Emerging Trends in Drugs, Addictions, and Health 5 (2025) 100168

Contents lists available at ScienceDirect

Emerging Trends in Drugs, Addictions, and Health

journal homepage: www.elsevier.com/locate/etdah

A systematic review on the effectiveness of anti-doping education for university students

Adam R. Nicholls [a,*], Lambros Lazuras [b], Michael Petrou [c], Ornella Corazza [d], Carlos Santos [e], António Júlio Nunes [e], Michał Rynkowski [f], João F. Martins [g], Thomas Zandonai [d], Uta Kühn [f], Łukasz Tota [h]

[a] School of Sport, Exercise, and Rehabilitation Sciences, University of Hull, HU6 7RX, United Kingdom
[b] University of Lincoln, United Kingdom
[c] Cyprus Anti-Doping Authority, Cyprus
[d] University of Trento, Italy
[e] Portuguese Anti-Doping Authority, Portugal
[f] Polish Anti-Doping Agency, Poland
[g] University of Lisbon, Portugal
[h] University of Physical Education in Kraków, Poland

ARTICLE INFO

Editor: Sulaf Assi

Keywords:
Attitudes
Clean sport
Morality
Performance enhancing drugs
Students

ABSTRACT

Background: Doping poses a threat to the integrity of sport and the health of athletes who dope, including university students. In this systematic review, we identified the content of anti-doping education that universities provide, the disciplines mainly targeted by such education (e.g., sports science, medicine, physiotherapy, etc.), and the effectiveness of anti-doping education on university students' anti-doping knowledge, attitudes, and other related constructs.
Method: We systematically searched the literature using nine different search engines, manually searched relevant journals, and used pearl growing.
Results: This review included four studies comprising 1,410 university students. The content of the education programmes varied, although information about prohibited substances and rules was included in all interventions. Two studies targeted a specific cohort of students (e.g., medical and sports science students), whereas the other two recruited university students without specifying the subject discipline. All intervention programmes had a positive impact on doping knowledge, two studies had a positive effect on anti-doping attitudes, and one study impacted morality.
Conclusions: These four studies are essential, but methodological limitations mean that better-designed education interventions for university students are required. Researchers could assess the effectiveness of education interventions on anti-doping knowledge and key psycho-social variables among this population.

1. Introduction

The World Anti-Doping Code (WADC), which was first issued in 2004, was created by the World Anti-Doping Agency (WADA) to promote health, equality, and fairness among athletes (WADA, 2021). This code's strategic objectives were to facilitate harmonizing policies, rules, and regulations relevant to monitoring, controlling, and preventing doping in competitive sports. The WADC (WADA, 2021) specifies 11 anti-doping rule violations (ADRVs), leading to sanctions for the inflicted parties. These are: (1) prohibited substances in an athlete's sample; (2) use of or attempts to use a prohibited substance; (3) evading a test, refusing a test, or failing to submit to a sample; (4) whereabouts failures; (5) tampering with a test or attempts to tamper with doping control; (6) possessing prohibited substances or methods; (7) trafficking or attempts to traffic prohibited substances or methods; (8) administering or attempting to administer prohibited substances or prohibited methods to athletes; (9) complicity; (10) associating with banned individuals; (11) Threatening or intimidating others to discourage them

* Corresponding author.
E-mail address: A.Nicholls@hull.ac.uk (A.R. Nicholls).

https://doi.org/10.1016/j.etdah.2024.100168
Received 25 September 2024; Received in revised form 18 December 2024; Accepted 21 December 2024
Available online 14 January 2025

from reporting information relating to doping. The most reported ADRV, which accounts for about 80 % of all doping misconduct cases, is testing positive for a banned substance (Lauritzen, 2022).

According to the International Testing Figures, published annually by WADA (2024), using anabolic agents was the most prevalent substance identified in laboratory tests of athletes' biological samples. Anabolic agents accounted for 40 % in 2021 and 43 % in 2022 of all Adverse Analytic Findings across all sports, which represents a significant health threat for athletes. Researchers have shown that anabolic agents (e.g., testosterone and its derivatives) are associated with kidney, liver, and heart dysfunction and failure, hormonal imbalance, higher psychiatric symptoms, suicidal ideation and attempts, and cognitive decline and abnormal brain ageing (Lindqvist et al., 2013; Bjørnebekk et al., 2019). Furthermore, injectable steroids are associated with increased risk for a higher prevalence of communicable diseases (e.g., hepatitis and HIV; Hope et al., 2014). Although anti-doping organizations test mainly elite athletes, there is evidence that university athletes also take banned substances.

1.1. Doping among university students

Researchers reported that university students used different types of drugs, including anabolic agents, to improve athletic performance and their physical appearance (e.g., Blank et al., 2016; Dietz et al., 2021; Maier et al., 2013; Majori et al., 2017; Papadopoulos et al., 2006; Singh et al., 2014). For example, Blank et al. (2016) found that 9.4 % of the 771 students reported using banned substances, identical to the percentage of students from Cameroon (Guessogo et al., 2021). Performance enhancement drug use among university students is not limited to athletic performance and physical appearance improvements but also extends to cognitive enhancement. Maier et al. (2013) found that 13.8 % of 6275 Swiss students abused prescription drugs for cognitive enhancement. Majori et al. (2017) reported a similar figure, as 11.3 % of Italian students engaged in cognitive enhancement drug use. Sharif et al. (2014) found that 25.3 % of university students living in the United Arab Emirates self-reported using cognitive enhancement drugs, too. Much lower use of PEDs was reported by Erickson et al. (2019), who reported that 99 % of their sample had not used growth hormones or anabolic androgenic steroids, whereas 95 % reported not taking cocaine, heroin, or methamphetamine in the previous three months.

While biological testing helps in doping monitoring and control, education provides an effective medium for doping prevention (Cléret, 2011). Scholars have suggested that anti-doping education should target both athletes and athlete support personnel (ASP), which embraces a broad category of professionals (e.g., medical doctors, physiotherapists/sports therapists, nutritionists, and pharmacists; Patterson et al., 2023). Indeed, a broader range of professionals, including psychologists, other mental health professionals, and lawyers, can play a vital role in informing anti-doping research and practice (Viret, 2020). One way of increasing awareness and knowledge of professionals who may work, directly or indirectly, with athletes is through their formal education at university. This is explicitly stated in the Recommendation (Rec, 2016) of the Monitoring Group on Anti-Doping Education Guidelines for Tertiary Education of the Council of Europe: "*By taking […] anti-doping studies, the students/specialists will gain and improve their skills in order to being capable of influencing the careers of both young talents and high performance/elite level athletes towards clean sport behavior*" (p.2). Nevertheless, the related research suggests that university students (Aguilar-Navarro et al., 2022; Akarsu and Yalman, 2023) and currently serving professionals that would be best suited to offer advice about substances, such as pharmacists (Lemettilä et al., 2021) and medical doctors (Backhouse and McKenna, 2011; Dunn et al., 2023), have poor knowledge and skills to support doping prevention efforts.

1.2. Doping knowledge and attitudes among students on sports courses

Aguilar-Navarro et al. (2022) examined knowledge of doping among Spanish students from 26 universities studying for an undergraduate degree in sports science. These students demonstrated a *"modest knowledge"* of anti-doping regulations and prevention. Their findings were comparable to sports science students from Turkey (Akarsu and Yalman, 2023), Poland (Posiadala et al., 2006), and Kenya (Rintaugu and Mwangi, 2020). University students possess minimal knowledge about doping. Finally, physical education students who played team sports demonstrated more knowledge of doping than individual sport athletes (Lok et al., 2010).

Regarding doping attitudes held by sports students, Puchades and Molina (2020) reported that 94.25 % were against PEDs being legalized, which is like Morente-Sánchez et al. (2015), who also found that most disagree with using PEDs. In contrast to these two studies, Vangrunderbeek and Tolleneer (2010) found that students in a sports science programme in Belgium had developed a more favorable attitude towards doping over time. Interestingly, Rintaugu and Mwangi (2020) reported that sport science students had a more favorable attitude to doping than physical education students (Rintaugu and Mwangi, 2020). Given the general lack of education for sport-based students, scholars have explored where they receive their knowledge from. Worryingly, this includes the media (Posiadala et al., 2006; Vangrunderbeek and Tolleneer, 2010) and social media, such as social influencers, for information about different substances (Shalby et al., 2018). Due to these findings about knowledge and attitudes, scholars have argued for anti-doping education to be included in university syllabuses (e.g., Aguilar-Navarro et al., 2022; Rintaugu and Mwangi, 2020).

1.3. Knowledge and attitudes towards doping among pharmacy students

The research regarding knowledge and attitudes towards doping among undergraduates with pharmacy degrees revealed some alarming findings, considering athletes may consult pharmacists for information. For example, Awaisu et al. (2015) reported that 85 % of Qatar pharmacy students did not know WADA existed. El-Hammadi and Hunien (2013) found that 90 % of Syrian pharmacy students did not know that several drugs (e.g., narcotics, beta-blockers, and diuretics) were on WADA's prohibited list. Forty-one per cent of Japanese students were unaware that over-the-counter drugs may contain substances on the banned list. Education appears very important, given that Chan et al. (2019) found that pharmacy students who studied a drug in the sports module demonstrated more knowledge about doping, less favorable attitudes, and the need to implement doping prevention when working as a pharmacist. All these studies concluded that pharmacy students required more information about doping and that this information should be incorporated into their undergraduate degrees because many pharmacy students consider doping prevention as an important part of their job.

1.4. The present study

In summary, individuals pursuing degree qualifications in disciplines directly related to sports have very little knowledge about doping. Some researchers have called for the inclusion of anti-doping education within university courses to combat this problem (e.g., Aguilar-Navarro et al., 2022; Rintaugu and Mwangi, 2020) because this is likely to reduce doping among this population and help them promote clean sport after graduating. However, researchers have yet to systematically review the literature on the doping provision for university students, which identifies content, effectiveness, and target populations (i.e., the types of students recruited). The purpose of this systematic review was threefold: (1) to identify the content of anti-doping education that universities provide, (2) to identify the disciplines mainly targeted by such education (e.g., sports science, medicine, physiotherapy, etc.), and (3) examine the impact of anti-doping education on university students' anti-doping

knowledge, attitudes, and other related characteristics. Understanding current doping provisions for students will allow researchers, universities, and national anti-doping organizations to develop 'best practice' education courses for undergraduate and postgraduate students.

2. Method

2.1. Information sources and search strategy

Aligned with the revised PRISMA guidelines (Page et al., 2020) and previous systematic studies (e.g., Nicholls et al., 2016, 2017, 2021), we used three distinct search strategies to identify studies that met our search criteria and thus explore the impact of anti-doping education programmes on knowledge and psychosocial factors. The first and second authors used the following search engines: Academic Search Premier, CINAHL Complete, Education Research Complete, ERIC, Medline, PsycARTICLES, PsycINFO, Google Scholar, and SPORTDiscus. We accessed these search engines in February 2024. No date limit was placed on the searches. Based on a previous systematic review of doping (Nicholls et al., 2017), the following keywords were used: "anabolic", OR "androgenic steroids", OR "blood doping", OR "blood transfusion", OR "doping", "drugs", OR "gene doping", OR "growth hormone", OR "performance-enhancing drugs", OR "nutritional supplements", OR "pharmaceuticals", OR "stimulants", OR and "substance"). These words were used in conjunction with "university students" AND "students" AND "education", AND "doping attitudes", AND "doping knowledge", AND "doping attitudes", AND "doping intentions", "doping susceptibility" AND "doping behavior".

Secondly, journals with a track record of publishing doping research were also searched. These were: Addiction (1903 to 2024), Archives of Pediatrics and Adolescent Medicine (2000 to 2017), British Journal of Sports Medicine (1964 to 2024), Clinical Journal of Sports Medicine (1991 to 2024), European Journal of Clinical Pharmacology (1968 to 2024), International Journal of Sport and Exercise Psychology (2003 to 2024), International Journal of Sport Psychology (1994 to 2024), International Journal of Sport of Sports Medicine (1980 to 2024), Journal of Adolescent Health (1980 to 2024), Journal of Applied Sport Psychology (1989 to 2024), Journal of Child and Adolescent Substance Abuse (1990 to 2024), Journal of Clinical Sport Psychology (2007 to 2024), Journal of Drug Education (1971 to 2024), Journal of Drug Issues (1971 to 2024), Journal of Health Psychology, (1996 to 2024), Journal of Science and Medicine in Sport (1998 to 2024), Journal of Sport Behavior (1990 to 2024), Journal of Sport and Exercise Psychology (1979 to 2024), Journal of Sports Sciences (1983 to 2024), Psychology of Sport and Exercise (2000 to 2024), Medicine and Science in Sports and Exercise (1969 to 2024), Performance Enhancement and Health (2012 to 2024), Research Quarterly for Exercise and Sport (2001 to 2024), Scandinavian Journal of Medicine and Science in Sport (1991 to 2024), Sport, Exercise, and Performance Psychology (2011 to 2024), Substance Abuse Treatment, Prevention, and Policy (2006 to 2024), and The Sport Psychologist (1987 to 2024). The third and final strategy involved searching all the reference lists of papers that met the inclusion criteria, which is known as Pearl Growing (Hartley, 1990). A protocol was not prepared, as the information is provided in the manuscript.

2.2. Eligibility criteria

To be included in this systematic review, articles had to be primary research, published in peer-reviewed journals, and written in English. Additionally, studies identified anti-doping education programs provided by universities to any of their students (i.e., sports students, medical students, law students, etc.). Articles were also required to explore the effectiveness of the anti-doping interventions on doping knowledge, attitudes, intentions, susceptibility, and/or behavior. Primary research articles not published in peer-reviewed journals or systematic reviews and meta-analyses were excluded. Book chapters, reports, editorials, and articles not in English were also excluded. The total number of identified records was 1104 (see Fig. 1). After removing 101 abstracts, titles, and duplicates, we screened 235 records. Because of this screening process, we excluded 191 studies. A second assessment involved reading the full papers was conducted for the remaining 44 studies (Lefebvre et al., 2019). Forty studies were excluded from the review because they did not meet the eligibility criteria, access was not available for the full paper, or the study was considered irrelevant. Four studies met the inclusion criteria and were included in this systematic review.

2.3. Assessment of methodological quality and risk of bias

The Cochrane Collaboration's Risk of Bias tool (Higgins et al., 2011), which was adopted by Ntoumanis et al. (2014) and utilized by Nicholls et al. (2017, 2021), assessed the bias risk among the four studies. Higgins et al.'s tool facilitates the systematic bias assessment within experimental, longitudinal, and cross-sectional studies. Research papers are scored as low risk, unclear, or high risk. Studies that scored low risk in each criterion were considered low risk. A study that scored high risk on one or more criteria was considered high risk. A study that scored unclear on one criterion was scored as unclear (see Table 1 for criteria scores and Table 2 for risk bias evaluations).

The first author (Nicholls) assessed the four included papers on the criteria presented by Ntoumanis et al. (2014). The second author (Lazuras) then applied this criterion to assess the risk of bias and methodological quality. Two papers required discussion (Murofushi et al., 2018; Poussel et al., 2013). The issue was resolved after this discussion, and Nicholls and Lazuras reached a 100 % agreement.

3. Results

3.1. Study characteristics

One thousand four hundred ten university students participated in the four studies included in this systematic review (M = 352.5, SD = 528.49). The number of students ranged from 58 (Poussel et al., 2013) to 1143 (Murofushi et al., 2018) participants. Students resided in China (Deng et al., 2022), Japan (Murofushi et al., 2018), Spain (García-Martí et al., 2022), or Switzerland (Poussel et al., 2013). All studies recruited males and females (See Table 1). Three studies adopted a quasi-experiment design (Deng et al., 2022; García-Martí et al., 2022; Poussel et al., 2013), and one study was cross-sectional (Murofushi et al., 2018).

3.2. Anti-doping education content

Two studies (Deng et al., 2022; Murofushi et al., 2018) used WADA's Athlete Learning Programme about Health and Anti-Doping (ALPHA). The ALPHA is an online education program, not specifically designed for university athletes, which contains sessions on the following topics: ethical reasons for not doping, medical reasons why athletes shouldn't dope, the doping control process, rights and responsibilities of athletes, therapeutic use exemptions, whereabouts, maximizing performance without doping, and identifying the risk factors for doping. The two remaining studies developed their anti-doping education intervention for university students. García-Martí et al. (2022) developed a course that lasted for 28 h and included topics such as regulations, lists of the consequences of doping, and how to prevent doping. Finally, Poussel et al. (2013) programme lasted one day. It contained information on various topics such as being physically active and healthy, women, pregnancy, sports, and doping in sports. Interestingly, Poussel's intervention was the only program that reported using role plays and included training on how students could speak to athletes about doping and manage situations in which suspected doping cases.

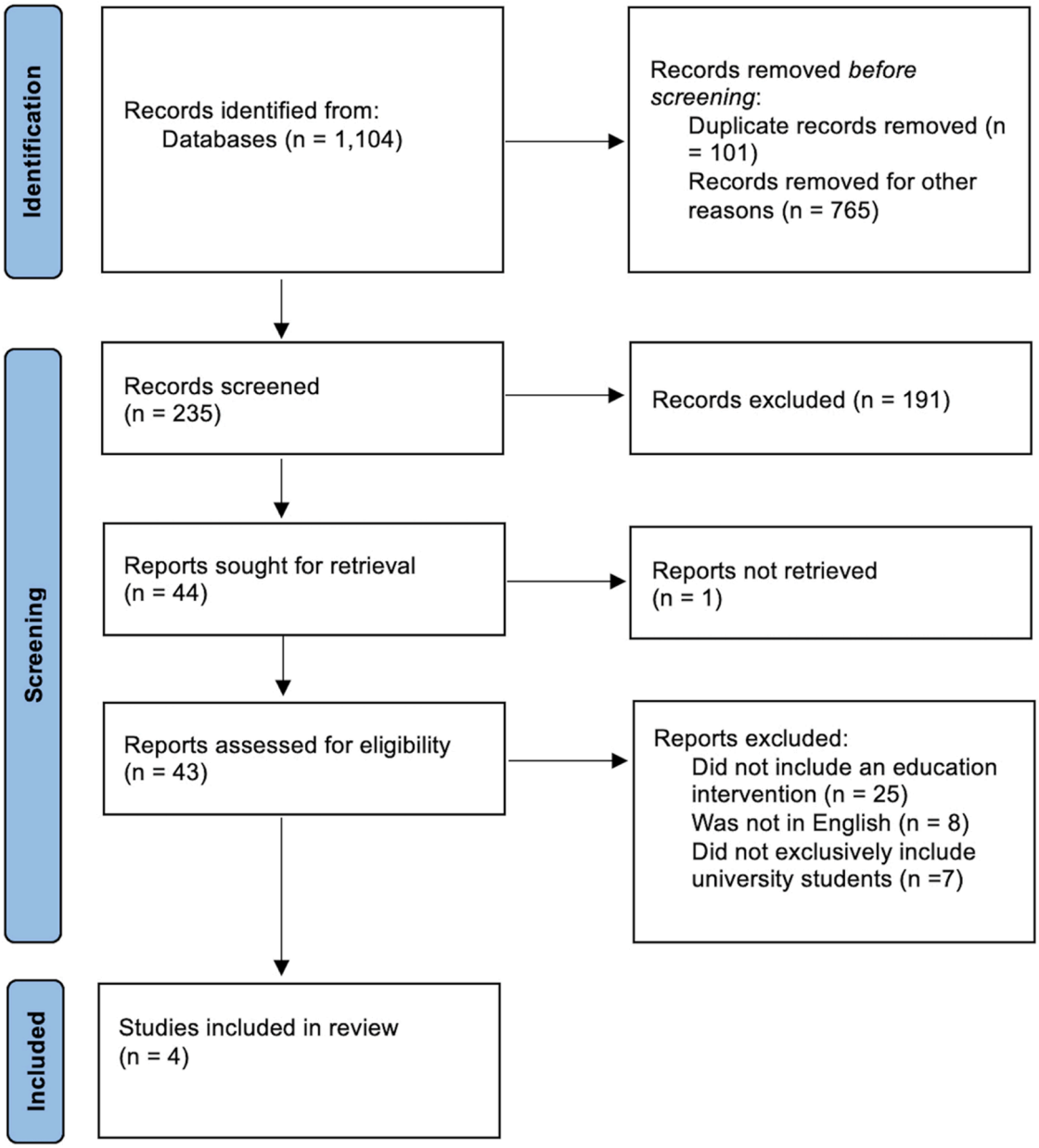

Fig. 1. PRISMA Flow Diagram.

3.3. *Target group of students*

Two studies targeted a specific cohort of university students. Poussel et al. (2013) recruited medical students, whereas García-Martí et al. (2022) recruited university students attending a sports degree. The other two studies recruited university students without specifying the degree course. However, Deng et al. (2022) reported a sample of athlete and non-athlete university students, whereas Murofushi et al. (2018) exclusively recruited university student-athletes.

3.4. *Effectiveness of the anti-doping provision*

All four studies reported that the anti-doping program positively affected some of the doping variables assessed. For example, three studies (e.g., Deng et al., 2022; García-Martí et al., 2022; Poussel et al., 2013) reported that the anti-doping education interventions increased doping knowledge, whereas Murofushi et al. (2018) found an increase in doping knowledge, but only when the students received anti-doping education on more than one occasion. The education programs positively influenced a variety of psycho-social factors. This includes attitudes (Deng et al., 2022; Poussel et al., 2013), morality (García-Martí et al., 2022), and confidence in speaking about doping (Poussel et al., 2013). However, education programs did not positively impact the doping likelihood (e.g., Deng et al., 2022).

4. Discussion

This systematic review explored the content of anti-doping education, identified the target group of students, and reported the impact of anti-doping provision among university students. Anti-doping education among university students is essential (e.g., Aguilar-Navarro et al., 2022; Rintaugu and Mwangi, 2020) because these are the individuals who can promote clean sports in their jobs as sports scientists, physicians, pharmacists, and lawyers after graduating. Educating these individuals is essential because some students lack knowledge about doping (e.g., Akarsu and Yalman (2023), and there is worrying evidence

Table 1
Risk of Bias.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Deng et al. (2022)	●	?	?	?	?	?	?	?	?	?	?	●	?	?	
García-Martí et al. (2022)	●	?	?	?	●	?	?	●	?	●	●	●	?	?	
Murofushi et al. (2018)	●	?	?	?	?	?	?								
Poussel et al. (2013)	●	?	?	?	●	●	●	●	●	?	?	?	?	?	

Risk of Bias: Low = ?, Unclear = ?, High = ●

Table Note: The risks of bias in studies included were assessed using the criteria below. Studies were assessed as having a) no or low risk of bias or b) potential risk of bias. The criterion for all studies involved: Sampling - 1. Participants are randomly selected, 2. Sample sizes are adequate, 3. Participants are representative of various demographic groups; 4. If some participants were excluded from the analyses, the exclusion is justified; 5. Participants were matched on other meaningful demographics when group comparisons were made, and 15. Other risks of bias. Measures - (i.e., 6. Validated measures are used, or the authors have provided sufficient supportive information on the psychometric properties of the measures they devised; and 7. The measures used were clearly defined and were appropriate. The criterion for studies that adopted a longitudinal or prospective design included 8. The authors examined whether dropout is random. 9. Missing data were treated appropriately. Finally, the following criterion was used for experimental designs: 10. Allocation sequence generated to produce comparable groups. 11. Allocation was concealed, 12. Whether blinding was done and its effectiveness, 13. Outcome data for all outcomes were reported. Incomplete outcomes due to attrition and exclusions were addressed, and 14—no selective outcome reporting.

Table 2
Study Characteristics.

Authors and Year	Participant information	Instrumentation	Design	Intervention	Risk of bias assessment	Main findings
Deng et al. (2022)	64 students from three universities in Shanghai, China.	Knowledge about doping was assessed using 12-item ALPHA questionnaire. The Chinese version of the Performance Enhancement Attitude Scale (PEAS), and doping likelihood (Ring et al., 2019).	Quasi-experimental.	World Anti-Doping Agency's Athlete Learning Programme about Health and Anti-Doping (ALPHA).	High.	The intervention group scored significantly higher on doping knowledge than the control group. Favorable attitudes towards doping were significantly lower after the intervention, in comparison to pre-intervention, for the experimental group. The intervention did not impact doping likelihood.
García-Martí et al. (2022)	145 sport science and physical activity students (m = 106, f = 39) from Spain.	A Spanish version of Donovan et al.'s (2015) research package for anti-doping organizations, which assessed knowledge of PEDs and morality.	Quasi-experimental.	Comprised of three parts: (1) 1 hour introduction, (2) 25-hour online section, which include regulations and lists of prohibited substances, the consequences of doping, the prevention of doping, and values. (3) 1-hour live session.	High.	Differences between pre- and post-intervention indicated more knowledge about the impact of PEDs on performance and health, and more students being morally against doping.
Murofushi et al. (2018)	1,143 students (m = 514, f = 629) from several Japanese universities.	The ALPHA questionnaire, which contains 12 questions.	Cross-sectional.	The education was not standardized, because anti-doping education is "informally and arbitrarily implemented." It includes lectures, booklets, and the internet.	High.	University students who were educated on more than one occasion scored significantly higher than the students who had only received anti-doping education once.
Poussel et al. (2013)	58 medical students (m = 33, f = 25), from Switzerland, who were in their final year of the General Practitioner training scheme.	A questionnaire adapted from Laure (1997), which assessed knowledge about PEDs, experience with doping, attitudes toward doping, and commitment to anti-doping prevention.	Quasi-experimental.	A one-day training programme. In the morning programme, there were 4, 45-minute sessions on exercise physiology; physical activity and public health; women, pregnancy, and sport; and doping in sport. In the afternoon, the group was split into the experimental group who engaged in role playing to strengthen the students' assertion to prevent doping, and the control group who received education on non-doping topics.	High.	Prior to the intervention, 97% of the medical students believed that they were not sufficiently trained about PEDs and doping prevention. 88% felt they had an important role to play in anti-doping. The intervention increased doping knowledge, and role playing was important in increasing the student's ability to prevent doping by identifying individuals who wanted medication for hidden performance enhancement reasons.

of university students doping (e.g., Dietz et al., 2021). As such, embedding anti-doping education within the university curriculum can reduce doping behaviors, improve athletes' health, and promote clean sports. Despite this, only four studies assessed the effectiveness of an anti-doping education programme among university students. Overall, these four studies revealed that anti-doping education enhanced the level of doping knowledge among university students (Deng et al., 2022; García-Martí et al., 2022; Murofushi et al., 2018; Poussel et al., 2013). Two studies also found the education reduced favorable doping attitudes (Deng et al., 2022; Poussel et al., 2013), and one study found it influenced morality (García-Martí et al., 2022), which are critical factors in predicting doping (i.e., Elbe and Brand, 2015; Ntoumanis et al., 2014) even though researchers have explored doping knowledge and attitudes among sport-related (e.g., Posiadala et al., 2006) and pharmacy students (e.g., Awaisu et al., 2015), the education interventions were designed exclusively for sport and medical students, even though graduates from other courses, such as law, nutrition, physiotherapy may be approached by athletes when they start working in their profession.

There were discrepancies between the length of the interventions, ranging from a day course (e.g., Poussel et al., 2013) to 28 h of education (García-Martí et al., 2022). Due to inconsistencies in the content of the interventions and measures used to assess the outcomes, it is unclear whether the length of the intervention impacted its effectiveness. Future scholarly activity could assess the impact of education duration and content to establish recommendations for optimal duration and content of anti-doping education. Further, the content of the programmes seemed centered around rules and regulations, which, although very important, other anti-doping interventions have also provided information on promoting clean sport, positive values, self-esteem, and well-being (Nicholls et al., 2020), which may be a more practical approach. Interestingly, role-plays were used in Poussel et al.'s anti-doping education with auspicious results. Carroll et al. (2007) reported that well-designed role-playing impacted the behaviours and attitudes of medical trainees. Farahani et al. (2019) also found that nursing students in a role-play education condition had superior learning outcomes to those in the control group. Role-plays were used in the iPlayClean (Nicholls et al., 2020) anti-doping education for high-level adolescent athletes and should be considered good practice for future anti-doping interventions.

4.1. Limitations

A limitation of this systematic review relates to the number of studies that met the inclusion criteria and the risk of bias in those four studies. Only four studies examined the impact of an anti-doping education programme among university students and university student-athletes. However, the median number of papers in a Cochrane review is 5.5 (Useem et al., 2015), and the median number of participants for each review was 945 (Mallett and Clarke, 2002). Although this systematic review falls below the median for the number of research papers in Cochrane reviews, the number of participants in this systematic review was higher than the Cochrane mean number. Further, there are anti-doping education programs provided by universities for students and health professionals, such as the HealthPro Advantage: Anti-Doping Education for the Health Professional (CME), which Stanford University created, but the effectiveness of this has not been reported in peer-reviewed journals. Another limitation relates to the bias among the papers included in this systematic review. All four studies scored high for the risk of bias (Deng et al., 2022; García-Martí et al., 2022; Murofushi et al., 2018; Poussel et al., 2013), which means that the interpretation of these findings should be taken with caution and exemplifies the necessity for well-designed anti-doping education interventions for university students.

4.2. Recommendations for future

4.2.1. Research and practice

More methodologically robust anti-doping education studies are required to assess anti-doping education's effectiveness for students accurately. Such studies should utilize a randomized controlled trial design, be fully powered, and involve randomly recruited students from different disciplines. Following this, researchers can provide evidence-based guidelines on how to deliver, structure, and what to include in anti-doping education for university students.

Furthermore, the present review corroborates the findings from previous research (e.g., Aguilar-Navarro et al., 2022; Akarsu and Yalman, 2023) that university students studying for a degree relevant to sport have poor anti-doping knowledge. Unless concerted efforts are made to improve university students' knowledge about doping, the future generation of professionals working with athletes will not have sufficient skills and knowledge to prevent doping in sports.

The Council of Europe's Anti-Doping Education Guidelines for Tertiary Education provide a framework for implementing measures ensuring that university students develop the essential skills and knowledge required to tackle doping effectively in their post-graduation professional practice. It should be noted, however, that these Guidelines were developed based on the 2015 WADC. As such, they are almost ten years old and require revising to reflect the changes applied in the 2021 WADC and contemporary anti-doping research. Anti-doping education in tertiary education is required because doping is widely acknowledged as a public health 'time bomb' that requires attention (UKAD, 2021). The Council of Europe's guidelines specify the degree programmes most relevant to implementing anti-doping education for students, spanning different disciplines. These include sports journalism, physical education, science, physiology, ethics, pharmacology, nutrition, medicine, administration, management, and sports law. Where tertiary education institutions offer no sport-specific degree programmes, the guidelines recommend that anti-doping education is embedded within the general degree programme of the disciplines identified.

5. Conclusions

The present review indicated that the extant studies on university-provided anti-doping education have addressed only sports science (García-Martí et al., 2022) or medical students (Poussel et al., 2013). Therefore, there is scope to expand the anti-doping education provision offered by universities/tertiary education institutions by targeting a more comprehensive range of disciplines per the guidelines' specifications. Universities could also offer anti-doping education to all sports clubs within their institution to raise awareness of the dangers of doping and to promote clean sports. Finally, more robust designs are required, particularly randomised controlled trials of anti-doping education interventions.

CRediT authorship contribution statement

Adam R. Nicholls: Writing – review & editing, Writing – original draft, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Lambros Lazuras:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Michael Petrou:** Writing – review & editing, Writing – original draft, Funding acquisition, Conceptualization. **Ornella Corazza:** Writing – review & editing. **Carlos Santos:** Writing – review & editing. **António Júlio Nunes:** Writing – review & editing. **Michał Rynkowski:** Writing – review & editing. **João F. Martins:** Writing – review & editing. **Thomas Zandonai:** Writing – review & editing. **Uta Kühn:** Writing – review & editing. **Łukasz Tota:** Writing – review & editing.

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.

Acknowledgment

This systematic review was funded by the European Commission's Education, Audiovisual and Culture Executive Agency [Unit A.6, Erasmus +: Sport, Youth and EU Aid Volunteers], which was awarded to the third author, Dr Michael Pet

Appendix A. PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	7
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	7
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	9
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	7–9
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	7–8
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	7
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	10
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	7
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	9
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	9–10
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	11
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	11
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	NA
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	NA
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	NA
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	NA
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	NA
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	NA
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	NA
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	28
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	NA
Study characteristics	17	Cite each included study and present its characteristics.	25–26
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	24
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	25–26
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	25–26
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	NA
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	NA
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	NA
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	NA
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	NA
DISCUSSION			

(*continued on next page*)

(*continued*)

Section and Topic	Item #	Checklist item	Location where item is reported
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	12
	23b	Discuss any limitations of the evidence included in the review.	13
	23c	Discuss any limitations of the review processes used.	13
	23d	Discuss implications of the results for practice, policy, and future research.	14
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	NA
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	9
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	NA
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	1
Competing interests	26	Declare any competing interests of review authors.	Submission
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	9

References

Aguilar-Navarro, M., Salas-Montoro, J.-A., Pino-Ortega, J., Salinero, J.J., González-Mohíno, F., Alcaraz-Rodríguez, V., Moreno-Pérez, D., Lanza, N., Lara, B., Moreno-Pérez, V., Romero-Moraleda, B., Pérez-López, A., García-Martí, C., Del Coso, J., 2022. Anti-doping knowledge of students undertaking bachelor's degrees in sports sciences in Spain. Nutrients 14 (21), 4523. https://doi.org/10.3390/nu14214523.

Akarsu, G.D., Yalman, E., 2023. Determining the information and thoughts of sports sciences faculty students about doping. CBÜ Beden Eğit. Spor Bilim. Derg. 18 (2), 386–398. https://doi.org/10.33459/cbubesbd.1156531.

Awaisu, A., Mottram, D., Rahhal, A., Alemrayat, B., Ahmed, A., Stuart, M., Khalifa, S., 2015. Knowledge and perceptions of pharmacy students in Qatar on anti-doping in sports and on sports pharmacy in undergraduate curricula. Am. J. Pharm. Educ. 79 (8), 119. https://doi.org/10.5688/ajpe798119.

Backhouse, S.H., McKenna, J., 2011. Doping in sport: a review of medical practitioners' knowledge, attitudes and beliefs. Int. J. Drug Policy 22 (3), 198–202. https://doi.org/10.1016/j.drugpo.2011.03.002.

Bjørnebekk, A., Westlye, L.T., Walhovd, K.B., Jørstad, M.L., Sundseth, Ø.Ø., Fjell, A.M., 2019. Cognitive performance and structural brain correlates in long-term anabolic-androgenic steroid exposed and nonexposed weightlifters. Neuropsychology 33 (4), 547–559. https://doi.org/10.1037/neu0000537.

Blank, C., Brunner, J., Kreische, B., Lazzeri, M., Schobersberger, W., Kopp, M., 2016. Performance-enhancing substance use in university students: motives, attitudes, and differences in normative beliefs. J. Subst. Use 22 (3), 324–330. https://doi.org/10.1080/14659891.2016.1208777.

Carroll, A.E., Vreeman, R.C., Buddenbaum, J., Inui, T.S., 2007. To what extent do educational interventions impact medical trainees' attitudes and behaviors regarding industry-trainee and industry-physician relationships? Pediatrics 120 (6), e1528–e1535. https://doi.org/10.1542/peds.2007-0363.

Chan, S.Y., Lim, M.C., Shamsuddin, A.F., Tuan Mahmood, T.M., 2019. Knowledge, attitude and perception of Malaysian pharmacy students towards doping in sports. J. Pharmacy Pract. Res. 49 (2), 135–141. https://doi.org/10.1002/jppr.1478. Portico.

Cléret, L., 2011. The role of anti-doping education in delivering WADA's mission. Int. J. Sport Policy Politics 3 (2), 271–277. https://doi.org/10.1080/19406940.2011.577084.

Deng, Z., Guo, J., Wang, D., Huang, T., Chen, Z., 2022. Effectiveness of the world anti-doping agency's e-learning programme for anti-doping education on knowledge of, explicit and implicit attitudes towards, and likelihood of doping among Chinese college athletes and non-athletes. Subst. Abuse Treat. Prev. Policy 17 (1). https://doi.org/10.1186/s13011-022-00459-1.

Dietz, P., Quermann, A., van Poppel, M.N.M., Striegel, H., Schröter, H., Ulrich, R., Simon, P., 2021. Correction: physical and cognitive doping in university students using the unrelated question model (UQM): assessing the influence of the probability of receiving the sensitive question on prevalence estimation. PLoS One 16 (10), e0258705. https://doi.org/10.1371/journal.pone.0258705.

Dunn, M., Piatkowski, T., Whiteside, B., Eu, B., 2023. Exploring the experiences of general practitioners working with patients who use performance and image enhancing drugs. Perform. Enhanc. Health N. Hav. 11 (2), 100247. https://doi.org/10.1016/j.peh.2023.100247.

El-Hammadi, M., Hunien, B., 2013. Exploring knowledge, attitudes and abuse concerning doping in sport among Syrian pharmacy students. Pharmacy 1 (2), 94–106. https://doi.org/10.3390/pharmacy1020094.

edited by Elbe, A.M., Brand, R., 2015. Ethical dilemma training–a new approach to doping prevention? In: Barkoukis, V., Lazuras, L., Tsorbatzoudis, H. (Eds.), The Psychology of Doping in Sport. Routledge, pp. 165–179. edited by.

Erickson, K., Stanger, N., Patterson, L., Backhouse, S.H., 2019. Substance use in university sport: a cross-national study of student-athlete substance use behaviors and perceived responses to witnessing substance use. Perform. Enhanc. Health 7 (1–2), 100151. https://doi.org/10.1016/j.peh.2019.100151.

Farahani, M., Dorri, S., Maserat, E., Haghani, H., 2019. Effect of role-playing on learning outcome of nursing students based on the Kirkpatrick evaluation model. J. Educ. Health Promot. 8 (1), 197. https://doi.org/10.4103/jehp.jehp_138_19.

García-Martí, C., Ospina-Betancurt, J., Asensio-Castañeda, E., Chamorro, J.L., 2022. Study of an anti-doping education program in spanish sports sciences students. Int. J. Environ. Res. Public Health 19 (23), 16324. https://doi.org/10.3390/ijerph192316324.

Guessogo, W.R., Hamadou, A., Bissou-Mahop, J., Mban-Bian, W., Djomo-Ngnoko, E.E., Magne-Talla, R.G., Temfemo, A., 2021. Knowledge, attitudes, and practices related to doping among Cameroonian university-level athletes: a cross-sectional study. Eur. J. Phys. Educ. Sport 9 (1). https://doi.org/10.13187/ejpe.2021.1.13.

Hartley, R.J., 1990. Online Searching: Principles and Practice. Bowker-Saur.

Higgins, J.P.T., Altman, D.G., Sterne, J.A.C., 2011. Assessing risk of bias in included studies. In: Higgins, J.P.T., Green, S. (Eds.), Cochrane Handbook for Systematic Reviews of Interventions. The Cochrane Collaboration. Available online at www.handbook.cochrane.org.

Hope, V.D., McVeigh, J., Marongiu, A., Evans-Brown, M., Smith, J., Kimergård, A., Parry, J.V., Ncube, F., 2014. Injection site infections and injuries in men who inject image-and performance-enhancing drugs: prevalence, risks factors, and healthcare seeking. Epidemiol. Infect. 143 (1), 132–140. https://doi.org/10.1017/S0950268814000727.

Lauritzen, F., 2022. Dietary supplements as a major cause of anti-doping rule violations. Front. Sports Act. Living. 4. https://doi.org/10.3389/fspor.2022.868228.

Lefebvre, C., Glanville, J., Briscoe, S., Littlewood, A., Marshall, C., Metzendorf, M.-I., Noel-Storr, A., Rader, T., Shokraneh, F., Thomas, J., Wieland, L.S., et al., 2019. Searching for and selecting studies. In: Higgins, J.P.T., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M.J., et al. (Eds.), Cochrane Handbook for Systematic Reviews of Interventions, 2nd ed. John Wiley and Sons Ltd.

Lemettilä, M., Leppä, E., Pohjanoksa-Mäntylä, M., Simula, A., Koskelo, J., 2021. Anti-doping knowledge and educational needs of Finnish pharmacists. Perform. Enhanc. Health 9 (2), 100195. https://doi.org/10.1016/j.peh.2021.100195.

Lindqvist, A.-S., Moberg., Ehrenberg, C., Eriksson, B.O., Fahlke, C., Rosen, T, 2013. Increased mortality rate and suicide in Swedish former elite male athletes in power sports. Scand. J. Med. Sci. Sports 24, 1000e1005. https://doi.org/10.1111/sms.12122.

Lok, S., Tasgin, E., Temel, V., Tasgin, O., Lok, N., 2010. A comparison of university students' knowledge levels about doping who are interested in individual and team sport. Selçuk Univ. J. Phys. Educ. Sport Sci. 12 (1), 19–22. Retrieved from. https://arastirmax.com/tr/system/files/dergiler/20631/makaleler/12/1/arastirmax-comparison-study-university-students-knowledge-levels-about-doping-who-are-interested-individual-and-team-sport.pdf.

Maier, L.J., Liechti, M.E., Herzig, F., Schaub, M.P., 2013. To dope or not to dope: neuroenhancement with prescription drugs and drugs of abuse among Swiss university students. PLoS One 8 (11), e77967. https://doi.org/10.1371/journal.pone.0077967.

Majori, S., Gazzani, D., Pilati, S., Paiano, J., Sannino, A., Ferrari, S., Checchin, E., 2017. Brain doping: stimulants use and misuse among a sample of Italian college students. J. Prev. Med. Hyg. 58 (2), E130–E140.

Mallett, S., Clarke, M., 2002. The typical cochrane review. Int. J. Tech. Assess. Health Care 18 (4), 820–823. https://doi.org/10.1017/s0266462302000624.

Morente-Sánchez, J., Freire-SantaCruz, C., Mateo-March, M., Zabala, M., 2015. Attitude towards doping in Spanish sport sciences university students according to the type of sport practised: individual versus team sports. Sci. Sports 30 (2), 96–100. https://doi.org/10.1016/j.scispo.2014.05.002.

Murofushi, Y., Kawata, Y., Kamimura, A., Hirosawa, M., Shibata, N., 2018. Impact of anti-doping education and doping control experience on anti-doping knowledge in Japanese university athletes: a cross-sectional study. Subs. Abuse Treat. Prev. Policy 13 (1). https://doi.org/10.1186/s13011-018-0178-x.

Nicholls, A.R., Taylor, N.J., Carroll, S., Perry, J.L., 2016. The development of a new sport-specific classification of coping and a meta-analysis of the relationship

between different coping strategies and moderators on sporting outcomes. Front. Psychol. 7. https://doi.org/10.3389/fpsyg.2016.01674.
Nicholls, A.R., Cope, E., Bailey, R., Koenen, K., Dumon, D., Constantin Theodorou, N., Chanal, B., Saint Laurent, D., Müller, D., Plata Andrés, M., Haahr Kristensen, A., Thompson, M.A., Baumann, W., Laurent, J-F., 2017. Children's first experience of taking anabolic-androgenic steroids can occur before their 10th birthday: a systematic review identifying 9 factors that predicted doping among young people. Front. Psychol. 8. https://doi.org/10.3389/fpsyg.2017.01015.
Nicholls, A.R., Fairs, L.R.W., Plata-Andrés, M., Bailey, R., Cope, E., Madigan, D., Koenen, K., Glibo, I., Theodorou, N.C., Laurent, J.-F., Garcia, G., Chanal, B., 2020. Feasibility randomised controlled trial examining the effects of the Anti-Doping Values in Coach Education (ADVICE) mobile application on doping knowledge and attitudes towards doping among grassroots coaches. BMJ Open Sport Exerc. Med. 6, e000800. https://doi.org/10.1136/bmjsem-2020-000800.
Nicholls, A.R., Fairs, L.R.W., Toner, J., Jones, L., Mantis, C., Barkoukis, V., Perry, J.L., Micle, A.V., Theodorou, N.C., Shakhverdieva, S., Stoicescu, M., Vesic, M.V., Dikic, N., Andjelkovic, M., Grimau, E.G., Amigo, J.A., Schomöller, A., 2021. Snitches get stitches and end up in ditches: a systematic review of the factors associated with whistleblowing intentions. Front. Psychol. 12, 631538. https://doi.org/10.3389/fpsyg.2021.631538.
Ntoumanis, N., Ng, J.Y.Y., Barkoukis, V., Backhouse, S., 2014. Personal and psychosocial predictors of doping use in physical activity settings: a meta-analysis. Sport. Med. 44, 1603–1624. https://doi.org/10.1007/s40279-014-0240-4.
Page, M.J., Moher, D., Bossuyt, P., Boutron, I., Hoffmann, T., Mulrow, C.D., … McKenzie, J. (2020). PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. doi:10.31222/osf.io/gwdhk.
Papadopoulos, F.C., Skalkidis, I., Parkkari, J., Petridou, E., 2006. Doping use among tertiary education students in six developed countries. Eur. J. Epidemiol. 21 (4), 307–313. https://doi.org/10.1007/s10654-006-0018-6.
Patterson, L.B., Backhouse, S.H., Jones, B., 2023. The role of athlete support personnel in preventing doping: a qualitative study of a rugby union academy. Qual. Res. Sport Exerc. Health 15 (1), 70–88. https://doi.org/10.1080/2159676X.2022.2086166.
Posiadala, D., Smorawiński, J., Lewandowska, M., Pluta, B., 2006. Doping in sport: a study of knowledge and attitudes among students of the University of Physical Education, in Poznan. Med. Sport. 6 (6), 323–328. Vol 22.
Poussel, M., Laure, P., Latarche, C., Laroppe, J., Schwitzer, M., Koch, J.-P., Heid, J.-M., Chenuel, B., 2013. Specific teaching about doping in sport helps medical students to meet prevention needs. Sci. Sports 28 (5), 274–280. https://doi.org/10.1016/j.scispo.2013.01.009.
Puchades, M., Molina, P., 2020. Attitudes towards doping among sport sciences students. Apunt. Educ. Fís. Deport. 140, 1–7. https://doi.org/10.5672/apunts.2014-0983.es.(2020/2).140.01.
Rintaugu, E.G., Mwangi, F.M., 2020. Knowledge, attitudes and perceptions on doping among university students in physical education and sport science-related degree programmes. J. Hum. Sport Exercise 16 (1). https://doi.org/10.14198/jhse.2021.161.16.
a Shalby, M.N., Elshemary, N., Mohamed Ahmed, E.E-D., Sakoury, M.M.A., et al., 2018. Sport college students uses and perceptions of social networking sites of sport doping information. J. Am. Sci. 14 (1), 60–66. https://doi.org/10.7537/marsjas140118.07.
Singh, I., Bard, I., Jackson, J., 2014. Robust resilience and substantial interest: a survey of pharmacological cognitive enhancement among university students in the UK and Ireland. PLoS One 9 (10), e105969. https://doi.org/10.1371/journal.pone.0105969.
United Kingdom Anti-Doping (2021). Image and performance enhancing drugs: UKAD's status report on IPEDs in the UK. Retrieved from: https://www.ukad.org.uk/sites/default/files/202001/UKAD%20IPED%20Report%20FINAL.pdf.
Useem, J., Brennan, A., LaValley, M., Vickery, M., Ameli, O., Reinen, N., Gill, C.J., 2015. Systematic differences between cochrane and non-cochrane meta-analyses on the same topic: a matched pair analysis. PLoS One 10 (12), e0144980. https://doi.org/10.1371/journal.pone.0144980.
Vangrunderbeek, H., Tolleneer, J., 2010. Student attitudes towards doping in sport: shifting from repression to tolerance? Int. Rev. Sociol. Sport 46 (3), 346–357. https://doi.org/10.1177/1012690210380579.
Viret, M., 2020. Prevalence for evidence-based doping regulation—a lawyer's perspective. Perform. Enhanc. Health 8 (2–3), 100167. https://doi.org/10.1016/j.peh.2020.100167.
World Anti-Doping Agency (2021). World anti-doping cope. Retrieved from: https://www.wada-ama.org/en/resources/world-anti-doping-code-and-international-standards/world-anti-doping-code.
World Anti-Doping Agency (2024). Anti-doping testing figures report. Retrieved from: https://www.wada-ama.org/en/resources/anti-doping-stats/anti-doping-testing-figures-report.