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THE PERSPECTIVE OF BLOOD DOPING CASES IN ELITE SPORT IN THE LAST DECADE

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ABSTRACT

Blood doping is a practice involving the manipulation of blood components using substances such as Erythropoietin and blood transfusions. Both Erythropoietin and blood transfusions influence the increase in oxygen transport capacity by raising hemoglobin concentration, potentially improving maximal oxygen consumption. This study aims to identify the prevalence of blood doping among athletes sanctioned by World Anti-Doping Agency over the past 10 years and to compare between genders and sports modalities. A total of 114 cases of blood doping were recorded. Erythropoietin use (105 cases) was observed in 84.8% of male athletes and 15.2% of female athletes. For blood transfusions (9 cases), 55.6% of cases were among male athletes and 44.4% among female athletes. In terms of sports modalities, cycling stood out as the sport with the highest number of cases (56.1%), followed by athletics (15.8%). The chi-square test revealed a significant association between gender and type of substance used ($\chi^2 = 4.888$, df = 1, p=0.027), with a Phi coefficient indicating a moderate nominal association ($\phi = -0.207$). The odds ratio indicates that female athletes have a significantly lower probability of using blood doping compared to male athletes (OR = 0.225, 95% CI: 0.054-0.928). It is concluded that there is a significant disparity in blood doping among athletes, with a prevalence of cases among male athletes. In terms of sports modality, cycling emerged as the sport with the highest incidence of blood doping cases

Key words: Doping in sports. Blood doping in sports. Blood transfusion. Eritropoetina. Athletes.

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RESUMO

A perspectiva dos casos de doping sanguíneo no esporte de elite na última década

O doping sanguíneo é uma prática que envolve a manipulação de componentes sanguíneos usando substâncias como eritropoietina e transfusões de sangue. Tanto a eritropoietina quanto as transfusões aumentam a capacidade de transporte de oxigênio ao elevar a concentração de hemoglobina, potencialmente melhorando o consumo máximo de oxigênio. Este estudo tem como objetivo identificar a prevalência do doping sanguíneo entre atletas sancionados pela Agência Mundial Antidoping nos últimos 10 anos, comparando entre gêneros e modalidades esportivas. Um total de 114 casos de doping sanguíneo foi registrado. O uso de eritropoietina (105 casos) foi observado em 84,8% dos atletas masculinos e 15,2% das atletas femininas. Para transfusões de sangue (9 casos), 55,6% dos casos ocorreram entre atletas masculinos e 44,4% entre atletas femininas. Em termos de modalidades esportivas, o ciclismo destacou-se como o esporte com o maior número de casos (56,1%), seguido pelo atletismo (15,8%). O teste qui-quadrado revelou uma associação significativa entre gênero e tipo de substância usada ($\chi^2 = 4,888$, df = 1, p = 0,027), com um coeficiente Phi indicando uma associação nominal moderada ($\phi = -0,207$). O odds ratio indica que atletas femininas têm uma probabilidade significativamente menor de usar doping sanguíneo em comparação com atletas masculinos (OR = 0,225, IC 95%: 0,054-0,928). Conclui-se que há uma disparidade significativa no doping sanguíneo entre atletas, com maior prevalência de casos entre atletas masculinos. Em termos de modalidade esportiva, o ciclismo emergiu como o esporte com maior incidência de casos de doping sanguíneo.

Palavras-chave: Doping no esporte. Dopagem sanguínea esportiva. Transfusão de sangue. Eritropoetina. Atletas

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INTRODUCTION

The initial definition of the term doping dates back to 1963, as established by the Council of the European Committee.

At that time, doping was characterized as the use of substances or physiological mediators that are not endogenous to the human body, meaning they are not naturally produced by the organism, introduced as an external intervention to enhance the physical and sporting capabilities of athletes during training and competitions (Thieme, Hemmersbach, 2009).

This initial definition laid the groundwork for the modern understanding of doping, highlighting the artificial and interventionist nature of these practices. In contemporary terms, the definition of doping has evolved and is formally established by the World Anti-Doping Code, which considers doping as any act or violation involving the use of a prohibited substance or method detected in urine or blood samples from athletes (Hughes, 2015).

This current definition broadens the scope of control, encompassing both banned substances and unauthorized methods, reflecting the increasing sophistication of doping practices and detection techniques.

With the rising prominence of the use of these banned substances and illicit practices, it has become imperative to identify and combat these violations to ensure the integrity of sport (Golub, Bennett, Elliott, 2015).

The responsibility for this task falls on the World Anti-Doping Agency (WADA), established as an independent organization in 1999 (Hughes, 2015).

The detection of doping carried out by WADA is an intricate process involving multiple steps and precise techniques.

The agency publishes and annually updates a list of prohibited substances and methods, providing a rigorous scientific basis for identifying the use of illicit substances by athletes(Lu et al., 2023).

Among several illicit practices, blood doping stands out as an old strategy that involves the manipulation of blood components (Oliveira, Bairros, Yonamine, 2014).

This includes the use of synthetic substances, such as Erythropoietin (EPO), and blood transfusion (BT) practices (Breenfeldt Endersen et al., 2024). EPO is a glycoprotein hormone primarily synthesized by the peritubular cells of the kidneys (Jelkmann, 2016).

Its primary role is to stimulate red blood cell production in the bone marrow, consequently boosting oxygen transportation throughout the body (Eschbach et al., 1987).

These physiological effects can potentially improve athletic performance, making it susceptible to misuse in the realm of sports. BT is another illicit practice used by athletes in various sports, consisting of the withdrawal, storage, and subsequent reinfusion of their own blood (Oliveira, Bairros, Yonamine, 2014).

The detection of blood doping involves two different strategies: the direct identification of exogenous substances, such as blood and other stimulant substances, and the indirect assessment, based on the effects of these substances on specific biomarkers (Robinson; et al., 2006).

The identification of homologous BT is conducted using flow cytometry, revealing incompatibilities in minor blood group antigens (Voss et al., 2007).

Furthermore, traditional laboratory techniques, such as isoelectric focusing, are also used to identify erythropoietic stimulants(Oliveira, Bairros, Yonamine, 2014).

Thus, once the athlete is discovered, such behavior compromises the integrity of sporting competitions and undermines public trust in the authenticity and fairness of sporting performance.

Therefore, the objective of this study is to identify the prevalence of blood doping use by athletes sanctioned by WADA in the last decade and make a comparison between the sexes, as well as between different sports.

Consequently, to offer a perspective of this scenario to raise awareness among athletes and coaches about the risks and consequences and contribute to the equity and integrity of sports.

MATERIALS AND METHODS

This research adopts a descriptive and retrospective study design, encompassing data analysis conducted between August 2023 and April 2024.

The study adheres rigorously to the ethical principles outlined in the Declaration of Helsinki.

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Participants

Participants in this study comprise international-level athletes who received sanctions from the World Anti-Doping Agency (WADA) over the preceding decade for blood doping. The selection process involved thorough scrutiny to ensure the integrity and accuracy of the data. Athletes whose implicated substances were not conclusively identified, those with incomplete demographic details such as gender and sport, and cases featuring duplicate names were excluded from the analysis to maintain data quality and integrity.

Data collection and analysis

Data collection was meticulous and comprehensive, drawing upon multiple reputable sources including official WADA records, sporting federations' databases, and validated public sources. Each case was individually assessed to ascertain the nature of the violation, the substances involved, the sport practiced by the athlete, and other relevant demographic information. Rigorous cross-referencing and verification procedures were employed to minimize errors and inaccuracies in the dataset. Ethical considerations were paramount throughout the study. The research adhered strictly to ethical guidelines, ensuring confidentiality and anonymity of the athletes involved. No personally identifiable information was disclosed in the analysis or reporting of findings to safeguard the privacy and rights of the individuals under study. The data were classified according to the observed frequencies and grouped by gender, sport modality, and type of blood doping. This categorization was represented by frequencies, percentages, medians, and means and standard deviations, as appropriate. The Shapiro-Wilk test was used to verify the normality of the distribution of the sample characterization variables. To verify the association between the variables, Fisher's Chi-square test (χ^2) was used and a significance level of 5% was used. The Phi coefficient and Crame's V were used to evaluate the strength of the relationship between the variables. This relationship was classified as: >0, none or very weak; >0.05, weak; >0.10, moderate; >0.15, strong, and >0.25, very strong (Akoglu, 2018). The Odds Ratio was calculated. The IBM SPSS statistics 25 software was used to perform the statistical analysis.

RESULTS

In absolute terms, 114 cases of blood doping were observed (94 men and 20 women). The percentage of use associated with each substance and sex can be seen in Figure 1.

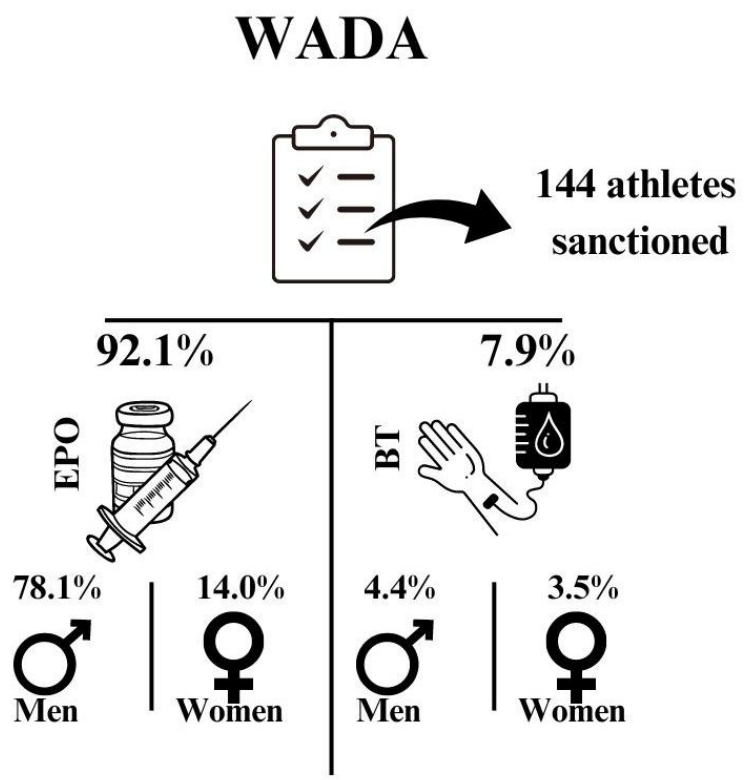

Figure 1 - Frequency of blood doping use in athletes.

Percentage analyses reveal that cycling has the highest number of cases, comprising 56.1%, followed by athletics with 15.8%. Table 1 presents the frequency and type of substances in each of the modalities.

Table 1 - Type of blood doping in different sports.

Sport	Erythropoietin (EPO)	Blood transfusion (BT)
	% (n)	% (n)
Cycling	60.0 (63)	11.1(1)
Athletics	12.4 (13)	55.6 (5)
Combat Sport	7.6 (8)	11.1 (1)
Weightlifting	5.7 (6)	11.1 (1)
Canoeing	5.6 (6)	-
Volleyball	3.8 (4)	-
Swimming	2.9 (3)	-
Triathlon	1.0 (1)	11.1 (1)
Soccer	1.0 (1)	-
Total	100 (105)	100 (9)

The X^2 test revealed a significant association between gender and the type of substance used ($\chi^2 = 4.888$, df = 1, p = 0.027). The Phi coefficient indicated a moderate nominal association ($\phi = -0.207$). The odds ratio indicated that female athletes are significantly less likely to use blood doping compared to male athletes (OR = 0,225, IC 95% 0,054-0,928).

DISCUSSION

The aim of this study was to identify the prevalence of blood doping use by athletes sanctioned by the WADA in the last 10 years, and to make a comparison between males and females, as well as between different sports.

The results highlight a significant disparity in the use of blood doping among athletes, with a clear predominance of cases for

male athletes for both EPO and BT. The χ^2 analysis showed a statistically significant association between gender and the type of substance used. The odds ratio indicated a lower probability of blood doping among female athletes (OR = 0.225, 95% CI: 0.054-0.928). In addition, cycling was the sport with the highest incidence of doping cases, representing 56.1% of the total occurrences.

Overall, the disparity in doping use between male and female athletes can be attributed to a complex intersection of physiological, social, and psychological factors (Collomp et al., 2022). Physiologically, hormonal differences, body composition, and metabolism may influence how athletes respond to illicit strategies in different sports contexts (Lewis, Kamon, Hodgson, 1986).

Socially, cultural norms, gender expectations, and societal pressures can shape attitudes toward the pursuit of doping (Aquino Neto, 2001).

Culturally, men are encouraged to strive for excellence at all costs, while women may face different expectations regarding their sports performance and physical appearance (Sekulic et al., 2016).

Psychologically, issues such as self-esteem, motivation for success, and compliance with social norms can influence the decision to use doping (Petroczi, Aidman, 2008).

In addition, the sports environment, including the lack of effective regulation and culture of tolerance for the practice, also play a significant role in the sex gap (Sekulic et al., 2016), in addition to a smaller number of tests performed on female athletes (Collomp et al., 2022).

In endurance sports, such as long-distance running and cycling, muscle oxygenation plays a crucial role in performance (Jelkmann, Lundby, 2011) and both EPO and BT influence the increase in oxygen transport capacity, increasing hemoglobin concentration, which translates into possible improvements in maximal oxygen uptake ($\dot{V}O_2max$) (Lundby et al., 2007; Seeger, Grau, 2020). In addition, the use of EPO has been associated with greater blood flow to the muscles and the release of norepinephrine, contributing to improve sports performance (Breenfeldt Andersen et al., 2024; Lundby et al., 2008; Nordsborg et al., 2015; Solheim et al., 2019).

Blood doping, classified as S2 by WADA standards, has been the subject of intense investigations (Heuberger, Cohen, 2019).

However, while studies reveal a low to moderate influence of EPO use on performance optimization during maximal exercise intensities in male athletes, its effects on female athletes remain unknown (Trinh et al., 2020).

This lack of understanding is concerning, as the effects of doping can vary between the sexes due to physiological differences such as blood volume, red blood cell count, and hemoglobin levels.

Additionally, the absence of comprehensive studies on this topic in female athletes should not be interpreted as an indication of its absence or lower prevalence of use. On the contrary, it may be a consequence of the lack of attention devoted to this population. The inability to identify and understand patterns of doping substance use in female athletes may lead to underestimation of health risks and associated ethical consequences (Buisson et al., 2023).

In the context of sports, there was a prevalence of blood doping in cycling, in agreement with previous studies (Sottas et al., 2011).

The intrinsic characteristics of this modality play a decisive role in this trend. Cycling events are predominantly aerobic, where aerobic endurance is the fundamental ability for performance, especially in long-duration competitions. $\dot{V}O_2max$ emerges as a critical factor for cyclists, and oxygen transport is essential to maintain an intensity of effort throughout the race (Jurov, Cvijic, Toplisek, 2023).

This same reasoning is applicable to athletics events, especially over longer distances, such as the marathon (Hoberman, 2007).

The practice associated with BT, which involves the removal and subsequent re-infuse of blood before competitions, is often combined with altitude training. Athletes often train in high-altitude regions, where lower atmospheric pressure induces a natural increase in the production of red blood cells in the blood.

This technique is then employed, allowing athletes to store this richer blood in red blood cells. Upon returning to sea level, they reinfuse this stored blood, in order to take advantage of the temporary increase in red blood cell numbers and gain a competitive advantage (Saugy, Schmoutz, Botre, 2022).

Despite the potential gains in performance, both the use of EPO and BT pose serious health risks to athletes. The administration of EPO can contribute to the development of cardiovascular complications, such as strokes and hypertension, as well as overload the circulatory system, promoting heart failure.

This is due to increased blood viscosity resulting from increased red blood cell production, which can lead to blood clots and obstructions in the arteries (Domen, 1998; Oliveira, Bairros, Yonamine, 2014).

One of the main risks associated with BT is decreased plasma volume, which can also lead to increased blood density and viscosity.

This increases the risk of blood clotting and obstruction of blood vessels, predisposing the athlete to thrombosis and pulmonary embolism. In addition, it can trigger adverse immunological reactions and there is a danger of contamination by pathogens, such as viruses and bacteria, if the procedures are not performed properly, increasing the risk of blood infections (Domen, 1998; Solheim et al., 2019).

In addition to the health implications, it is crucial to highlight the ethical dimension of doping. This issue becomes even more complex due to the dilemma faced by athletes who choose not to resort to banned substances, putting themselves at a disadvantage compared to competitors who opt for such illicit practices (Costa et al., 2008).

Underpinning the ethical rejection of doping are pillars such as respect for sports legislation, the promotion of fairness in competition, and the recognition of the serious damage to health associated with the use of these substances. In addition, doping is not only limited to athletes and competitions, but also affects sports organizations, spectators, and society in general.

Thus, it is crucial to invest in sports education focused on health and ethics, combined with the strict application of anti-doping rules, as a strategy to effectively combat this problem and preserve the fundamental values of sport for future generations.

Despite painstaking efforts to ensure the accuracy and completeness of the data, this study may be subject to certain limitations inherent in retrospective analyses.

Many of the available lists contained incomplete information or did not follow a pattern of data availability, which made it impossible to analyze other important information, such as the time of sanction, the country of origin of the athletes, the sex, and the sport practiced.

This lack of uniformity in the records may have impacted the breadth and depth of the analysis, limiting the full understanding of the phenomenon of blood doping among high-level athletes.

For future research, it is crucial to address the gaps identified in this study, especially regarding the standardization and availability of data related to blood doping among international-level athletes. Investments in enhanced methods of data collection and sharing, along with the implementation of more consistent reporting protocols, can facilitate a more comprehensive and accurate understanding of the prevalence, characteristics, and impacts of blood doping in the sports world.

Additionally, it is essential to continue developing and refining doping detection and analysis techniques, aiming for early and effective identification of illicit practices.

Concurrently, education and awareness programs should be strengthened to inform athletes, coaches, and other sports professionals about the risks and consequences of doping, thus promoting a culture of integrity and fair play in the global sports arena.

CONCLUSIONS

There is a significant disparity in the use of blood doping among athletes, with a clear predominance of cases among male athletes. In relation to the sport, cycling emerged as the sport with the highest incidence of doping cases.

CONFLICTS OF INTEREST

The authors have no conflicts of interest.

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