboxy-THC	3
Glucocorticoids	19	Betamethasone	9
		Dexamethasone	5
		Hydroxy Triamcinolone	1
		Methylprednisolone	1
		Prednisolone	1
		Triamcinolone Acetonide	1
		No data	1

4. Discussion

To understand the differences in doping behaviours among football disciplines associated to CONMEBOL, the goal of this investigation was to analyse the number and distribution of samples analysed and adverse analytical findings per drug class in the sporting disciplines of this continental federation. The main outcomes of this investigation were a) in general, the number of anti-doping controls increased on a yearly basis, with a slight reduction in the number of samples analysed in 2020 due to the COVID-19 pandemic. Nevertheless, the percentage of adverse analytical findings remained relatively stable at below 1% during this whole period (Fig. 1). The distribution of samples obtained in competition and out of competition was 81.9% and 18.1%, respectively, while the distribution of adverse analytical findings in competition and out of competition was 95.6% and 4.4%, respectively. Although out-of-competition testing is often considered particularly relevant for detecting certain prohibited substances, this pattern may be explained by the much higher number of in-competition tests conducted and by the presence of substances prohibited specifically during competition, such as glucocorticoids and stimulants. Therefore, differences in the frequency between in-competition and out-of-competition adverse analytical findings should be interpreted in light of the unequal distribution of testing and the specific substances more likely to be detected in each setting. b) The most commonly detected groups of banned substances were anabolic agents, glucocorticoids and diuretics and masking agents (Table 1). c) The proportion of cannabinoids was higher than expected in futsal players (Fig. 2). d) Finally, the number of banned substances detected in anti-doping control tests were different depending on sex with male having a higher proportion of anabolic agents and female having a higher proportion of diuretics and masking agents (Fig. 3). Collectively, these findings indicate that despite an increase in doping controls, the prevalence of adverse analytical findings (i.e. detection rates) remained low and stable, with notable variations in substance type based on sex and a higher-than-expected frequency of cannabinoid use in futsal. Practically, these insights can guide the development of more targeted anti-doping strategies, such as discipline- and sex-specific testing protocols and educational efforts tailored to the distinct risk profiles observed within each subgroup. Last, given the low absolute number of adverse analytical findings, all comparisons should be interpreted as descriptive indicators of detection patterns rather than

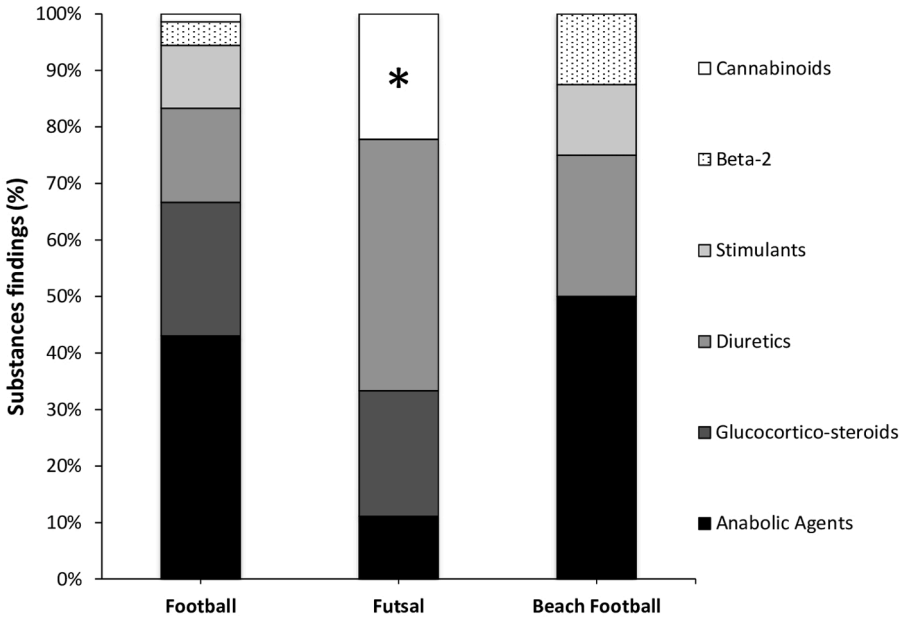

Fig. 2. Distribution of adverse analytical findings per category of banned substances in South American Football Confederation from 2014 to 2024.

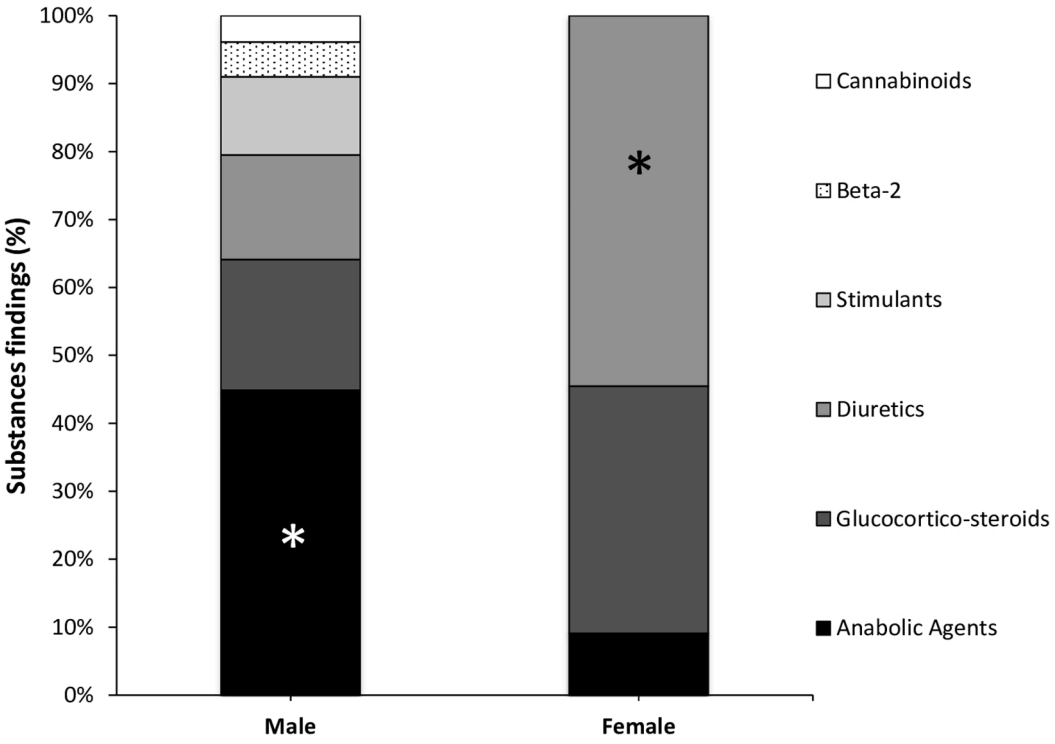

Fig. 3. Distribution of adverse analytical findings per category of banned substances in football disciplines from 2014 to 2024. * The distribution was different from that expected at $p < 0.05$.

as inferential evidence of differential risk.

Among various anti-doping strategies, the implementation of doping control tests during major competitions is considered one of the most effective, largely due to their deterrent effect; the possibility of being tested at high-stakes events discourages footballers from using prohibited substances, as the consequences of a positive result—such as suspension, reputational damage, and loss of career opportunities—are significantly amplified in these contexts (de Hon & van Bottenburg, 2017). To judge by the data of this investigation, the Antidoping Unit of CONMEBOL has multiplied the number of doping controls by 572% in the last decade, as it increased from 586 in 2014 to 3935 in 2024. This corresponds to a normal trend worldwide in football and in other sports (Aguilar-Navarro et al., 2020a), facilitated by several mandates of WADA such as the technical Document for Sport Specific Analysis (TDSSA), which mandates minimum levels of testing for specific drug classes in each sport (World Anti-Doping Agency, 2025a). Along with this higher number of doping control tests, there have been advances in testing technology, with improved sensitivity of analytical methods,

including longer detection windows (Metushi et al., 2024). Interestingly, despite higher anti-doping pressure and better analytical methods, the prevalence of adverse analytical findings (i.e., detection rates) in the CONMEBOL remained low and stable throughout the study period. Although 2020 was affected by the COVID-19 pandemic, anti-doping testing activity within CONMEBOL competitions remained substantial during that year, with 1,781 samples collected, and therefore does not represent a methodological outlier in the present analysis. In an analysis of the doping control tests carried out in world football from 2003 to 2015, the prevalence of adverse analytical findings was approximately 1.2% (Aguilar-Navarro et al., 2020a). In the current analysis, examining this same variable but from 2014 to 2024, the overall proportion of adverse analytical findings in football was lower, indicating a lower detection rate of prohibited substances under the existing anti-doping testing framework in South American Football. These findings suggest that while increased testing frequency and improved analytical techniques enhance the capacity to detect doping, their true impact may lie more in reinforcing a preventive framework and promoting a culture of deterrence, rather than in significantly increasing detection rates. These results support the continuation and refinement of CONMEBOL's testing strategy, suggesting that future anti-doping efforts could benefit from reallocating resources toward more targeted testing—particularly in high-risk disciplines, competitions, or athlete profiles—while also expanding educational initiatives to reinforce deterrence and prevent substance use before it occurs.

Regarding the proportion of substance per drug class in all football disciplines associated to CONMEBOL, the results point toward a low and similar use of prohibited substances in football disciplines, despite the fact that the physiological and performance determinants of each discipline are slightly different. As in previous research (Aguilar-Navarro et al., 2020b), anabolic agents represented the most commonly found adverse drug finding of in football (when analysing all disciplines together as a unique sport), followed by glucocorticoids and diuretics and masking agents. The most commonly identified drug classes in the study were boldenone, clenbuterol, betamethasone, dexamethasone and hydrochlorothiazide. These compounds, which are classified as anabolic agents, glucocorticoids or diuretics, have been associated with considerable enhancements in athletic performance. It should also be acknowledged that some adverse analytical findings may be associated with the legitimate medical use of prohibited substances, for example under therapeutic use exemptions, particularly in the case of substances such as glucocorticoids. As such, not all findings necessarily reflect intentional performance enhancement or misuse. Boldenone, in particular, is employed specifically to augment muscle mass and facilitate recovery, thereby enabling athletes to engage in more intensive and frequent competition regimens (Gómez et al., 2012). Likewise, Clenbuterol, an anabolic steroid, is well-known for its bronchodilatory effects and its ability to promote muscle hypertrophy and fat reduction, which may lead to substantial improvements in both strength and endurance among football players (Evans, 1997; Parkinson & Evans, 2006; Sagoe et al., 2014). Additionally, glucocorticoids such as betamethasone and dexamethasone are utilized to reduce inflammation, allowing players to effectively manage injuries and maintain peak competitive performance (Vernec et al., 2020). Hydrochlorothiazide, despite this substance not having a clear advantage in sports requiring motor skills, functioning as a diuretic, has the potential to influence doping test results by diluting urine samples (Cadwallader et al., 2010). Currently, CONMEBOL is investigating nine adverse analytical findings for boldenone that occurred during the Venezuela 2024 Pre-Olympic tournament (CONMEBOL, 2025b). For this reason, a study has been initiated in collaboration with the Cologne Laboratory in Germany to investigate whether boldenone can be found in human urine due to food contamination. The fattening of cattle with substances on the WADA Prohibited List is a problem that highlights the importance of careful nutrition for athletes in the face of possible sources of unintentional doping (Merlo et al., 2024). These findings underline the need for strengthened food safety monitoring, targeted nutritional guidance, and region-specific education programmes to minimise the risk of inadvertent doping in elite football.

Regarding the discipline, futsal players showed a higher frequency of cannabinoids compared to other football disciplines. Since there is no evidence supporting the ergogenic benefits of cannabinoids in sports (Hudzik et al., 2023), it is likely that the elevated levels found in doping tests among these players stem from the substance's popularity as a recreational drug. Nevertheless, the absence of a performance-enhancing effect does not undermine the need to prohibit cannabinoids in sport, given the documented negative impact these substances have on athletes (Robinson et al., 2022). In South America, culturally specific practices such as the traditional consumption of coca leaf products (e.g., coca tea) have previously been associated with the detection of cocaine metabolites, including benzoylecgonine, in anti-doping controls, highlighting the potential for inadvertent exposure and the importance of regionally tailored athlete education (Mazor et al., 2006). Future research should further investigate how cultural, regional, and contextual factors may influence adverse analytical findings and the risk of inadvertent doping in football, particularly when comparing different regions of the world with distinct social practices, dietary habits, and substance use norms.

Specifically, anabolic agents were found more frequently in male players. The use of these substances, which is more popular among men than women (Karila et al., 2024), is primarily associated with the pursuit of improvements in physical performance and recovery (Andrews et al., 2018). These substances promote increased muscle mass, strength, and endurance, highly valued characteristics in high-performance football. In a highly competitive environment like football, where differences between players can be minimal, some may resort to anabolic agents to gain advantages over their rivals. However, given the limited number of adverse analytical findings, these observations should be interpreted as descriptive detection patterns rather than evidence of substance use prevalence, highlighting the need for further exploratory research to better inform future prevention and education strategies. Experience from other sporting and recreational contexts suggests that effective prevention strategies combine increased out-of-competition testing, targeted biological monitoring, and education programmes addressing performance pressures, body image, and long-term health consequences of anabolic steroid use (Backhouse et al., 2012; de Hon et al., 2015). In particular, intelligence-led testing, athlete biological passport profiling, and early-career education interventions have proven valuable in reducing anabolic agent misuse in strength- and power-oriented sports (Sottas et al., 2011). Adaptation of these approaches to football may enhance deterrence and prevention in male players.

An interesting finding in the present study is the high rating of diuretics and masking agents found in female players. The use of diuretics among female players can primarily be attributed to several interconnected factors that reflect broader socio-cultural and sports-specific pressures (Godoy-Izquierdo & Díaz, 2021; Staśkiewicz-Bartecka, Aktaş, et al., 2024). One significant reason is the desire for rapid weight loss, which diuretics can facilitate by promoting the elimination of excess fluid from the body (Cadwallader et al., 2010). This can be motivated by personal and external pressures to achieve a certain body image or meet specific weight criteria (Staśkiewicz-Bartecka, Kalpana, et al., 2024) even though such pressures might not be officially dictated in sports like football. Additionally, there is often a misguided belief that reducing body weight can enhance agility and performance on the field, although this is not supported by scientific evidence. Furthermore, diuretics are sometimes used to mask the presence of other performance-enhancing drugs by diluting urine samples, a practice that is strictly prohibited by anti-doping regulations (Cadwallader et al., 2010). It should also be considered that some diuretic-related adverse analytical findings may be associated with legitimate medical use under Therapeutic Use Exemptions, as diuretics can be prescribed for certain clinical conditions, such as hypertension or certain renal conditions.

Therefore, not all findings necessarily reflect intentional misuse or performance-related motivations. Perhaps, diuretics might be employed to mask the use of anabolic agents and glucocorticoids in football. Taken together, these findings suggest that prevention strategies may benefit from addressing body image concerns, weight-control behaviors, and performance-related anxieties in female football players. Future research is needed to better understand the underlying reasons for diuretic use among female players, including both quantitative and qualitative approaches to explore behavioral, medical, and contextual factors.

Indeed, anti-doping testing data should not be interpreted in isolation. While analytical findings provide objective evidence of prohibited substance detection, they represent only one component of a complex anti-doping ecosystem. Future research should integrate testing data with qualitative and behavioral evidence, intelligence reports, and education outcomes to more comprehensively inform policy and prevention strategies. Additionally, the persistently low detection rate may support the expansion of long-term sample storage and the application of emerging analytical techniques for retrospective analysis which have previously demonstrated their value in uncovering anti-doping rule violations in elite sport (Kolliari-Turner et al., 2021). Lastly, it is important to acknowledge that adverse analytical findings may be associated with heterogeneous circumstances, and that not all cases ultimately result in confirmed anti-doping rule violations, as sanctions are subject to a results management process that considers factors such as inadvertent exposure or negligence rather than intentional doping (de Hon & van Bottenburg, 2017).

A number of study limitations are worth mentioning to draw conclusions about the control of banned substances within CONMEBOL. First, the analysis is restricted to adverse analytical findings obtained from doping control tests categorized by drug type. Previous research has suggested that the current anti-doping system may only detect a fraction of the total number of athletes engaging in the use of banned substances (Maennig, 2014). Consequently, the adverse analytical findings presented in this study may only represent a subset of the overall incidence of prohibited substances used in football disciplines of South American football.

Second, it is important to note that not every adverse analytical finding results in an anti-doping rule violation (Aguilar-Navarro et al., 2021a). Some substances may have been detected under legitimate circumstances, such as approved therapeutic use exemptions or inadvertent exposure. The publicly available CONMEBOL reports do not provide information on the adjudication of adverse analytical findings, including whether cases resulted in confirmed anti-doping rule violations or the duration of any sanctions imposed. As a result, the data presented here may not accurately reflect the total number of confirmed doping offences.

Third, the reports of the Medical Commission and the Anti-Doping Unit of CONMEBOL did not provide sufficient methodological and athlete-level contextual information. Specifically, data on the number of samples collected (urine and blood) by discipline were not available, precluding the calculation of the frequency of adverse analytical findings by discipline. In addition, the absence of detailed athlete-level information (e.g., age, playing status, competition level, education exposure), together with the lack of adjudication data indicating whether adverse analytical findings resulted in confirmed anti-doping rule violations, limits the interpretation of potential risk patterns. Although adverse analytical findings in female players were detected in CONMEBOL-organised elite club competitions (e.g., Libertadores and Libertadores Futsal) as well as in youth international tournaments (e.g., Sub17 and Sub20 competitions), the small number of cases precludes the definition of generalisable risk profiles or conclusions regarding differential risk across competition levels. Given the very small number of adverse analytical findings in female players, these results should be interpreted as descriptive and hypothesis-generating, reinforcing the need to expand sex-specific anti-doping analyses in women's football to better characterise potential substance use patterns.

To address these limitations, future research would benefit from designs that move beyond descriptive surveillance toward integrative approaches combining laboratory findings with adjudication outcomes and athlete-level contextual information. Moreover, the development of standardised reporting frameworks by continental and international federations—detailing sample distribution, testing context, and case resolution—would substantially improve the interpretability, comparability, and policy relevance of anti-doping data.

Finally, the blood samples collected for the Athlete's Biological Passport were not included in our analysis because this information was not publicly available in the CONMEBOL Medical Commission and Anti-doping Unit reports for any year between 2014 and 2024.

5. Conclusions

In summary, the analysis of CONMEBOL Medical Commission and Anti-Doping Unit reports from 2014 to 2024 reveals a consistently low detection rate of adverse analytical findings across football disciplines. Despite a significant increase in testing over the last decade, the percentage of positive findings remained stable at ~0.4%, reflecting stable detection outcomes under the existing testing framework rather than evidence of changes in doping prevalence. Given the low absolute number of adverse analytical findings, these results should be interpreted as descriptive and hypothesis-generating and may contribute to informing future anti-doping education and testing strategies when considered alongside complementary sources of evidence, such as athlete education data, behavioural research, and intelligence-led investigations.

Ethics Statement

This study is based on the analysis of aggregated, publicly available data from official reports of the South American Football Confederation (CONMEBOL). The dataset does not contain identifiable personal information, and no direct interaction or intervention with human participants was conducted. According to international research ethics guidelines, studies based exclusively on publicly available and anonymized data are exempt from requiring formal ethical approval. Furthermore, all doping control procedures are conducted in accordance with the World Anti-Doping Agency (WADA) International Standard for Testing and Investigations (ISTI), which ensures that sample collection and data handling comply with established ethical and regulatory frameworks.

Availability of data and supporting materials section

All the data used in this investigation is publicly available on the CONMEBOL official website.
https://www.conmebol.com/comision-medica/

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CRediT authorship contribution statement

Millán Aguilar-Navarro: Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Conceptualization. **Jorge Domínguez-Carrión:** Writing – original draft, Methodology, Formal analysis, Conceptualization. **Osvaldo Pangrazio:** Visualization, Validation, Investigation, Data curation. **María Gabriela Gossen:** Visualization, Validation, Investigation. **Elías Paredes:** Visualization, Investigation, Data curation. **Francisco Forriol:** Visualization, Investigation, Data curation. **Juan Del Coso:** Writing – review & editing, Supervision, Methodology, Investigation, Formal analysis,

Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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