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Women in anti-doping sciences & integrity in sport 2021/22

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Published in
Frontiers in Sports and Active Living

ISSN 1664-8714
ISBN 978-2-8325-3092-4
DOI 10.3389/978-2-8325-3092-4

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Women in anti-doping sciences & integrity in sport: 2021/22

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Citation

Petroczi, A., Schneider, A. J.-A., Nolte, K., eds. (2023). *Women in anti-doping sciences & integrity in sport: 2021/22*. Lausanne: Frontiers Media SA.

doi: 10.3389/978-2-8325-3092-4

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frontiers | Frontiers in Sports and Active Living

TYPE Editorial
PUBLISHED 11 July 2023
DOI 10.3389/fspor.2023.1248720

OPEN ACCESS

EDITED AND REVIEWED BY
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Université de Lausanne, Switzerland

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RECEIVED 27 June 2023
ACCEPTED 28 June 2023
PUBLISHED 11 July 2023

CITATION
Petróczi A, Nolte K and Schneider AJ-A (2023) Editorial: Women in anti-doping sciences & integrity in sport: 2021/22.
Front. Sports Act. Living 5:1248720.
doi: 10.3389/fspor.2023.1248720

Editorial: Women in anti-doping sciences & integrity in sport: 2021/22

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KEYWORDS

anti-doping, integrity, research output, impact, gender difference

Editorial on the Research Topic
Women in anti-doping sciences & integrity in sport: 2021/22

To address the frequently observed gender inequality in research, considerable efforts have been made on international and national levels via informing policymakers, creating more equal opportunities for women scientists, and improved governance (1–3). Calls have been made to pay attention to the impact of gender disparities in funding allocations (4), impact assessment (5), peer reviews of grant application (6) and publications (7). Evidence also indicates that women's qualifications and ability are underestimated (8, 9) leading to different outcome expectations (10) and women receiving less credit (11, 12), their outputs being more critically scrutinised (13) or held to higher standards (14).

These are just examples of where gender bias against women exists. All in all, there is ample evidence showing that research is an unwelcoming field for women despite the fact that they can bring unique contributions to the table by creating impact with fewer outputs and less money, and a natural orientation toward making societal impact via research focus, and a communication 'style' coined as the female scientific voice that suits users of scientific knowledge outside academia better (**Figure 1**). Despite more modest self-presentation (15), lower number of outputs (16) and patents (17), women are equal if not better than male researchers when it comes to research impact (18, 19). This might be explained by the research focus where women are more likely to tackle societal issues (20), and gender differences in definition and attitude toward impact (21) in which women see impact in societal context (i.e., achieving social justice and equality) as opposed to male researchers who tend to focus on academic impact, accountability and responsibility toward society. There are stronger tendencies for women to engage in meaning-making research via exploratory and qualitative investigation (22). Lastly, it has been observed that women are more willing to collaborate, and when they do, they tend to 'pair up' (23), work with a smaller number of collborations but there is no agreement whether women have more transient (24) or stable (25) collaborations.

The collection in this special issue features 10 papers spearheaded by women researchers featuring 35 unique authors in total, of which almost half (48.6%) are male (**Figure 2**, https://public.flourish.studio/visualisation/14246812/). These papers include three studies on gender differences focusing on the prevalence of prohibited substances and methods

FIGURE 1
Valuable characteristics of women's research and research outputs.

by female athletes (Collomp et al.), research standing and strength of women scientists in anti-doping (Kiss et al.), and women's sport as a protected category (Schneider et al.). The remaining seven papers cover non-gender related topics but authored by women as first (Schneider et al.) or corresponding author (Lehtihet et al.). Seven papers feature original research (Blank et al., Collomp et al., García-Grimau et al., Kiss et al., Lehtihet et al., Schneider et al.), followed by two brief research reports (Melzer et al., Pöppel and Büsch) and an opinion piece (Teetzel). Only one paper (Lehtihet et al.) falls within the natural sciences domain, with a focus on detecting Anabolic Androgenic Steroid use. Subject areas of the submitted studies shows a diverse picture both in terms of topics and methodology. Four papers focused more on societal issues such as prevalence (Collomp et al.),

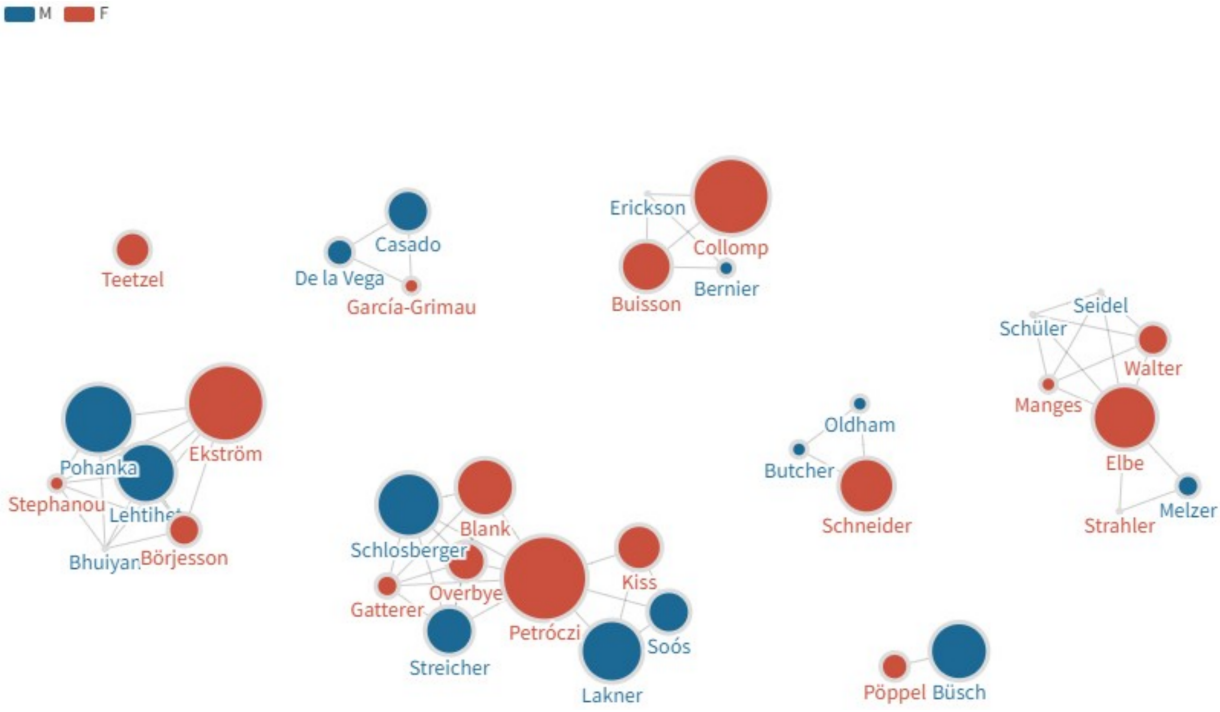

FIGURE 2
Authorship network map. Colour denotes gender, size of the nodes corresponds to the authors' H-indices based on Web of Science in 2022 December). Authorship positions are displayed in the interactive version of this network map: https://public.flourish.studio/visualisation/14246812/. Move the cursor above the nodes to see the authorship positions on the interactive map.

sanctioning young athletes (Teetzel), women's sport (Schneider et al.), or the role women researchers played in generating anti-doping knowledge to date (Kiss et al.). Others concentrate on practical aspects such improving doping testing (Lehtihet et al.), values-based anti-doping education programme for adolescent athletes (Manges et al.), need for tailored education programme for young athletes (Pöppel and Büsch) evaluation of anti-doping education (Blank et al.), antecedents of doping attitude (García-Grimau et al.) and analgesics use (Melzer et al.).

Despite the offer for a protected space for underrepresented women researchers, the pool of authors in this special issue seems to feature established women researchers and less prolific or impactful male researchers (see: https://public.flourish.studio/visualisation/14246812/ and **Supplementary Material**). This could reflect the possibility that established women researchers tend to be supportive and nurturing of younger researchers, who still tend to be male. Notably, established male researchers publishing with a female researcher as first or corresponding author is missing from the collection. This might have been a consequence of how the themed collection was promoted. Submission was open to anyone (providing that the authorial team met the requirements for this collection) but female researchers were directly contacted and invited to submit an article, which might have skewed this outcome. Nonetheless, networking and collaboration deserve attention because there is a careful balance for women researchers to aim at. On the one hand, inter-gender collaboration may benefit male researchers more than females, especially if the male authors are at high academic level (26), but on the other hand, outputs with male authors being either first or corresponding author are more likely to describe the results in positive terms, which in turn leads to higher downstream citations (15).

The overall picture from this collection gives reassurance that women researchers do well in anti-doping sciences compared to other fields but it also raises forward-looking questions of how research collaboration can be encouraged to benefit from the unique contribution women can bring to advance the field. A further challenge is how underrepresented female researchers can be supported in closing the gender gap if not by offering a protected space where competition is limited to other female researchers. Following Li et al. (27) recommendations for mentoring, perhaps we also need to find ways to incentivise established 'star' female researchers to work with and mentor emerging, early career female researchers for scientific communication and impact.

Authors contribution

All authors contributed to the article and approved the submitted version.

Acknowledgments

The authors thank Anna Kiss and Sándor Soós for providing bibliometric details for the Supplementary file of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fspor.2023.1248720/full#supplementary-material

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frontiers in Sports and Active Living

ORIGINAL RESEARCH
published: 11 March 2022
doi: 10.3389/fspor.2022.842959

Moral Disengagement, Social Norms, and Motivational Profiles Influence Attitudes Toward Doping Among Spanish Athletics Coaches

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OPEN ACCESS

Edited by:
Angela Jo-Anne Schneider, University of Western Ontario, Canada

Reviewed by:
Daniel Westmattelmann, University of Münster, Germany
Elijah Rintaugu, Kenyatta University, Kenya

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Specialty section:
This article was submitted to Anti-doping Sciences, a section of the journal Frontiers in Sports and Active Living

Received: *24 December 2021*
Accepted: *10 February 2022*
Published: *11 March 2022*

Citation:
García-Grimau E, De la Vega R and Casado A (2022) Moral Disengagement, Social Norms, and Motivational Profiles Influence Attitudes Toward Doping Among Spanish Athletics Coaches. Front. Sports Act. Living 4:842959. doi: 10.3389/fspor.2022.842959

Coaches strongly influence athletes' attitudes toward doping and can shape athlete's beliefs, behaviors, and decisions to be for or against doping. Coached-centered studies examining multiple factors affecting coaches' doping attitudes and behavior are scarce. The aim of this study was to analyze for the first-time attitudes toward doping in athletics coaches using the Sport Drug Control Model (SDCM) as a theoretical framework. A secondary aim was to determine the factors in the model predicting attitude and susceptibility toward doping. A cross-sectional study was carried out using a sample consisting of 201 Spanish athletics competitive level coaches from whom 11.4% were female. Participants completed a cross-sectional online survey. Structural equation modeling showed a good fitness of the SDCM. Positive attitudes toward doping predicted high susceptibility to doping ($\beta = 0.39$, $p < 0.001$). Moral disengagement ($\beta = 0.58$, $p < 0.001$), descriptive norms ($\beta = 0.42$, $p = 0.001$), ego-oriented goals ($\beta = 0.34$, $p < 0.05$), and self-efficacy to refrain from doping ($\beta = 0.26$, $p < 0.05$) displayed a significant influence on attitudes toward doping. Self-reported doping prevalence in coaches was 4.5%. These variables should be considered when designing anti-doping research projects and educational programs aiming at modifying coaches' attitudes toward doping. It is recommended to focus more efforts on coaches, without putting aside the athletes, and therefore turn coaches into reliable doping prevention factors. To this end, it is necessary to enhance scientific research and then develop, implement, and promote more educational programs targeting coaches, on a mandatory basis while covering the specific needs of coaches so that they can perform their role as anti-doping educators in an effective, committed, and proactive manner.

Keywords: anti-doping, doping, moral disengagement, social norms, coaches, competitive sport, athlete support personnel, motivational profile

INTRODUCTION

Coaches strongly influence athletes' attitudes toward doping and can shape athlete's beliefs, behaviors, and decisions to be for or against doping (Barkoukis et al., 2019; García-Grimau et al., 2021). The impact of the athlete's entourage on attitudes toward doping has been reported in different studies (Backhouse and McKenna, 2012; Mazanov et al., 2014; Engelberg and Moston, 2016) and the coach is considered part of the Athlete Support Personnel (ASP) as well as parents/guardians, physiotherapists and other professionals supporting and working directly with athletes, as defined by the World Anti-Doping Code (WADC) (World Anti-Doping Agency, 2021a). Some specific roles and responsibilities of the ASP are the following: cooperating with anti-doping organizations, complying with anti-doping regulations that are applicable to them or their athletes, and using their influence on athletes' values and behavior to foster anti-doping rules (World Anti-Doping Agency, 2021a). Coaches could engage on doping behavior, act as social facilitators in doping in sport (Vakhitova and Bell, 2018) and incite their athletes to commit anti-doping rule violations (ADRVs) (i.e., those displayed in articles ranging from 2.5 to 2.11 of the Code). In these cases, coaches would have conflicted with their responsibility of encouraging their athletes to avoid the use of doping. According to the current anti-doping legislation (World Anti-Doping Agency, 2021a), seven ADRVs are applicable to ASP: tampering or attempted tampering, possession of a prohibited substance or method, trafficking or attempted trafficking, administration, or attempted administration to any athlete of any prohibited substance or method, complicity, or attempted complicity, prohibited association, and acts to discourage or retaliate against reporting to authorities. These non-analytical ADRVs are typically reported in this population. For example, 16 sanctions were imposed worldwide on ASP in 2018 (World Anti-Doping Agency, 2020) and 155 members of ASP are currently serving a period of ineligibility (World Anti-Doping Agency, 2021b).

Beyond the legislative framework, different studies reported a lack of anti-doping knowledge in coaches (Mazanov et al., 2014; Morente-Sánchez and Zabala, 2015; Engelberg and Moston, 2016). Other studies analyzed their beliefs about threats to health (Scarpino et al., 1990; Laure et al., 2001) and their attitudes toward doping and doping prevention. Fung and Yuan (2006) examined perceived knowledge, actual knowledge, attitudes, subjective norms, and behavior in relation to doping and anti-doping in sport in 114 coaches through the conceptual framework of the theory of Planned Behavior (Ajzen, 1991). Results revealed a negative correlation between the perceived and actual knowledge, which implies that coaches may under-estimate or over-estimate their knowledge regarding performance enhancing drugs/substances (PES) and doping control. This finding reflects the complexity of the phenomenon of doping in sport (Fung and Yuan, 2006). The authors suggest the need to design mandatory educational programs specifically designed for coaches. Furthermore, coaches are typically aware that they have an important role in doping prevention and generally display negative attitudes toward doping (Backhouse et al., 2015). Nevertheless, they are not fully committed to the prevention of doping (Patterson et al., 2014; Engelberg et al., 2019), and they need more resources and support to be able to proactively prevent doping among their athletes (Barkoukis et al., 2019).

Attitudes toward doping represents a strong predictor of doping susceptibility and behavior (Gucciardi et al., 2010; Barkoukis et al., 2013; Blank et al., 2016; García-Grimau et al., 2020). However, studies analyzing factors affecting coaches' doping attitudes and behavior are scarce. Nonetheless, a few psychological factors among coaches which may influence the use of doping in their athletes have been highlighted. Sullivan et al. (2015) explored the doping confrontation efficacy in coaches through the Doping Confrontation Efficacy Scale. They reported that coaches who are more prone toward task-involved climates tend to show higher efficacy on confronting athletes, thus preventing them from doping use (Sullivan et al., 2015). Findings from a cluster randomized controlled trial reported that coaches adopting a motivational climate reduced athlete willingness to dope (Ntoumanis et al., 2021). In addition, moral disengagement was strongly correlated with doping attitudes and intentions toward doping in athletes (Kavussanu et al., 2019; García-Grimau et al., 2021) and plays an important role in coaching style and climate (Hodge and Lonsdale, 2011; Chen et al., 2017). Moreover, recent qualitative evidence (Patterson and Backhouse, 2018; Barkoukis et al., 2019) reported that displacement and diffusion of responsibility, which are considered two of the mechanisms involved in the moral disengagement construct (Bandura et al., 1996), influence coaches' opinions and behavior toward doping. Coaches delegate their role in anti-doping prevention on authorities, which reflects an unwillingness to proactively engage in anti-doping education; furthermore, Barkoukis et al. (2019) reported that the stigmatization of doping behavior prevents athletes and coaches from being effectively educated about doping. Horcajo and De La Vega (2016) carried out an experimental study in which the conviction about attitudes related to doping and the effect of deliberative thinking (i.e., high- vs. low-elaboration likelihood) on that conviction were analyzed in soccer coaches. They reported that coaches with high elaboration likelihood showed more conviction about their attitudes than those with low elaboration likelihood. Morente-Sánchez and Zabala (2015) examined knowledge, attitudes, and beliefs toward doping in 237 soccer technical staff (including 101 coaches) and highlighted their lack of doping-related knowledge.

Overall, coaching style and climate, and psychological and moral factors have been quantitatively and independently analyzed in the doping literature to finally understand their relationships with doping attitudes in athletes. However, studies examining a large number of factors influencing coaches' doping attitudes and behavior under a specific theoretical framework are scarce. Literature reviews carried out by Backhouse et al. (2007, 2015) confirmed the lack of quantitative research guided by a theoretical framework on doping attitudes and behavior in coaches. The Sport Drug Control Model (SDCM) was developed by Donovan et al. (2002) and incorporates

different frameworks from the behavioral sciences such as the Theory of Reasoned Action (Fishbein, 1979) and the Theory of Planned Behavior (Ajzen, 1991). The SDCM analyzes several factors influencing athletes' attitudes toward and susceptibility to doping: morality, legitimacy, benefits and threat appraisals, motivational profiles, beliefs about reference groups' endorsement of doping methods/substances, use of legal supplements, beliefs about the availability of PES and relevant authorities' control over trafficking of doping methods/substances, beliefs about the affordability of doping methods/substances, attitudes toward doping, susceptibility to doping, and self-reported use of banned PES or methods (PESM). The World Anti-Doping Agency integrated this model as a guideline for anti-doping organizations (World Anti-Doping Agency, 2015) and it has been tested in athletes (Gucciardi et al., 2010; Jalleh et al., 2013; García-Grimau et al., 2021) showing validity and reliability. Jalleh et al. (2013) and García-Grimau et al. reported that the most influential factors were morality, reference group opinion, and legitimacy. Moreover, Donovan et al. (2002) observed that the SDCM could be adapted for application to ASP but has not yet been applied to coaches. In this study, the SDCM is applied for the first time in coaches with the aim of assessing the reproducibility of the model in ASP. Secondary study purpose was to determine the factors in the SDCM that most influence coaches' attitudes and susceptibility toward doping, and their doping prevalence.

MATERIALS AND METHODS

Participants and Design

Athletics is the third summer Olympic sport most affected by doping, reporting 15% of the total ADRVs worldwide in 2018 (World Anti-Doping Agency, 2020). However, to the best of the authors' knowledge no study analyzing attitudes and behavior toward doping in Spanish athletics coaches has been conducted previously. Thus, athletics coaches were recruited between February and March 2021 to participate in a cross-sectional online survey *via* e-mail from the database of the National School of Coaches of the Royal Spanish Athletics Federation. The questionnaire was sent to 1,432 coaches of whom 163 completed the survey. To achieve a suitable statistical sample size for structural equation modeling (SEM) (Tabachnick and Fidell, 2013), 38 athletics coaches were further online recruited *via* e-mail from the Athletics Federations of the Spanish regions of Madrid, Aragón, and Navarra in April 2021. In the first section of the online survey, coaches received information explaining the aims and procedures of the study and consent to take part. Participants were reassured about the anonymity and confidentiality of their responses and about their right to withdraw at any time. A final sample of 201 Spanish athletics coaches successfully completed the survey, from whom 62.2% were aged between 30 and 59 years and 88.6 and 11.4% were male and female, respectively. Coaches were specialized in middle- and long-distance running (38.8%,), sprinting/hurdle (26.9%), jumping/throwing (19.9%), combined events (10.0%), and race walking (4.5%). Regarding the level of performance achieved by their athletes, coaches were training an athlete who had participated at least once in Olympic Games (9.5%), World Athletics Championships (11.9%), European Athletics Championships (10.0%), other international events with the national team (15.4%), national Athletics Championships (45.8%), and regional Championships (7.5%).

Instrument

The Spanish SDCM questionnaire which was previously used on athletes and provided validity and reliability (García-Grimau et al., 2021), has been adapted for coaches to measure the following constructs: (1) moral disengagement; (2) benefits appraisal; (3) threat appraisal; (4) self-efficacy to refrain from doping; (5) goal orientations; (6) subjective norms: reference groups' endorsement of doping methods/substances; (7) descriptive norms: belief of doping use in others; (8) attitudes toward doping, and (9) susceptibility to doping. The questionnaire measures are described as follows.

Moral Disengagement

Morality construct was measured with the Moral Disengagement in Doping Scale, which has shown good internal consistency, reliability, and validity (Kavussanu et al., 2016). Coaches were asked to indicate their level of agreement with six statements measured on a Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Example items are: "Athletes cannot be blamed for doping use if their teammates pressure them to do it" and "Athletes should not be blamed for doping use if everyone is doing it."

Benefits Appraisal

In line with previous research (Jalleh et al., 2013; García-Grimau et al., 2021), benefit appraisal is measured in terms of (1) perceived performance-enhancing effects of banned substances and methods use and (2) likelihood of potential positive outcomes for performing well in sport. Questions were reformulated to adapt them to coaches. For example, to assess (1), participants were asked to rate from definitely would not (1) to definitely would (5) "If any of your athletes were to use a banned PESM of his/her choice, how likely is it that he/she would improve his/her performance?" To assess (2) participants were asked "To what extent does your sport offer you these outcomes if your athletes perform well?" and rate from a lot (1) to not at all (3) six answer-items (i.e., national celebrity status, future financial security).

Threat Appraisal

Threats relating to (1) deterrence and (2) ill-health effects were measured. To assess (1) coaches were asked two questions to measure their perceived likelihood of an athlete being tested in and out of competition, and of evading detection if using doping in and out of competition, using a 5-point scale ranging from (1) very likely to (5) not at all likely. To assess (2) participants were asked to score the harm level of six different PESMs using a 5-point scale from 1 (a lot of harm) to 5 (no harm).

Self-Efficacy to Refrain From Doping

To assess coaches' ability to avoid the use of PESMs within their athletes or resist doping temptation, the ten-item Doping Self-efficacy scale (Lucidi et al., 2008) was used and adapted to coaches (i.e., "to avoid using PESMs with my athletes before a competition even when I know I can get away with it," "to resist the temptation to use PESMs with my athletes to improve their performance"). Participants were asked to rate from completely capable (1) to not at all capable (7).

Goal Orientation

Research indicates that ego-oriented goals increase doping use likelihood (Ring and Kavussanu, 2018a) while task-oriented goals are related to lower susceptibility to doping (Ntoumanis et al., 2021). Coaches were asked to indicate their level of agreement with six statements from the ego-oriented subscale (i.e., "I am the best," "I show other people I am the best") using a five-point Likert scale from strongly disagree (1) to strongly agree (5).

Subjective Norms

In line with previous research (García-Grimau et al., 2021) coaches' perceptions of others' attitudes toward doping were assessed with the following question: "If any of your athletes decided to use a PESM, to what extent do you think each of the following people would approve or disapprove or would not care either way if they did that?" Six-response items were presented to participants (i.e., parents, teammates, sport doctors, and manager) and asked them to rate from would definitely approve it (1) to would definitely disapprove it (5).

Descriptive Norms

To assess coaches' beliefs regarding others' use of doping, they were asked to indicate the percentage of perceived doping prevalence in five statements (i.e., "Out of 100%, how many athletes in your sport do you believe engage doping to enhance their performance," "Out of 100%, how many coaches in your sport do you believe would encourage their athletes to use doping to enhance their performance?").

Attitudes Toward Doping

Following the work of Petróczi (2002) a single-item was used to measured coaches' attitudes toward the use of PESM: "In your sport, how necessary do you believe it is for athletes to use banned performance-enhancing substances at least at some time, to perform at the very highest levels?" Responses were rated on a Likert scale ranged from 1 (definitely have to use) to 5 (definitely don't have to use).

Susceptibility to Doping

Susceptibility to doping is measured using a hypothetical scenario adapted from previous research (Bamberger and Yaeger, 1997; García-Grimau et al., 2021). Coaches were asked to imagine a situation to use a PESM with their athletes to enhance their performance. The scenario is described below:

> "If you were offered a banned PES under medical supervision at low or no financial cost and the banned PES could make a significant difference to your athletes' performance and was currently not detectable, how much consideration do you think you might give to this offer?"

Responses were rated from not at all consideration (1) to a lot of consideration (4).

Doping Prevalence

Doping prevalence among coaches is measured in terms of self-reported administration or attempted administration to athletes of a PESM (lifetime or in the last 12 months). For the lifetime doping prevalence, participants were presented with seven items/statements and told to indicate which one of the statements most applies to them. Each item was scored from 1 (I have never considered using a banned PESM with my athletes) to 7 (I regularly try or use banned PESM with my athletes). This variable was transformed in a dichotomous variable range from 0 (never use PESM) to 1 (ever use). For the prevalence of doping in the last 12 months, coaches were presented with six different PESM and asked: "In the last 12 months, how often have you used any of the following PESM with your athletes, for whatever reason?" Responses were rated from 1 (have never used) to 6 (more than 10 times). This variable was transformed in a dichotomous variable range from 0 (never use PESM) to 1 (use 12 months). These two variables were combined and recoded into a single variable measuring total doping prevalence among coaches. This variable only measures one of the seven possible ADRV that ASP can commit (see introduction and WADC).

Indirect Doping Prevalence Among Athletes

Indirect doping prevalence among athletes were measured by asking coaches the following dichotomous question: "Have any of your athletes ever tested positive for a banned PES?"

Protocol

Ethics committees from Isabel I de Castilla International University (UI1-PI016) and World Anti-Doping Agency (2019-A2) provided ethical approval for the completion of the present study. All the participants signed a consent form to participate in this study which was conducted in accordance with the Declaration of Helsinki. Athletes were informed about the aims and purposes of the study and reassured about their anonymity and confidentiality of their data.

Data Analysis

Descriptive statistics, reliability, and internal consistency analysis of the study variables were performed through the Statistical Package for the Social Sciences (SPSS) version 24.0 (IBM, Armonk, NY, USA). Missing values were checked before statistical analysis. Missing data for each variable was low (i.e., 0.0–4.4%) and replaced through the expectation maximization method (Graham, 2009). Means (95% confident intervals [CI]), standard deviations (SDs), McDonald's ω, average variance extracted (AVE) and composite reliability (CR) were calculated as a measure of reliability and internal consistency. SEM was carried out to test the SDCM in coaches through AMOS package for SPSS version 24.0. An examination of the measurement portion of the model and setting constraints was made to avoid identification issues. To evaluate the adequacy of the model

the fit indices recommended in guidelines (Hair et al., 2010; Tabachnick and Fidell, 2013) were employed: ratio of the χ^2 to the degrees of freedom ($\chi^2/df < 2$), comparative fit index (CFI > 0.9), Tucker Lewis Index (TLI > 0.9), root-mean-square error of approximation (RMSEA $\leq$ 0.08) and Standardized Root-Mean-Square Residual (SRMR $\leq$ 0.10).

RESULTS

Descriptive statistics for the different variables analyzed (see **Table 1**) indicate that coaches reported on average negative attitudes toward doping and low levels of susceptibility to doping and moral disengagement. With respect to psychological factors, coaches stated on average a high self-efficacy to refrain from doping and moderate ego-oriented goals. Regarding social norms, they reported a high subjective norm. They believed that, on average, reference groups would disapprove doping behaviors. With respect to descriptive norms, coaches perceived an average doping prevalence of 19.5% (1.95 $\pm$ 1.74 [mean $\pm$ SD]) (see **Table 2** for further details). Measures showed good internal consistency and reliability, with omega (ω) values > 0.6, AVE values > 0.4 and CR values > 0.7 (see **Table 1**). Self-reported doping prevalence among coaches was 4.5%, and 3% acknowledged having had an athlete who has tested positive for a prohibited substance. The SEM analysis of the SDCM in coaches (**Figure 1**) revealed a good fit of the data: $\chi^2/df = 1.76$, $p < 0.001$, CFI = 0.93, TLI = 0.96, RMSEA = 0.062 (90% CI = 0.054, 0.070), and SRMR = 0.09. Covariance between moral disengagement and subjective norms, and between subjective norms and descriptive norms did not change the model fitness and improved the standardized parameter estimates and significance. Among the standardized parameter estimates (**Figure 1**), all the relationships were significant excepting threat appraisal, benefit appraisal, and subjective norms. Moral disengagement ($\beta = 0.58$, $p < 0.001$) and descriptive norms ($\beta = 0.42$, $p < 0.001$) were the strongest predictors of attitudes toward doping in coaches. Regarding motivational and psychological profiles, ego-oriented goals ($\beta = 0.34$, $p \leq 0.01$) and self-efficacy to refrain from doping ($\beta = 0.26$, $p < 0.05$) were also good predictors of coaches' doping attitudes, while ego-oriented goals displayed a greater level of significance and higher standardized parameter estimate than self-efficacy. Moreover, attitudes toward doping predicted doping susceptibility significantly ($\beta = 0.39$, $p < 0.001$).

DISCUSSION

The main study objectives were to analyze attitudes and susceptibility toward doping in coaches while testing the SDCM for the first time in ASP, and to determine which factors were the strongest predictors of their doping attitudes. So far, the SDCM had been applied to athletes, its application in a new population is an added value to this research. The most important findings in regard to the relationship between the variables were that attitudes toward doping predicted high susceptibility to doping, and were highly influenced by moral disengagement and descriptive norms in athletics coaches. The observed strength of the relationship between attitudes toward doping and doping susceptibility agrees with results from other studies carried out in athletes (Barkoukis et al., 2013; Blank et al., 2016; García-Grimau et al., 2021). However, to the best of the authors' knowledge by the time of writing, this relationship was not previously tested in coaches and the SDCM was not ever adapted and examined in coaches, hence this study brings innovation to anti-doping research.

In addition, the fact that morality and more particularly moral disengagement was found to be the factor with the strongest influence on attitudes toward doping in coaches reveals that the more they are morally disconnected, the more their favorable attitudes toward doping. These results are in line with other studies in athletes (Jalleh et al., 2013; García-Grimau et al., 2021) and coaches (Patterson and Backhouse, 2018; Barkoukis et al., 2019) in which moral disengagement displayed a strong influence on doping likelihood acting as a direct predictor or mediator (Ring and Kavussanu, 2018b). The relevance of moral variables on doping prevention has been proven in empirical research. For example, a recent anti-doping interventional study which focused on developing morality in British and Greek athletes reported a reduction in the likelihood of doping use (Kavussanu et al., 2021). In this sense, morality variables should be considered when implementing educational programs targeting ASP and coaches in particular.

Social norms were measured in the present study through subjective and descriptive norms. Our results show that descriptive norms were a significant and positive predictor of attitudes toward the use of doping in coaches, which reflects that the perception of high prevalence of doping in others could enhance their attitudes toward doping, as they tend to normalize this behavior. Their perception of incidence of performance enhancing drug use across all sports and for athletics were 23.4 and 20.0%, respectively (see **Table 2**). These results are consistent with those by Moston et al. (2015b), who reported that doping prevalence perception in 92 Australian coaches across all sports was 20.9%. Additionally, coaches believe that 25.3% of athletes will be engaged in doping in the next 2 years.

Subjective norms (i.e., social approval of significant others) did not display a significant influence on doping attitudes, which contrasts with findings from other studies performed in athletes (Lazuras et al., 2010; García-Grimau et al., 2021). For example, a recent SDCM analysis in Spanish national standard and elite track and field athletes reported that moral disengagement and subjective norms were the variables with the greatest influence on attitudes toward doping (García-Grimau et al., 2021). Therefore, the absence of influence of this construct on coaches' doping attitudes, which contrasts with that in athletes, reflects their need to receive anti-doping education from sporting bodies and anti-doping organizations given their important role as anti-doping educators. Overall, this finding highlights that normative beliefs can be considered determinants of attitudes and behavior toward doping in the sport society.

TABLE 1 | Descriptive statistics, reliability, and internal consistency estimates for the variables measuring the sport drug control model through structural equation modeling.

Variables	Range	Mean (CI)	SD	ω	AVE	CR
Susceptibility to doping	(1) not at all to (4) a lot of consideration	1.08 (1.04, 1.13)	0.32	–	–	–
Attitudes toward doping	(1) definitely don't have to use to (5) definitely have to use	1.67 (1.52, 1.81)	1.05	–	–	–
Moral disengagement	(1) Strongly disagree to (7) strongly agree	1.37 (1.28, 1.46)	0.66	0.68	0.48	0.77
Benefit appraisal	Performance enhancing effect: (1) would not to (5) definitely would	3.21 (3.06, 3.36)	1.07	0.89	0.59	0.89
	Positive outcomes: (1) a lot to (3) not at all	1.50 (1.45, 1.55)	0.34	0.72	0.48	0.82
Threat appraisal	Testing likelihood: (1) very likely to (5) Not at all likely	3.57	1.27	–	–	–
	Evading detection: (1) Very likely to (5) Not at all likely	2.83	1.20	–	–	–
	Ill-health effect: (1) A lot of harm to (5) no harm	2.07 (1.9, 2.24)	1.10	0.94	0.73	0.94
Motivational profiles: self-efficacy to refrain from doping	(1) completely capable to (7) Not at all capable	1.59 (1.37, 1.80)	1.54	0.98	0.84	0.98
Motivational profiles: ego-oriented goals	(1) strongly disagree to (5) strongly agree.	2.14 (2.03, 2.26)	0.83	0.82	0.53	0.87
Subjective norms: Reference Groups' Endorsement of Doping Methods/Substances	(1) would definitely approve to (5) would definitely disapprove	4.14 (4.04, 4.24)	0.74	0.88	0.61	0.95
Descriptive norms: perception of others' use of doping		19.5* (17.1, 22.0)	17.4	0.93	0.76	0.94

*CI, confident intervals; SD, standard deviation; ω, McDonald's ω; AVE, average variance extracted; CR, composite reliability. *Average percentage of perceived doping.*

Regarding motivational profiles, self-efficacy, and ego-oriented goals were significant predictors of coaches' doping attitudes in the present study. Coaches with ego-oriented goals and less ability to resist temptations may be more prone to doping. This finding is consistent with results from Matosic et al. (2016, 2020), who reported that coach narcissism is positively associated with controlling coaching behavior, and athletes' perceptions of coach behavior predict athletes' attitudes toward doping. Moreover, self-regulatory efficacy in coaches helps to create a motivational climate (Sullivan et al., 2015), reduce athlete willingness to dope (Ntoumanis et al., 2021) and, according to our findings, prevent them from displaying positive attitudes toward doping. Hence, those motivational factors are strong predictors of attitudes and susceptibility to doping in both coaches and athletes.

Benefit and threat appraisal factors did not significantly predict coaches' doping attitudes. That means that the potential benefits or positive outcomes that a coach could achieve by cheating, and the level of threat perceived by the coach due to deterrent effect or risk to health, are not significant factors influencing their attitudes toward doping. Moston et al. (2015a) analyzed the perceived incidence of deterrents on drug use in Australian athletes and coaches and reported that coaches saw deterrents as less credible than athletes, with a low perceived likelihood of detection. Similarly, 75% of the coaches who participated in our study perceived the likelihood of being tested out of competition as low (not at all likely or not likely) and generally considered that doping has positive effects on athletes' performance. However, the latter would not result in substantial economic benefits or positive outcomes for coaches given that 81.3% of the coaches surveyed reported an average annual income derived from their coach role of <10,000 euros.

TABLE 2 | Descriptive norms: coaches' beliefs regarding others' use of doping.

Statements	Mean (SE)
Out of 100%, how many athletes in your sport do you believe engage doping to enhance their performance	20.0 (1.3)
Out of 100%, how many elite athletes in your country do you believe engage in doping to enhance their performance?	23.4 (1.6)
Out of 100%, how many elite athletes do you believe will be engaged in doping during the next 2 years to enhance their performance?	25.3 (1.7)
Out of 100%, how many coaches in your sport do you believe would encourage their athletes to use doping to enhance their performance?	12.8 (1.0)
Out of 100%, how many coaches in elite sports in your country do you believe would encourage their athletes to use doping to enhance their performance?	16.5 (1.4)

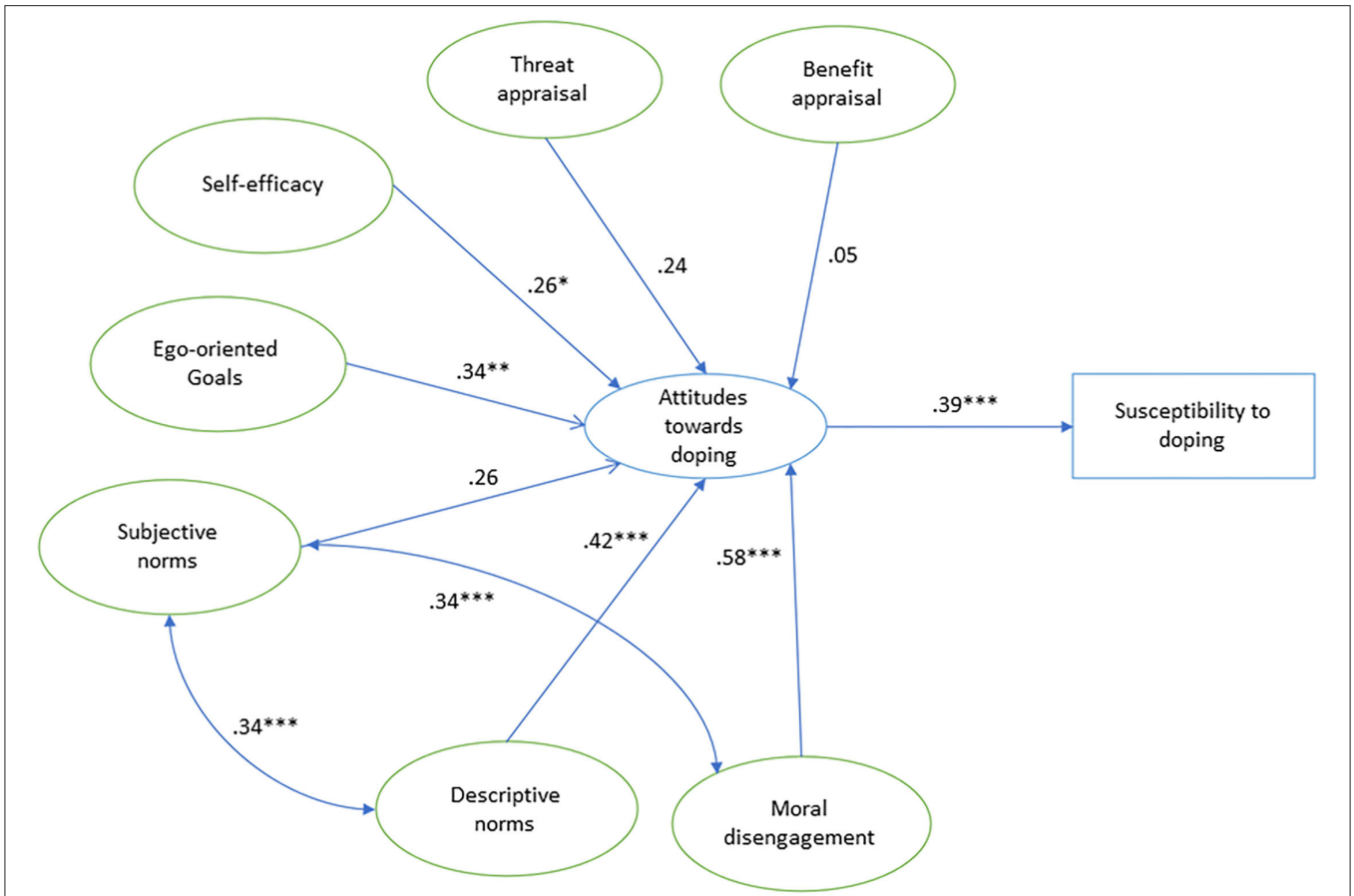

FIGURE 1 | Overview of results of structural equation model analysis with standardized parameter estimates. Different levels of significance according to *p*-value: $^{*}p \leq 0.05$, $^{**}p \leq 0.01$, and $^{***}p \leq 0.001$.

Coaches have a key role in doping prevention (Kirby et al., 2011), but they can also represent a risk factor regarding doping use in their athletes as they may encourage them to dope or supply them with banned PESM (Allen et al., 2017; Vakhitova and Bell, 2018). In our study, the percentage of self-reported doping administration was 4.5% among coaches. Despite the lack of studies analyzing doping prevalence in coaches in the current literature, Morente-Sánchez and Zabala (2015) reported that 8.1% of the Spanish soccer coaches analyzed in their study used banned substances while a literature review (Backhouse and McKenna, 2012) indicated that 4–6% of the coaches and rest of ASP analyzed reported personal use of banned substances. Moreover, doping in sport is a prohibited and socially rejected practice, methods for assessing doping prevalence remain unclear and therefore data prevalence is potentially underestimated due to the sensitivity of the question. The prevalence of doping in elite sports is likely to be between 14 and 39% (De Hon et al., 2015). A recent meta-analysis study shows a disparate range between 0 and 73% (Gleaves et al., 2021) where authors suggest best practice recommendations and guidelines to improve the evidence quality in this field. The use of multiple measures to triangulate doping prevalence data, and indirect measures like randomized response technique (RRT) may provide more reliable measurements (Gleaves et al., 2021).

Overall, adaptation and application of the SDCM in ASP proves its reproducibility in other population. Our results show that moral disengagement, social norms, and motivational profiles are the strongest predictors of attitudes toward doping among coaches and 4.5% of them supply their athletes with prohibited substances or methods. Therefore, it is necessary to address these psychological-, attitude-, and behavior-related issues through educational programs targeting coaches. Furthermore, sanctions applied to coaches and the rest of professionals conforming the ASP seem scarce (World Anti-Doping Agency, 2020), probably due to the non-analytical nature of these ADRV, since it is difficult to prove their doping behaviors and therefore to sanction them. In addition, most of the social science research literature on doping in sport has focused on athletes, while coach-centered studies remain limited (Backhouse et al., 2015; García-Grimau et al., 2020). The results of the present study alongside those from others reveal that coaches tend to morally disengage through a lack

of commitment and a diffusion of their responsibilities as educators in doping prevention (Barkoukis et al., 2019), and consider that they do not have adequate tools to prevent their athletes from doping use, while being aware of their role as antidoping educators though (Engelberg et al., 2019; Patterson et al., 2019). All this scientific evidence paints a worrying picture, as coaches could rather represent a doping risk. On the one hand, the threshold prevalence of doping among coaches is considerable (i.e., between 4.5 and 8.1%). On the second hand, they manifested an absence and lack of interest in doping prevention. In the complex context of elite sport in which the influences of sport environment and reference group on athletes are crucial, the absence of doping prevention may involve the presence of risk of its use. Perhaps it is time to focus more efforts on coaches, without putting aside the athletes, and therefore turn coaches into reliable doping prevention factors. To this end, it is necessary to enhance scientific research and then develop, implement, and promote more educational programs targeting coaches, on a mandatory basis while covering the specific needs of coaches so that they can perform their role as anti-doping educators in an effective, committed, and proactive manner.

Limitations and Future Research

The participants in our study declared that they would not obtain any economic benefit if their athletes doped, and have low economic income derived from their activity as coaches. However, benefit appraisal did not influence their attitudes toward doping and it would not necessarily be the case in other cultural and social contexts. Reproducing this study in other countries would allow us to elucidate the specific impact of this variable and others influencing doping attitudes and behaviors in coaches. More specifically, further studies examining in depth the relationship among moral variables, descriptive norms, motivational and psychological profiles, and doping attitudes in coaches from other cultural contexts are encouraged. In addition, further studies analyzing the effectiveness of interventions aiming at avoiding moral disengagement in coaches are recommended, and it would be useful to analyze other sociodemographic variables in coaches, as for example, if they were competitive athletes. The model explaining attitudes toward doping in coaches seems to be less complex than that in athletes given that it displays fewer influencing factors. Doping prevalence among coaches was measured in terms of self-reported administration or attempted administration to athletes of a banned PESM, but the six remaining ADRVs included in the Code of the World Anti-Doping Agency (2021a) were not tested in the present study. In addition to the limitation of the bias response in self-reported doping, outcome of doping prevalence may be underestimated.

CONCLUSION

Attitudes toward the use of doping in Spanish track and field national coaches were analyzed for the first time to the best of authors' knowledge through the SDCM adaptation for coaches, which displayed reproducibility. Moral disengagement, social norms, and motivational profiles were the strongest predictors of positive attitudes toward doping among these coaches. Accordingly, further design of anti-doping research and education should target on developing and improving these abilities in coaches. It is necessary to enhance coach-centered research, provide more assistance to sport coaches, and establish effective and mandatory anti-doping education in them.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available for ethical reasons according to an explicit condition set by the Ethics Committee from the World Anti-Doping Agency (2019-A2). Requests to access the datasets should be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Isabel I de Castilla International University (UI1-PI016) World Anti-Doping Agency (2019-A2). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

EG-G: designed, conceptualized, performed analysis, and wrote the paper. EG-G and AC: collected the data. AC and RD: contributed to the writing. All authors contributed to the article and approved the submitted version.

FUNDING

This work was funded by the World Anti-Doping Agency, within their Social Science Research Grants program and Isabel I de Castilla International University.

ACKNOWLEDGMENTS

The authors gratefully thank Carlos Cordente and the National School of Coaches of the Royal Spanish Athletics Federation (CENFA) for the useful help provided during the data collection process through the dissemination of the questionnaire to athletics coaches.

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frontiers in Sports and Active Living

ORIGINAL RESEARCH
published: 15 March 2022
doi: 10.3389/fspor.2022.842192

GRADE IT—A Literacy-Based Assessment Tool for *Generating Research-Based Assessment Data to Evidence the ImpacT of Anti-doping Education* via Athletes' Capability to Make the Right Decision

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OPEN ACCESS

Edited by:
Thierry Zintz, Catholic University of Louvain, Belgium

Reviewed by:
Jules Woolf, University of Illinois at Urbana-Champaign, United States
Laura Capranica, Foro Italico University of Rome, Italy

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Specialty section:
This article was submitted to Anti-doping Sciences, a section of the journal Frontiers in Sports and Active Living

Received: *23 December 2021*
Accepted: *14 February 2022*
Published: *15 March 2022*

Citation:
Blank C, Gatterer K, Overbye M, Schobersberger W, Streicher B and Petróczi A (2022) GRADE IT—A Literacy-Based Assessment Tool for Generating Research-Based Assessment Data to Evidence the ImpacT of Anti-doping Education via Athletes' Capability to Make the Right Decision. Front. Sports Act. Living 4:842192. doi: 10.3389/fspor.2022.842192

The International Standard for Education (ISE) mandates Code Signatories to plan, deliver, and evaluate anti-doping education. Performance-based evaluation of anti-doping education requires alignment between educational goals, content, and defined outcomes. Based on an existentialist teaching and learning philosophy, we aimed to develop and test an anti-doping impact evaluation tool, to assess the impact of anti-doping education on doping awareness, literacy (DAL), perceived trust, and legitimacy. We propose that the impact of anti-doping education is best captured through assessment of situation-specific (social) cognitive mediators of actions that influence athletes' choices in the context of sport-related goals. In phase one, we aimed to develop and test the Generating Research-based Assessment Data to Evidence the ImpacT of anti-doping education (GRADE IT) evaluation tool that comprised a set of social cognitive components: anti-doping knowledge, DAL, perceived trust, and legitimacy of anti-doping (organizations). In phase two we assessed whether anti-doping education impacts knowledge, the three DAL stages (functional, interactive, and critical literacy), perceived trust and legitimacy. Phase one enrolled 986 junior elite athletes, and we showed that all GRADE IT components performed well. After revision of the tool for phase two, we validated the assumption that anti-doping education impacts the likelihood that athletes will make the "right" choice (based on a new set of data from 1,255 junior elite athletes). Comprehensive education was associated with higher scores for all stages of DAL, as well as perceived trust and legitimacy. Even athletes reporting no education had positive scores for all included outcomes, supporting the assumption that most athletes wish to engage in clean sport behaviors and might need anti-doping education not to prevent them from doping, but rather to reinforce their commitment to clean sport. In conclusion, GRADE IT, which is available in 23 languages, is a suitable tool for application

to young, emerging athletes to satisfy the ISE requirement for evaluating anti-doping education programs. Researchers and practitioners alike are advised to collect additional data to further validate the tool for adult athletes, and to apply it longitudinally to identify if changes in doping prevention policies have a delayed effect on DAL, perceived trust, and legitimacy.

Keywords: anti-doping education, literacy, evaluation, decision-making, junior elite athletes

INTRODUCTION

Using education to raise awareness, inform and communicate is one of the main aims of the World Anti-Doping Agency's (WADA) strategy to prevent intentional and unintentional anti-doping rule violations (ADRV; World Anti-Doping Agency, 2021c). Prevention, as defined in a public health context (Hurrelmann et al., 2009), focuses on identifying risk factors for a certain outcome, with the aim of minimizing these factors and decreasing the likelihood of undesired outcomes. Accordingly, most behavioral anti-doping research conducted in the last two decades focused on identifying risk factors for doping behavior (Ntoumanis et al., 2014; Blank et al., 2016), with the long-term aim of establishing an evidence base as a foundation for preventive measures to eliminate risk factors. Despite this growing body of research, resulting evidence-based preventive strategies have apparently not been implemented (Gatterer et al., 2020). Gatterer et al. (2020) review showed that a significant proportion of anti-doping organizations limits their anti-doping education to information provision, with only a few National Anti-Doping Organizations (NADOs) offering comprehensive programs considering both risk and protective factors. This limited focus, however, may not hinder the impact of the programs, because a large proportion of athletes would not dope anyway due to their values and upbringing (Petróczi et al., 2021a; Shelley et al., 2021). The athletes in these studies had already decided to be compliant with anti-doping rules before receiving any anti-doping education, yet the dominant approach to anti-doping education remains preventive, and assumes that athletes need to be "saved" from doping. As such, evaluating the success of anti-doping education solely based on a decrease in the incidence of ADRV—which is largely determined by detection and sanctioning—is neither sufficient nor appropriate.

Additionally, there is evidence of a lack of alignment between learning outcomes (which are evidence-based) and the elements of existing anti-doping education (Woolf, 2020), which might explain the seemingly unsuccessful education initiatives. Moreover, these learning outcomes are not aligned to WADA's definition of doping. In detail, most research assessing risk factors for doping behavior define it as the use of prohibited substances and/or prohibited methods (Ntoumanis et al., 2014; Blank et al., 2016), which only refers to two of the 11 ADRV defined by the World Anti-Doping Code (WADC; World Anti-Doping Agency, 2021c). Some exceptions include Chan et al. (2019) and Chan et al. (2020).

From the perspective of content, research suggests that variables identified as risk factors (Ntoumanis et al., 2014; Blank et al., 2016) are in fact a mixture of risk factors for doping (Petróczi et al., 2017; Gatterer et al., 2019) and protective factors against doping (Overbye et al., 2013; Erickson et al., 2015; Englar-Carlson et al., 2016). This is problematic, as it has been argued that reasons to dope (risk factors) and reasons not to dope (protective factors) pertain to two distinct goals and thus cannot be considered as the opposite of each other (Overbye et al., 2013; Petróczi et al., 2017, 2021a; Gatterer et al., 2019). This problem was also highlighted by a recent synthesis of qualitative research on barriers to, and factors promoting, clean sport (Williams et al., 2021). The authors of the review outlined the importance of knowledge as both an "enabler" and barrier to doping, and highlighted the lack of understanding of the complexity of motivation, which involves both physical and psychological capabilities. It was further argued that motives to dope were mostly associated with functional reasons, such as the pressure to win, fear of losing sponsors, and preventing a loss in performance when injured (Whitaker et al., 2017; Gatterer et al., 2019).

Further research highlighted that risk factors must be considered on multiple levels (including structural risks) in the interactions between the environment and individual (Petróczi and Aidman, 2008; Petróczi, 2013; Petróczi et al., 2017). For example, it has been suggested that sports environments are "dopogenic," with multiple influencing factors at the local level and structural factors interacting to increase risks for athletes (Backhouse et al., 2018). Moreover, elite sport has been characterized as a risky occupation with unique features influencing interactions and interdependencies between individuals and their environment (Overbye, 2018). While these approaches focus on prevention, they also support the need for empowering athletes to cope with the pressures and risks posed by different environments.

Based on the above research, and as already discussed by Petróczi et al. as part of the Erasmus+ projects Safe You+ (Petróczi, 2018) and RESPECT (Petróczi et al., 2021a), it may be time to rethink the theoretical foundations of current anti-doping education approaches, by transitioning from an epidemiological and psychological perspective to one of health promotion and literacy. In health sciences, health promotion and literacy perspectives play an important role in the ability to stay healthy while facing health risks. Translated to doping, this would mean the ability to remain committed to clean sport behavior and compliant with anti-doping rules, which are two dissociable dimensions (Clancy et al., submitted) despite both being associated with the pressure of the sporting system. Judicious decision-making is a significant concept in health literacy arising

from the paradigm of health promotion. If intentional doping is often a coping strategy (Petróczi and Aidman, 2008), as much of the evidence tends to support, it can be considered a decision, i.e., a deliberate choice. It may be a "bad" decision from anti-doping and health perspectives, but is nonetheless something that athletes decide to do, irrespective of whether it is based on a thorough risk-benefit analysis. Anti-doping education should thus address this decision-making process, to help athletes make the "right" decision according to their specific context and circumstances by increasing their literacy.

Concepts of Health Promotion and Health Literacy

Health promotion is "the process of enabling people to increase control over, and to improve their health," as defined by the World Health Organization's Ottawa Charter (World-Health-Organization, 1986. p. 1). Health promotion activities aim to increase resources, capacities, and abilities, to empower individuals to make the right choices in terms of health. Making the right choice is in turn closely related to the concept of health literacy. Nutbeam (2000, p. 263), defines health literacy as an outcome of health education, and more specifically as the "personal, cognitive, and social skills which determine the ability of individuals to gain access to, understand, and use information to promote and maintain good health." An essential role in achieving the desired conditions and applying newly acquired knowledge is played by self-efficacy. In detail, Nutbeam (2000) specifies three types of literacy, which are assumed to build upon each other and ultimately lead to greater empowerment: (a) basic/functional literacy (i.e., factual information), (b) communicative/interactive literacy (i.e., developing personal skills based on knowledge), and (c) critical literacy (i.e., information on social and economic determinants of health important to achieve policy changes). These three types of literacy have also been shown to be associated with several health-related outcomes, including compliance with prescribed therapeutic regimes (Ad Hoc Committee on Health Literacy for the American Councol on Scientific Affairs, 1999; Nutbeam, 2000).

Applying the Health Literacy Concept to Anti-Doping

We argue that applying the health literacy concept to the doping context is a promising approach to enable elite athletes (competing at international level) to make the right decisions. The concept of Doping Awareness Literacy (DAL; see **Figure 1**), was originally developed by Andrea Petróczi and her team at Kingston University for the EU ERASMUS+ funded "SAFE YOU" project (safeyou.eu), and directly built on the health literacy concept applied to performance-enhancing drugs in competitive sport. This initial model captures the process of DAL development in three distinctive stages: Knowing (Functional Literacy), Deciding (Interactive Literacy), Leading (Critical Literacy). The DAL model is progressive and incremental, and aims to strengthen self-efficacy to promote informed decisions about the use of performance- and image-enhancing drugs (PIEDs) for better self-care and health (direct and indirect outcomes, respectively; Petróczi et al., 2021b).

Vamos and Steinmann (2019) also discussed the idea of health literacy in the context of youth sport in Germany; however, they did not directly link it to doping. Their focus was on improving health literacy in young professional sportspeople, to decrease the potential harm caused by pursuing professional sport (where doping is only one of several possible health risks). Vamos and Steinmann (2019) argued that health literacy can be considered an asset that might help sportspeople overcome personal and structural barriers to health within the context of elite sport, and enhance control over social, environmental, and economical health determinants.

The International Standard for Education (ISE) mandates Code Signatories to plan, deliver, and evaluate anti-doping education initiatives (World Anti-Doping Agency, 2021b); this does not directly address doping literacy, but it is considered key that education programs help athletes make ethical decisions. According to the Guide to the ISE (World Anti-Doping Agency, 2021a), making an informed decision involves values, awareness, information, and anti-doping education (in terms of Code compliance). From a doping literacy perspective, information and awareness are important as a basis for increasing Functional Literacy, whereas anti-doping education is necessary for Interactive Literacy, which reflects the development of skills and capabilities to handle specific situations. Lastly, even though not explicitly stated, the values component of the ISE can be considered as part of Critical Literacy, because it extends beyond the athlete him/herself and to encompass the environment, culture and values.

The ISE mandates that organizations with responsibility for anti-doping develop a plan for evaluating and demonstrating the effectiveness of their anti-doping education. This point was cited as a barrier to the implementation of anti-doping education by Gatterer et al. (2020). In detail, a representative from Asia stated that "Lacking proper method of education evaluation would be a setback to justify the effectiveness of doping prevention programs, which could hinder it from getting more attention and funding from the stakeholders," and a representative from Europe cited the lack of ability to demonstrate impact (Gatterer et al., 2020. p. 235). Thus, organizations responsible for anti-doping education must present a plan pertaining to the anti-doping education measures that they are aiming to implement, and how they intend to assess their effectiveness. A tool to assess the effectiveness of anti-doping education, in terms of a decrease in ADRV, is lacking. Generally, evaluating prevention initiatives is methodologically challenging, especially if the outcome cannot easily be measured—as is the case with ADRVs. However, assuming similar associations between DAL and clean sport behavior, as well as commitment to Anti-Doping rules, it would be worthwhile to develop a tool for measuring associations between anti-doping education and the stages of DAL. Such a tool could be used for longitudinal studies to observe changes and connect them to possible changes in doping prevention strategies (e.g., the introduction of new rules and national legislative approaches, etc.).

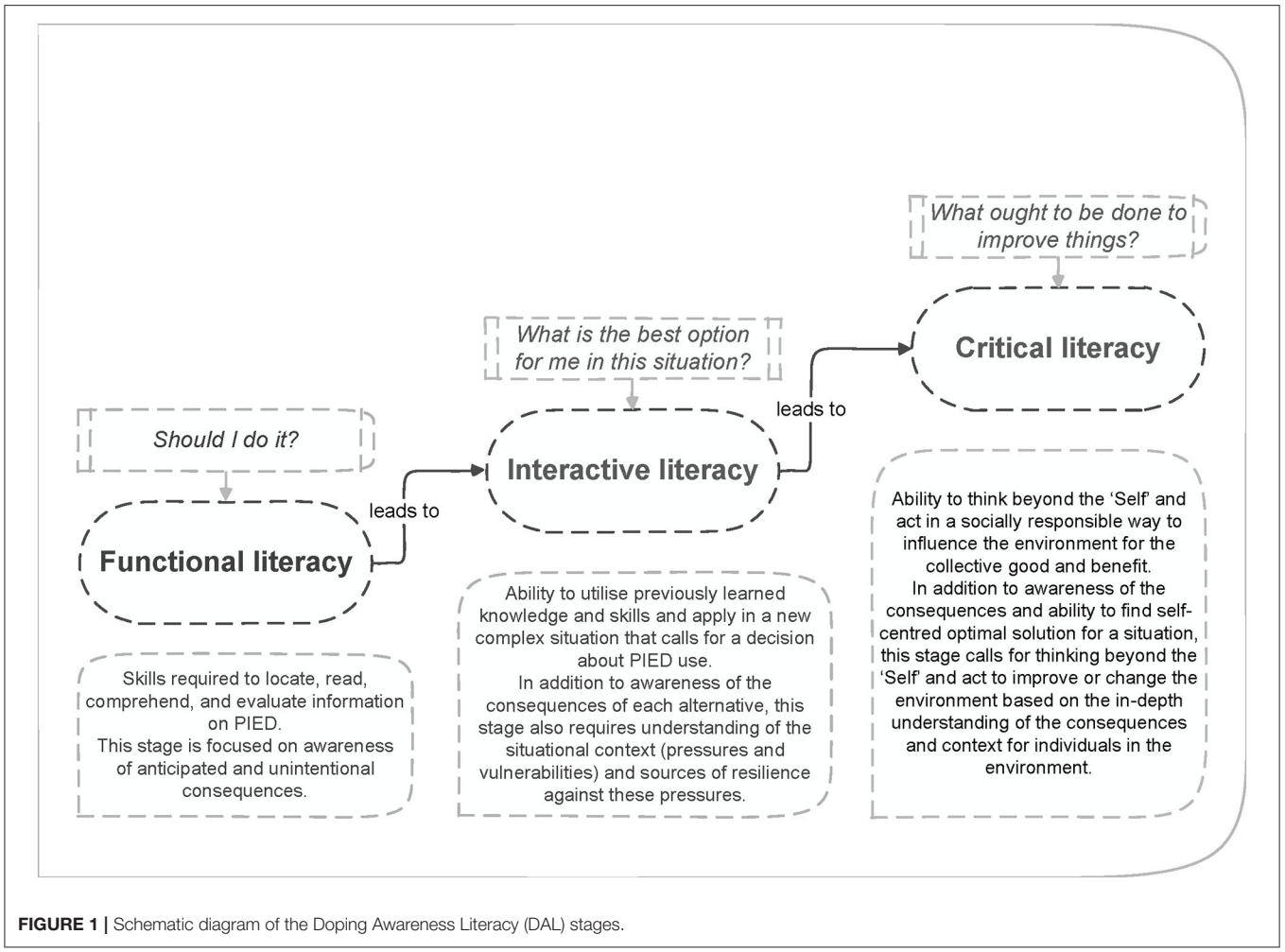

FIGURE 1 | Schematic diagram of the Doping Awareness Literacy (DAL) stages.

Aims

The current study is a part of a larger project funded by the International Olympic Committee (IOC). The project's overall aim is to explore current anti-doping education and its possible effects. Whereas the previous phase of the study focused on the provider (Gatterer et al., 2020) and consumer sides (Gatterer et al., 2021) of anti-doping education, the primary goal of the current study was to develop and test a tool for assessing the expected outcomes of the anti-doping education provided by NADOs and International Federations (IFs) under the ISE. We operationalized these outcomes through the DAL stages of awareness, knowledge, and self-efficacy. We also expected anti-doping education, even though it is not a direct education goal, to influence the perceived legitimacy of anti-doping and perceived trust of the involved organizations. As described in detail below, we approached these aims in a stepwise fashion.

Conceptual Framework for Developing the Evaluation Tool

There are multiple ways to evaluate anti-doping education, each presenting its own challenges (Petróczi et al., 2017). This project is based on existentialist teaching and learning philosophy. Stemming from Lawless' succinct statement that there are "no universal standards for a human life: we are what we do, the sum of our actions" (Lawless, 2005, p. 326), existentialist teaching and learning philosophy promotes learner agency, and aims to empower learners to make their own decisions, as opposed to dictating to them as to what they should and should not do. In this framework, anti-doping rules are a set of conditions that regulate participation in competitive sport, just like the rules of a specific sport. In line with this approach, we view the role of anti-doping education as enhancing athletes' skills and capacity for knowledge and understanding, and to then apply these rules for authentic choices and behavioral conduct. Consequently, effectiveness is not primarily evaluated according to the number of athletes resisting doping, although better awareness and knowledge of the rules is expected to reduce the number of unintentional ADRV. Instead, we propose that the impact of anti-doping education is best captured through situation-specific (social) cognitive mediators of actions (Bandura, 1986, 2001) influencing athletes' choices in the context of sport-related goals, expected outcomes and socio-structural constraints (such as barriers and opportunities associated with

particular sport settings, as well as political, economic, or environmental systems).

Based on a substantial body of evidence from health science on the associations among health literacy, perceived trust and the legitimacy concepts outlined above, we infer that these concepts are also a proxy for making the right decisions in the context of anti-doping. As such, we are especially interested in the question of whether anti-doping education influences athletes' DAL, as well as trust and legitimacy perceptions (Woolway et al., 2020). We hypothesized that anti-doping behavior can be promoted by increasing awareness and literacy. Using the DAL model, **Figure 2** outlines the skills and knowledge we expect to be accrued in each stage of effective anti-doping education.

The aim of anti-doping education is to enable athletes to make informed decisions related to clean sport principles and performance enhancement, and to be able to adhere to anti-doping rules. To make such decisions, athletes need awareness of the problem, and the capability and ability, i.e., the literacy, to make the right decision to address it. It is important that this process starts early, i.e., at the beginning of an athlete's career, as they appear to be more prone to risky behavior and peer pressure during adolescence, when critical thinking develops (Flammer and Alsaker, 2002; Oerter and Dreher, 2008; Steinberg, 2016). This change in perspective does not necessarily equate to a change in current doping prevention initiatives. Even before the implementation of the ISE, information- and values-based education were key pillars of doping prevention, even though a recent study analyzing 53 National Anti-Doping Organizations with respect to their prevention measures revealed that the majority were mostly concerned with information (Gatterer et al., 2020).

The Role of Legitimacy, Trust, and Trustworthiness

Perceived legitimacy of authorities, such that their actions are regarded as proper, just, and appropriate (Tyler, 2006), is considered an important factor in anti-doping rule compliance. Related concepts such as trustworthiness (an attribute of the "object," e.g., WADA as organization can be trusted) and trust (an attribute of the "person," e.g., I, as an athlete, trust WADA) also play an important role in the decision-making process about compliance, and how athletes feel about being compliant (Woolway et al., 2020). Although legitimacy is not the same as trustworthiness, nor perceived legitimacy equates to trust, but they are closely related concepts. Especially in the context of doping, trust in anti-doping organizations cannot be operationally defined without the ingredients of legitimacy. Legitimacy is what organizations are set out to do (that is what should work in principle); trustworthiness is a characteristic of this organization judged on past and present conducts, and trust (by a person) is an anticipation of what organizations will actually do in a specific context. Dreiskämper et al. (2016) trustworthiness scale for anti-doping organizations is based on the three pillars of trust—ability, benevolence, and integrity—that were originally proposed by Mayer et al. (1995)—and showed its importance in anti-doping.

In the context of health science, the positive association between health literacy and compliance was shown to be affected by the level of trust in the health provider (Mancuso, 2010; Naghavi et al., 2019), as well as in the medical establishment (Bender and Bender, 2005). These concepts are expected to be similarly relevant to doping science. In support of this, Shelley et al. (2021) showed that clean athletes could be strong advocates for doping prevention, but only if they trust the current system. In support, Woolway et al. (2020) suggested that a low level of perceived legitimacy of anti-doping rules and organizations might result in a low level of compliance with the anti-doping system and called for research about the role of anti-doping education in perceived legitimacy. Additionally, Petróczi et al. (2021a) concluded that the inequalities and unfairness of the doping control system (an aspect of perceived legitimacy), as perceived by elite athletes, undermine trust in anti-doping and that this issue should be acknowledged and addressed.

Stepwise Approach of the Aims

Phase One

The aim of phase one was to develop an effective assessment tool with high content validity, in collaboration with internationally renowned experts in anti-doping with different research backgrounds. We named this tool GRADE IT, standing for "Generating Research-based Assessment Data to Evidence the ImpacT of anti-doping education;" and included markers/variables that we identified as relevant for promoting clean sport behavior or preventing anti-doping rule violations (linked to the outcomes of current doping prevention initiatives, as identified by desktop research; Gatterer et al., 2020); these variables map onto the DAL stages. The markers are intended to be sufficiently sensitive to detect changes in doping prevention strategies, as well as evidence-based. The research questions for phase one were as follows: (a) how appropriate is the item difficulty (for the knowledge test questions) and is the discriminatory power sufficient? (b) are the markers sensitive to changes? and (c) is anything missing that should be added based on (a) the feedback of the athletes questioned and (b) new developments in doping prevention initiatives? The research project started in 2017, when the development of the ISE was in progress but not yet implemented. Thus, a secondary goal was to refine GRADE IT not only based on the results of the first study, but also on the progress of the ISE.

Phase Two

The aim of phase two was to assess whether anti-doping education makes a difference to the three literacy concepts of Functional, Interactive and Critical Literacy, as well as to the concepts of perceived trust and legitimacy, by surveying athletes using the assessment tool refined on the basis of phase one.

MATERIALS AND METHODS

Participants

Participants were recruited at the Youth Olympic Games (YOG) in Buenos Aires (2018) and European Youth Olympic Festival (EYOF) in Sarajevo (2019) (for phase one), and at the EYOF

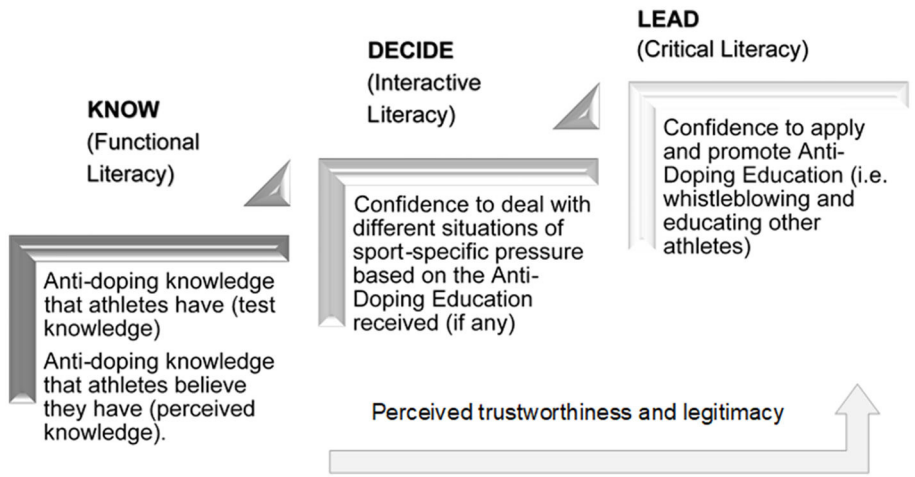

FIGURE 2 | Stages of DAL and associated skills.

Baku (2019) and YOG Lausanne (2020) (for phase two). The athletes completed the questionnaire at the sport events, on tablets or computers, or on their own mobile devices (using a QR code). Participation was anonymous and voluntary. Informed consent was provided by all athletes prior to completing the questionnaire. For more details on participant recruitment, please refer to Gatterer et al. (2021). The study was approved by the ethics board of the first author's university (RCSEQ 2444/18).

Procedure and Data Collection

The procedure of the two phases is detailed in **Figure 3**. Details are also provided as part of the results for phase one, as this phase focused on the development of the tool. The two versions of the tools are attached as **Supplemental Materials 1, 2**; differences between the two versions are highlighted in yellow.

Empirical data were collected by distributing the tool online to the junior elite athletes (accessible *via* tablets and QR codes for their phones). To connect with the athletes, several "gatekeepers" were used [Chef de Mission Seminar, Medical Meeting, Young Ambassadors, and direct contact with the Youth Olympic Villages; for details, refer to Gatterer et al. (2021)]. Athletes also made verbal comments (at random) through the tool, which we recorded as notes. This feedback was not thematically analyzed but considered in the discussions at the expert meetings.

Data Analysis

Data from GRADE IT were analyzed using SPSS software [(version 26); IBM Corp., Armonk, NY, USA]. Data were analyzed descriptively and are presented as frequencies, means and standard deviation. To assess item difficulty (for the knowledge test using a true-false format) and the discriminatory power of the answer options (for Likert scale questions), frequencies (test questions), and mean and standard deviations (Likert scale responses) were computed. To determine whether the markers are sensitive enough to detect changes in doping prevention strategies focusing on anti-doping education, and depending on the heterogeneity of variance, a univariate analysis of variance (ANOVA) or Welch test was used to compare outcome variables among groups of athletes receiving different levels of education. *Post-hoc* tests were applied to significant results (Bonferroni or Tamhane) to determine the groups that were different. The level of significance was set at $p < 0.05$.

RESULTS OF PHASE ONE—TOOL DEVELOPMENT AND TESTING

Step 1: First Expert Meeting

In total, seven internationally renowned experts, mostly senior researchers in their respective fields with 2–20 years (or more) of experience in anti-doping research (for details, refer to **Figure 3**), formed the expert panel. Five of the seven experts participated in the meeting held in Hall in Tyrol in 2017, and two experts, who could not personally attend the meeting, discussed it thereafter. Those five experts (present in Hall in Tyrol in 2017) continued to be involved throughout 2019, and four of these experts (co-authors of this paper) participated in the last expert meeting in 2020 (for details, refer to **Figure 3**). Regarding motives to dope or not dope, the expert panel agreed (based on scientific evidence) that athletes are likely to dope for functional reasons (i.e., coping with specific pressures), whereas motives not to dope are value-based (social, cultural, attitude, and norms; Gatterer et al., 2019). As it cannot be assumed that most athletes dope (especially at the age of 14–19 years), both motives to dope and refrain therefrom should be considered, even though they are not explicitly distinguished within GRADE IT. Given the lack of alignment of the content of anti-doping education with the intended learning outcomes (Woolf, 2020), as supported by Gatterer et al. (2020), and the expert group opinion that the implementation of value-based education is lacking, it seemed unlikely that variables or constructs reflecting values (i.e., attitudes, norms etc.) would be sensitive to changes in DAL, perceived trust or legitimacy, simply because they are not included in current doping education programs. Therefore, we decided to focus on

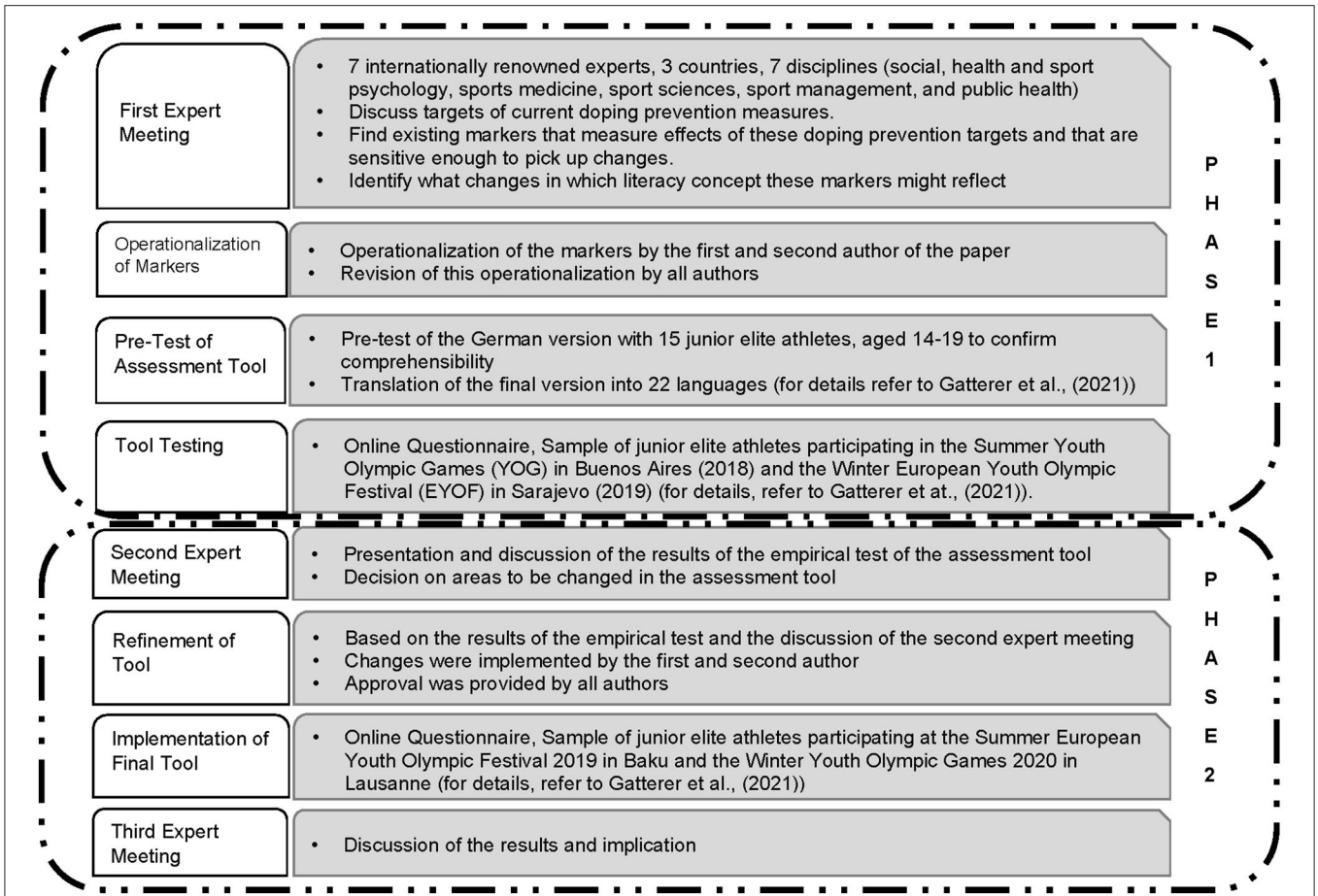

FIGURE 3 | Description of the procedure and data collection for phases one and two.

the components of the ISE aligned to the stages of DAL (refer to **Figure 2**) including knowledge, confidence to deal with pressure and confidence to apply and promote anti-doping education (i.e., whistleblowing and education of other athletes), as these reflect the levels of the DAL, as well as perceived legitimacy and trust (further outlined in **Table 1**). Based on its content, GRADE IT can be considered as an anti-doping education impact evaluation tool.

Step 2—Operationalization of the Markers

The operationalization of the variables was further discussed, and a decision was made that the wording should be simple, and that questions must be specific (i.e., no open-ended questions). In addition to the markers, GRADE IT also captures socio-demographic information and assesses whether athletes have received anti-doping education. Respondents can indicate the content of any education received; for data analysis purposes, three mutually exclusive groups were distinguished based on this variable: "no education," "information," and "comprehensive education"—the latter two groups are based on the classification of Gatterer et al. (2020).

Measures

Socio-demographic Characteristics

The online questionnaire captured socio-demographic information (age, gender, sport, and country), and whether the athletes had experience with anti-doping education. Athletes with anti-doping education had to indicate the content thereof, which was then classified into three groups: no education, information, and comprehensive education [for details, refer to Gatterer et al. (2020)].

DAL—Functional Literacy

Nutbeam (2000), defined functional literacy as "factual knowledge" and based on the DAL concept that translated the concept of health literacy to the doping context (Petróczi et al., 2021b), the stage of Functional Literacy was described with "knowing." Therefore, we operationalized Functional Literacy as objective test knowledge of rules and responsibilities under the WADC as well as the level of perceived factual knowledge for the purpose of this paper. Test knowledge was measured using 10 items pertaining to roles and responsibilities (according to the WADC 2015) and three items on the consequences of a positive doping test. Responses were recorded using a

TABLE 1 | Markers to be included in GRADE IT.

Level of DAL	Marker/variable: content	Measures' status and changes of effects of:
Markers that directly reflect anti-doping literacy		
Functional DAL	Functional DAL includes information on the anti-doping knowledge of athletes, including self-assessed (perceived) knowledge and knowledge based on test questions.	Information-based prevention
Interactive DAL	Interactive Literacy includes questions on how to deal with pressure. Athletes who indicated that they had received education on dealing with pressure were asked about the education received. Those who did not receive any education were asked about their confidence in dealing with sport-specific pressures.	Education prevention strategies based on informed decision-making
Critical DAL	Critical Literacy includes questions pertaining to whether athletes feel confident in applying and promoting doping prevention measures. In detail, athletes were questioned about whistleblowing and the education of other athletes.	Education prevention strategies and anti-doping policies
Markers that might affect compliance with DAL		
Trust in organizations	Might inform Interactive and Critical DAL. Athletes might be more compliant if they consider anti-doping organizations trustworthy. This goes beyond capability, and might influence the actual decisions of an athlete/their willingness to show compliant behavior.	Anti-doping policy
Legitimacy	Might inform Interactive and Critical DAL. Athletes might be more compliant, and feel happier about this, when there is a high level of perceived legitimacy with respect to the rules. This goes beyond capability, and might influence the actual decision of an athlete to show compliant behavior.	Anti-doping policy

"True"/"False"/"Cannot assess" format. Perceived knowledge was indexed by nine items pertaining to how well-informed athletes are about the rules and responsibilities specified in the WADC 2015 (nine items in total). A Likert response scale was used, with the additional option of "Cannot assess" (for the English version of the initial questionnaire, refer to **Supplementary Material 1**).

DAL—Interactive Literacy

The self-efficacy section, designed to represent Interactive Literacy, comprised five items pertaining to various forms of pressure [e.g., "physical limitations (injuries, illness, fatigue, and overtraining")] and how confident they felt in dealing with them without using prohibited substances and/or methods. Athletes who indicated that they had received education were then asked how confident they felt based on that education. The response scale was a Likert scale with the additional option of "Cannot assess" (for the English version of the initial questionnaire, refer to **Supplementary Material 1**).

DAL—Critical Literacy

Based on the DAL concept that translated the concept of health literacy to the doping context (Petróczi et al., 2021b), the stage of Critical Literacy was described with "leading" and includes the "ability to think beyond the self" to "influence the environment." Therefore, we operationalized Critical Literacy as the perceived confidence to act and influence the direct environment in a positive way with respect to anti-doping. Critical Literacy was indexed by two items with a "True"/"False"-format pertaining to whether athletes felt confident about educating other athletes and reporting doped athletes, based on the education that they had received (for the English version of the initial questionnaire, refer to **Supplementary Material 1**).

Perceptions of Anti-doping Legitimacy and Trust

Anti-doping legitimacy was assessed by three statements covering normative (anti-doping is important because it protects clean sport, which is worth protecting) and procedural (fair process and fair outcome) legitimacy (Woolway et al., 2020). The perceived trust of different organizations was assessed using three statements pertaining to ability, benevolence and integrity, as important factors in perceived trust (Mayer et al., 1995) also applied by Dreiskämper et al. (2016) in the context of anti-doping. In this study, ability was operationalized as trust in the capability of an organization to fulfill its designated role; benevolence referred to the concern of the organization for its members and integrity (keeping of promises). A Likert response scale with the additional option of "Cannot assess" was used again (for the English version of the initial questionnaire, refer to **Supplementary Material 1**).

Since the athletes' ranged in age from 14 to 19 years, the final wording of the questions was discussed with an expert in developmental psychology, to ensure age-appropriateness. The initial GRADE IT is included in the **Supplementary Material 1**.

Steps 3 and 4: GRADE IT (Pre-) Testing

Description of Sample and Level of Education Received

Prior to implementation, the survey was pilot-tested on 25 Austrian junior professional athletes aged 14–19 years, which did not result in any additional changes to GRADE IT. Following the pilot testing, in phase one, 968 athletes fully completed the survey (19.8% of all athletes attending the events) and were thus included in the data analyses. The socio-demographic characteristics are shown in detail in **Table 2**.

Of the 968 elite youth athletes, 28.9% had never received anti-doping education, 32.4% received information, and 38.4% received comprehensive education; 0.2% did not provide an answer. Based on the country classification of Gatterer et al. (2021), 44% of the athletes ($n = 426$) originated from countries whose NADOs provided information only, and 41.4% ($n = 401$) were from countries whose NADOs provided comprehensive education. For 14.6% ($n = 141$) of the athletes, the country data were missing. Of the 426 athletes from countries whose NADOs technically provide information only [as defined by Gatterer et al. (2020)], 37.3% ($n = 158$) indicated that they had never received any information, while 31.6% ($n = 134$) indicated that they

TABLE 2 | Socio-demographic characteristics of the study cohort—phase one.

	n	%	
Event			
Buenos Aires (Summer YOG)	468	48.3	
Sarajevo (Winter EYOF)	500	51.7	
Origin			
Europe	648	68.1	
Asia	80	8.4	
North America	30	3.1	
South America	101	10.4	
Africa	63	6.5	
Oceania	30	3.1	
Gender			
Female	477	49.3	
Male	435	44.9	
Sport			
Individual	670	69.2	
Team	215	22.2	
Member of RTP	253	26.1	
Gender			
Male	435	44.9	
Female	477	49.3	
	Mean	**SD**	**Min-Max**
Age (y)	16.62	0.93	14–18

% values do not all sum to 100% due to missing data.
YOG, Youth Olympic Games; EYOV, European Youth Olympic Festival; RTP, Registered Testing Pool.

had received more than information only, i.e., comprehensive education (e.g., role plays). Of the 401 elite youth athletes from countries whose NADOs technically provide comprehensive education [as defined by Gatterer et al. (2021)], 20% ($n = 80$) indicated that they had never received any education and 27.7% ($n = 115$) indicated that they had only received information. Chi square analysis revealed significant incongruence, i.e., participants from countries providing comprehensive education also reported receiving information only, and no education. Also, some participants from countries providing information only reported receiving no education, but also comprehensive education (for details, refer to **Figure 4**).

Discriminatory Power of Items and Item Difficulty

Descriptive statistics for each individual item for Functional and Interactive Literacies, as well as for perceived trust and legitimacy, are displayed in **Supplementary Tables 3, 4**. To allow for comparison, the scores for test knowledge were transformed to scores between 0 (no correct answers) and 1 (all answers correct).

With respect to Critical Literacy, only athletes who received anti-doping education could answer the questions ($n = 689$). Item one, pertaining to whether they felt confident to educate other athletes based on their own education, was answered by 534 athletes, 12.2% ($n = 65$) of whom did not feel confident. Regarding item two, pertaining to whether they felt confident to report doping athletes (whistle blow) ($n = 460$), 15.2% ($n = 70$) of the respondents did not feel confident. There was no difference on the scores for these items according to whether the athletes received information only or education (Chi square = 0.24, $p = 0.62$ and Chi square = 2.0, $p = 0.16$, respectively).

Marker Sensitivity to Detect Changes in DAL, Perceived Legitimacy, and Trust Based on the Doping Education Received

Details on the statistics are displayed in **Supplementary Tables 3, 4**. We found significant differences in almost all markers with respect to the level of anti-doping education received. In detail, the more anti-doping education that athletes received, the higher the levels of Functional and Interactive Literacy. There was no significant difference in Functional Literacy between the information and comprehensive education groups. However, compared to the no education group, the information only group exhibited significantly improved test performance. This also applied to all items for the Interactive Literacy stage. Likewise, the perceived legitimacy and trust increased with the level of knowledge, except for the item pertaining to rules being implemented globally and equally, the mean value of which was the lowest among all three legitimacy items. Scores for this item did not differ by education level. The IOC was the only federation for which education did not impact perceived trust on all items (i.e., member concerns and keeping promises). For all other items, education increased perceived trust, with comprehensive education being associated with the highest values.

RESULTS OF PHASE TWO

Step 1: Results of the Second Expert Meeting—Phase One Discussion

The aim of phase one was to develop an effective assessment tool with high content validity, in collaboration with internationally renowned experts in anti-doping, to fulfill the overall aim of the research project. In this phase, the focus was on the discriminatory power of the items, sensitivity of the markers to detect differences in doping prevention strategies, and determination of whether anything should be added to GRADE IT based on the feedback of the athletes and developments in doping prevention initiatives.

Based on the first expert meeting, four markers were included (distributed among the three levels of Functional, Interactive and Critical Literacy) based on their potential to denote code-compliant behavior: perceived knowledge, test knowledge (Functional Literacy), confidence in dealing with pressure (Interactive Literacy) and the confidence to whistle blow (Critical Literacy). The latter marker used a "True"/"False" format, so the results are not presented in **Supplementary Tables 3, 4**, but rather in the text. Two markers of legitimacy and trust were also included, as they were considered relevant to anti-doping education (Shelley et al., 2021) as well as compliance with anti-doping rules (Woolway et al., 2020). They might exert indirect effects on the final decision to be code-compliant, although this is speculative and was not tested as part of this research. Most

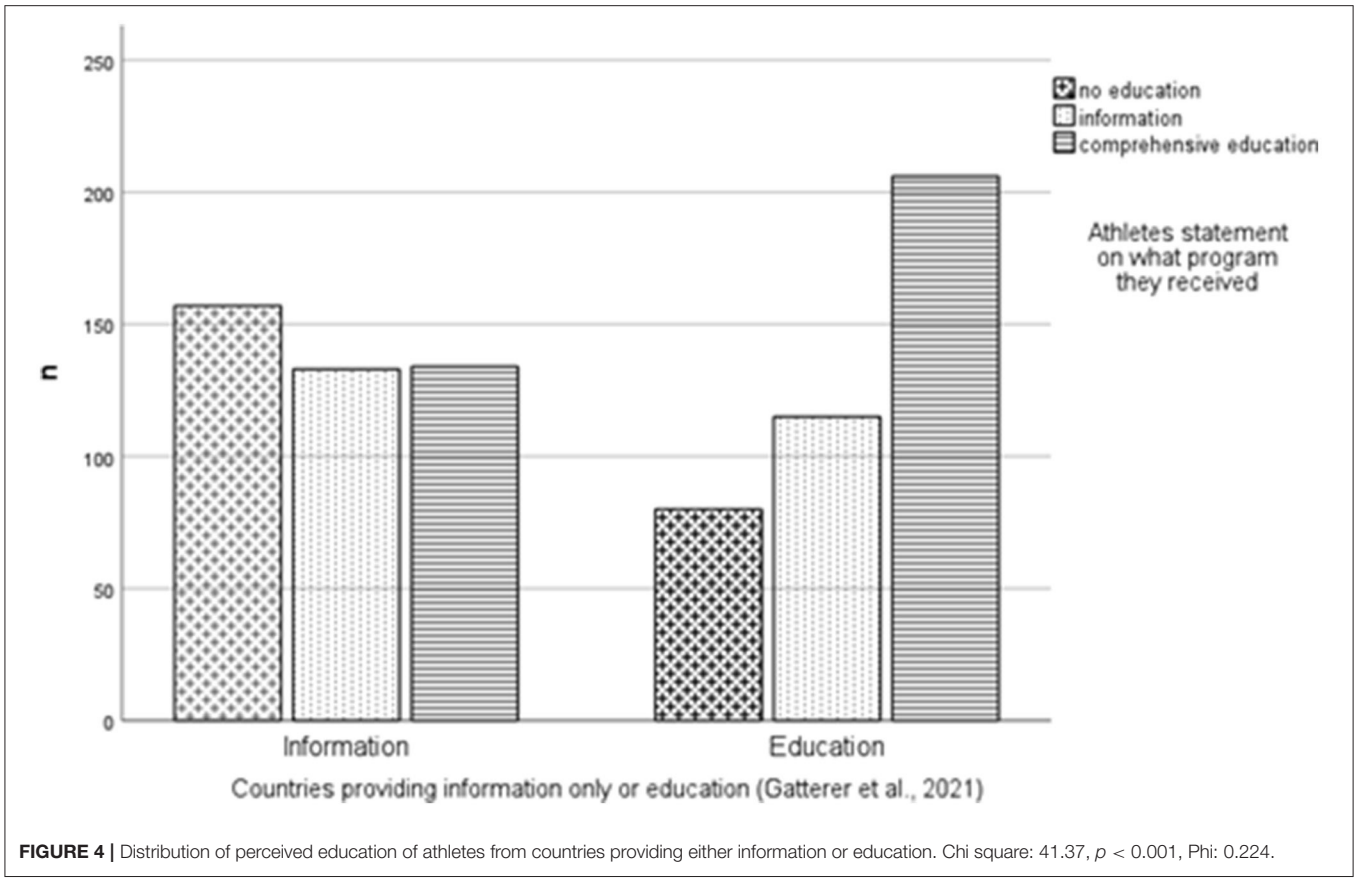

FIGURE 4 | Distribution of perceived education of athletes from countries providing either information or education. Chi square: 41.37, $p < 0.001$, Phi: 0.224.

of the items had satisfactory discriminatory power; only the item pertaining to confidence of being successful in one's chosen sport without doping had low discriminatory power, reflected in the generally high scores and low standard deviation. Thus, it can be inferred that all athletes were confident of success in their sport. As this item did not provide any additional information, it was omitted from GRADE IT.

Almost all of the included variables demonstrated the ability to detect differences according to anti-doping education; the answers differed significantly according to that variable, except for the two Critical Literacy items (asking athletes whether they felt confident in educating other athletes or reporting a doped athlete). One reason for this could be that the "no education" group was not analyzed (because this group did not receive the question), and the items were not sensitive enough to detect differences between athletes who received information only compared to those receiving comprehensive education. Another reason could be that the answer scale did not allow for nuanced answers.

In the discussion with the experts, we focused especially on the incongruence between athletes who reported receiving anti-doping education (either comprehensive education or information) despite residing in a country that does not provide any such education, as established by Gatterer et al. (2020). This positive incongruence [that is athletes who reported to have received comprehensive education or information but come from a country that does not provide any education or only information seems easy to explain as the study of Gatterer et al. (2020)] could be explained by such athletes receiving information or education from other sources, such as their federation, school, or club, where Gatterer et al. (2020) recorded only the prevention initiatives of NADOs. It is more challenging to explain why some athletes from countries offering information or comprehensive education indicated that they had not received such education, or only information (negative incongruence).

Step 2: Refining GRADE IT

Based on the discussions during the second expert meeting, four areas requiring changes were identified. First, we changed the wording for some questions based on the athletes' feedback and discussions with the experts during the second meeting. Additionally, we changed and added some items to improve specificity, as we felt that some items addressed two aspects concurrently. For example, we changed the initial wording of "After a positive doping test…" to "After being caught doping…," because the correct answer here could also be to open the B-sample. Furthermore, for items pertaining to perceived trust, we replaced "judiciary" with "legal system," as we suspected that not all athletes fully understood the meaning of the former word. Additionally, we changed "their members" (referring to federations) to "their people/athletes" to enhance precision (all changes are listed in **Supplementary Table 2**).

Second, the operationalization of Critical Literacy was evaluated. In alignment with the other two levels of DAL,

we expected to see a difference in Critical Literacy between athletes with no education and those who have received education. However, this item was only presented to athletes who indicated that they had received education. Thus, the item was transformed into a filter question and also presented to athletes who had not received any education. Additionally, the answer scale was changed to a Likert format for consistency, and the items were revised to be more specific and cover a broader spectrum of Critical Literacy. In detail, we changed one item to "…know how to take action (reporting doping, whistleblowing)" and also added the item "… would report a doped teammate."

Third, the issue of incongruence between the education reportedly received by the athletes and that actually provided by the NADOs warranted attention. We decided not to change GRADE IT in this regard, but rather to add an additional aim to phase two of the study. In detail, we aimed to determine whether athletes' levels of DAL, trust and legitimacy differed according to educational incongruence. The limitation of the classification of Gatterer et al. (2020), i.e., the inclusion only of anti-doping education provided by NADOs, is further discussed in the limitations section.

Fourth, we realized that we neglected to include the respective NADOs within the perceived trust questions, and therefore added them.

Step 3 Implementation of the Final Tool

Sample Description and Level of Education Received

In phase two, 1,255 athletes (27.4% of all athletes attending the events) fully completed the survey and were included in the data analyses; their socio-demographic characteristics are described in **Table 3**.

Of the 1,255 elite youth athletes, 25.1% had never received anti-doping education, 19.8% received information and 54.3% received comprehensive education; 0.8% did not provide an answer. Based on the country classification of Gatterer et al. (2021), 47.4% of the athletes ($n = 595$) originated from countries whose NADOs provided information only, and 51.3% ($n = 644$) were from countries whose NADOs provided comprehensive education. For 1.3% of the respondents ($n = 16$), the country was not analyzed due to missing data. Of the 595 athletes from countries whose NADOs technically provide information only [as defined by Gatterer et al. (2020)], three were not included in further analysis because of missing data. Of the remaining 592 respondents, 37.3% ($n = 221$) indicated that they had never received education and 46.3% ($n = 274$) indicated that they had received comprehensive education (i.e., including role plays, for example). Of the 644 athletes from countries whose NADOs technically provide comprehensive education [as defined by Gatterer et al. (2020)], six were excluded from further analysis due to missing data. Of the remaining 638 respondents, 13.6% ($n = 87$) indicated that they had never received education and 23.2% ($n = 148$) reported only receiving information. Chi square analysis revealed significant educational incongruence (see **Figure 5**).

TABLE 3 | Socio-demographic characteristics of the study cohort—phase two.

	n	%	
Event			
Baku (Summer EYOF)	695	55.4	
Lausanne (Winter YOG)	560	44.6	
Origin			
Europe	1.094	87.6	
Asia	83	6.2	
North America	37	3.0	
South America	13	1.0	
Oceania and Africa	23	1.8	
Gender			
Female	624	49.6	
Male	523	41.7	
Sport			
Individual	893	71.2	
Team	215	17.1	
Member of RTP	272	21.7	
Gender			
Male	523	41.7	
Female	623	49.6	
	Mean	**SD**	**Min-Max**
Age	15.98	0.97	14-18

% values do not all sum to 100% due to missing data.
Due to low participant numbers, Oceania and Africa were combined to ensure data protection; YOG, Youth Olympic Games; EYOV, European Youth Olympic Festival; RTP, Registered Testing Pool.

Impacts of Anti-doping Education on DAL, Perceived Trust, and Legitimacy

All items and scales, including the modified and newly added ones, showed similarly high discriminatory power and similar difficulty (for details, refer to **Supplementary Tables 5, 6**). We could even validate the Functional Literacy scale as there was an association between the level of perceived knowledge and "don't know answers" of the test knowledge questions. In detail, as expected, athletes who answered don't know had a significantly lower level of perceived knowledge compared to those who correctly or incorrectly answered in all items expect three (for these three, it was only significantly lower compared to athletes who gave the correct answer). Therefore, we decided to further analyze the data to determine whether we can find support for our expectation that anti-doping education impacts on DAL and, even if not a direct education goal, influences the perceived legitimacy of anti-doping and perceived trust of organizations.

As expected, the developed tool was sufficiently sensitive to detect differences in all DAL stages, as well as perceived anti-doping legitimacy and trust. Athletes with a comprehensive education had the highest scores for Functional, Interactive and Critical Literacy, as well as perceived trust and anti-doping legitimacy. The only exception was the "fair process" component of procedural legitimacy, for which the scores were uniformly low (compared to the other components of legitimacy) regardless of education level. Also, for parts of Functional Literacy, the

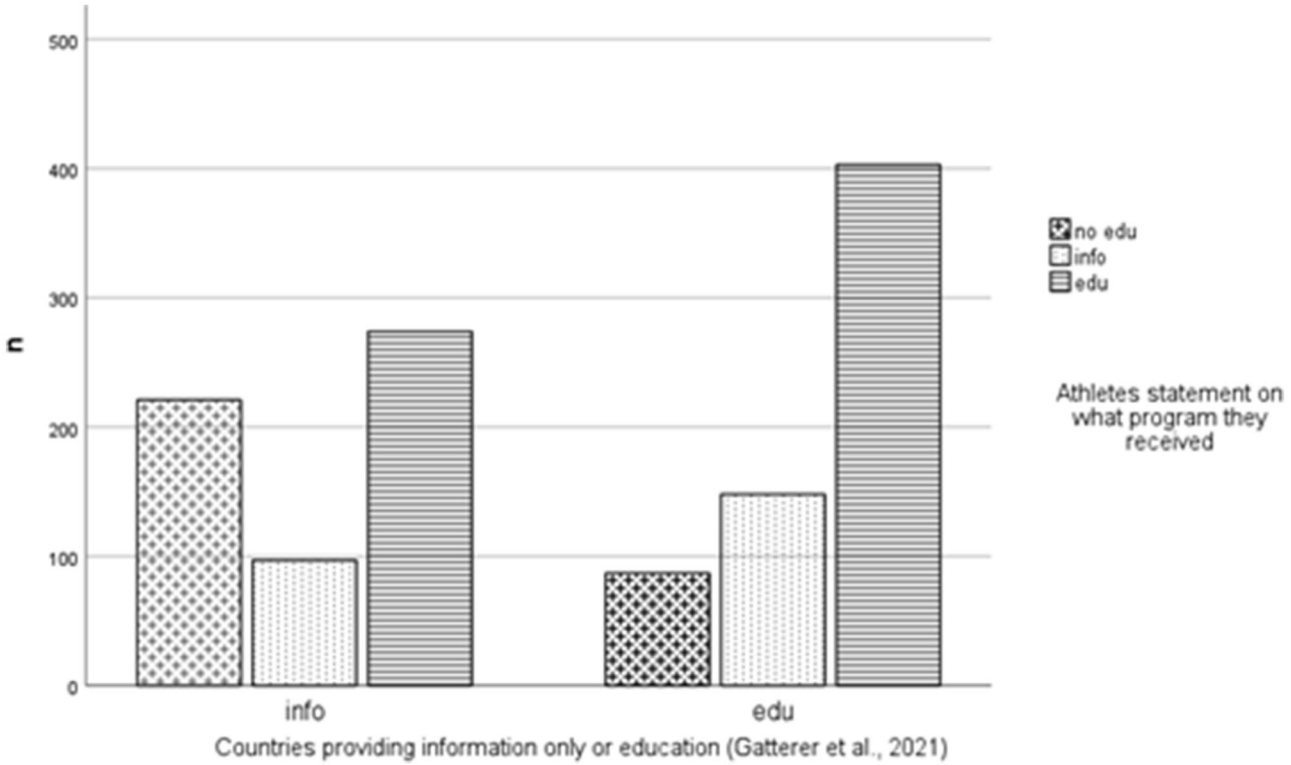

FIGURE 5 | Distribution of perceived education of athletes from countries providing either information or education. Chi square 91.90, $p < 0.001$, Phi = 0.273.

provision of information made a difference (relative to no education). With respect to Interactive and Critical Literacy, information alone does not seem to be sufficient, as the scores did not differ significantly for those athletes compared to the no education group. For details, refer to **Figures 6**, **7** and **Supplementary Tables 5, 6**.

Impact of Educational Incongruence

As indicated above, an additional ("*post-hoc*") research question arose from the discussion that took place after phase one, pertaining to the educational incongruence defined previously. For these analyses, only athletes from countries whose NADO provided any kind of education (n = 1,239), as defined by Gatterer et al. (2020), were included, as we did not have sufficient information for the remaining countries. Both positive and negative incongruence had significant effects on DAL. In detail, all DAL stage scores were highest if athletes receiving comprehensive education, and in most cases, information improved the scores compared to no education. However, the highest scores for perceived knowledge (Functional Literacy), some aspects of Interactive Literacy (i.e., confident in the role of elite athlete, and in dealing with career/life changing events and physical limitations), and Critical Literacy were achieved by athletes with congruence in terms of the reported and actually received education; athletes who received comprehensive education from countries who were classified as providing it scored highest. The results are graphically displayed in **Supplementary Figures 1, 2**, and detailed statistical information is provided in **Supplementary Tables 7, 8**.

PHASE TWO DISCUSSION

The aim of phase two was to use the assessment tool refined in phase one to determine whether anti-doping education makes a difference to Functional, Interactive and Critical Literacy, as well as to perceived trust and legitimacy. Additionally, the impact of educational incongruence was further analyzed. In sum, the extent of education received (no education, information only, comprehensive education) had an impact on almost all markers assessed; as expected, athletes who received comprehensive education scored highest for all markers. In line, a recent systematic review on doping prevention measures targeting young age groups also concluded that programs that actively engage participants are considered to be better than lecture-based knowledge transfer (Pöppel, 2021). Regarding the DAL components, educational incongruence seemed to have a negative effect, especially for Critical Literacy. Even though the ISE (World Anti-Doping Agency, 2021b) was not in effect when this study was planned and implemented, the results fit well with most parts of the ISE, as we outline below.

Impact of Education on the Doping Awareness Literacy Stages

Information-only approaches had a significant effect on Functional Literacy and one aspect of Critical Literacy. However,

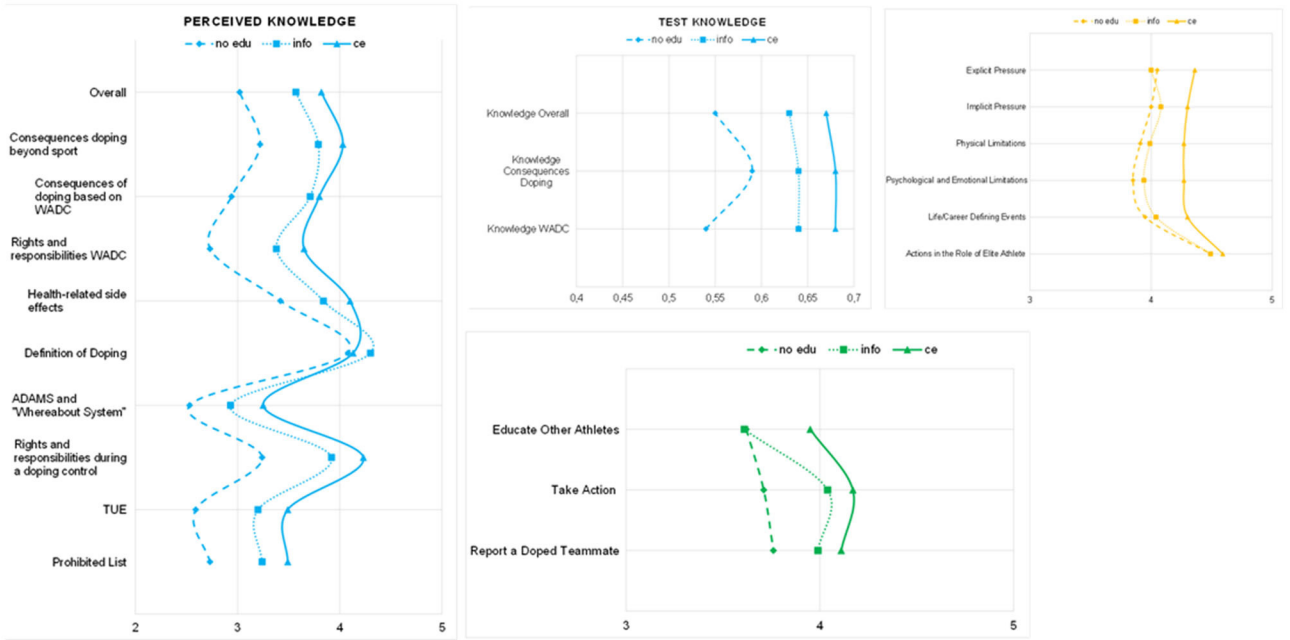

FIGURE 6 | The DAL stages. Functional Literacy: blue; Minimum–Maximum Perceived Knowledge: 1–5; Minimum–Maximum Test Knowledge: 0–1 →figures are scaled to provide more detailed information; PK, perceived knowledge; WADC, World Anti-Doping Code; TUE, Therapeutic Use Exemption; ce, comprehensive education. All changes were significant. For details on *p*-values and *post-hoc* tests, refer to **Supplementary Table 5**. Interactive Literacy: orange; Minimum–Maximum: 1–5; →figure is scaled to provide more detailed information; ce, comprehensive education. All changes were significant except for "Actions in role as an elite athlete." For details on *p*-values and *post-hoc* tests, refer to **Supplementary Table 5**. Critical Literacy: green; Minimum–Maximum: 1–5; →figure is scaled for more detailed information; ce, comprehensive education. All changes were significant. For details on *p*-values and *post-hoc* tests, refer to **Supplementary Table 5**.

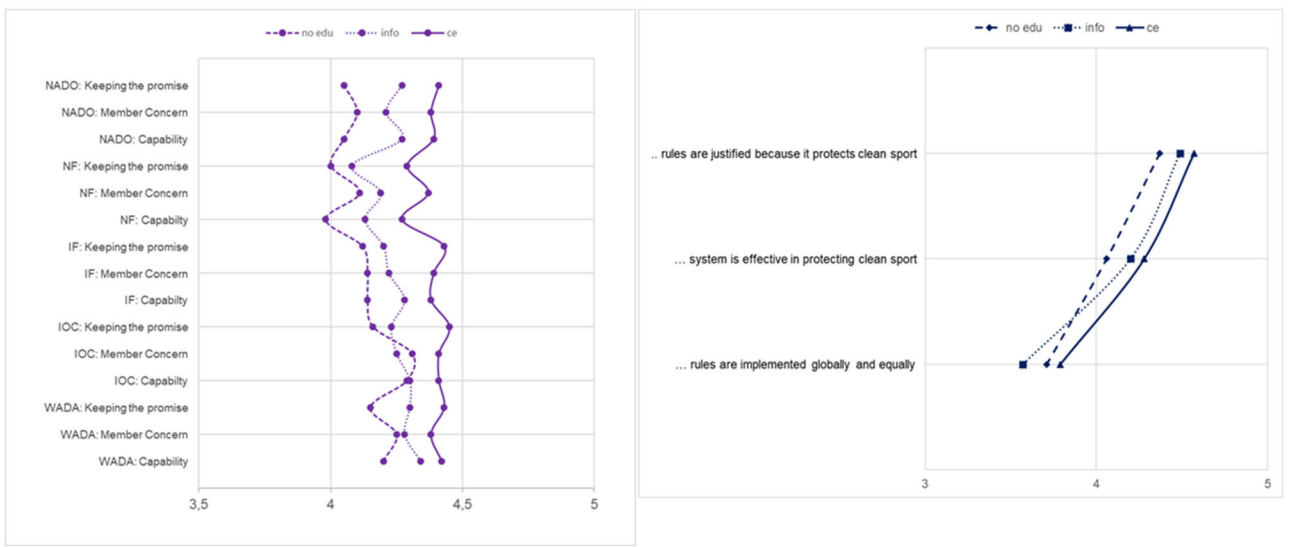

FIGURE 7 | Differences in perceived trust and legitimacy according to the level of education received. Trust: Minimum–Maximum: 1–5; →figure is scaled to provide more detailed information; ce, comprehensive education. All changes were significant, except for "WADA: member concern" and "IOC: capability." For details on *p*-values and *post-hoc* tests, refer to **Supplementary Table 5**. Legitimacy: Minimum–Maximum: 1–5; →figure is scaled to provide more detailed information; ce, comprehensive education. All changes were significant, except for "rules are implemented equally and globally." For details on *p*-values and *post-hoc* tests, refer to **Supplementary Table 5**. NADO, National Anti-Doping Organization; NF, National Sport Federation; IF, International Sport Federation; IOC, The International Olympic Committee; WADA, World Anti-Doping Agency.

according to our results, comprehensive education was crucial for both Interactive Literacy and Critical Literacy.

Elements of Functional Literacy included perceived and actual (test) knowledge about anti-doping rules, and athletes' roles and responsibilities under the WADC. These elements can be classified according to the ISE's two components of awareness-raising and information provision (World Anti-Doping Agency, 2021b), and represent information according to the classification of Gatterer et al. (2020). As expected, the scores on all items pertaining to these variables were significantly higher for athletes who received information at least. Interestingly, the level of perceived knowledge even showed a significant difference between the group of athletes who received information only and those who received comprehensive education. Whereas the test knowledge increase associated with information provision was not further increased by comprehensive education, perceived knowledge can be further increased with comprehensive education. In the context of DAL, perceived knowledge might be associated with Interactive Literacy, as this refers to the ability to apply knowledge. It could be hypothesized that the level of perceived knowledge of the athlete is more closely associated with acting on such knowledge compared to test knowledge. In line with this idea, comprehensive education was more important for Interactive Literacy and Critical Literacy. Overall, the results suggest that information-based prevention is sufficient to ensure a high level of Functional Literacy, which is an important component of DAL. In this context, the fact that most global anti-doping organizations offer information-based education is advantageous (Gatterer et al., 2020). However, as stated in the Introduction section, Functional Literacy alone is not sufficient to increase self-efficacy with respect to making informed decisions about doping.

The second important concept, of Interactive Literacy, refers to the ability to apply learned knowledge and skills in complex situations, to make the right decision with respect to PIED use. This stage also demands understanding of the situational context and sources of resilience (Petróczi et al., 2021b). Interactive Literacy can be related to the anti-doping education of the ISE, which is intended to empower athletes to make informed decisions regarding clean sport (World Anti-Doping Agency, 2021b). Interactive Literacy can be operationalized as the confidence to deal with pressure based on the education received (if any). The results show that information-only approaches (aligned to the ISE components of information provision and awareness-raising; World Anti-Doping Agency, 2021b) do not affect the level of Interactive Literacy, but only the provision of comprehensive education (aligned to the ISE components of value-based education and anti-doping education; World Anti-Doping Agency, 2021b) seems to have an effect. As with Functional Literacy, the athletes who received comprehensive education displayed the highest scores for Interactive Literacy. This points to the first gap that needs to be addressed by all organizations entrusted with anti-doping education, where research has shown that comprehensive education is provided by relatively few international ADOs (Gatterer et al., 2020), even though it seems crucial to ensure a high level of Interactive Literacy, which in turn leads to Critical Literacy.

Regarding Critical Literacy, defined as the ability to think beyond the "self" (Petróczi et al., 2021b), the results are more diverse. Information-only approaches do not seem to increase the confidence of athletes to educate others about anti-doping, but appear sufficient for increasing athletes' confidence to report on doping (whistle-blowing). The confidence to whistle blow is further increased by comprehensive education. The outcomes of Critical Literacy can be assigned to the values-based component of the ISE (World Anti-Doping Agency, 2021b); similar to anti-doping education, it has not yet been implemented widely in doping prevention measures (Gatterer et al., 2020). Critical Literacy is especially important, as we expect it to be critical not only for making the right decision in the context of doping itself, but also in terms of being an ambassador for a clean sport identity, which has been shown to be a strong protective factor against doping (Petróczi et al., 2021b).

Finally, we would like to further discuss the point made in the Introduction that doping prevention should be rephrased to anti-doping education. The mean scores for all of the literacy stages were above the midpoint of the scale (i.e., > 3.5 on a Likert scale), even for athletes who did not receive any education, which might be by chance due to the True/False format of the tool. Yet, it might be argued that the role of education is not to "prevent" something, as the athletes showed high levels of literacy from the outset, but rather to augment the "good" that is already there. This is in line with the belief that most athletes want to compete in a clean sport environment, show clean sport behavior and comply with anti-doping rules. This supports the new perspective of focusing on why athletes do not dope, and strengthening protective factors that help them making the right choices. It must be noted that the study cohort comprised adolescent elite athletes (aged between 14 and 19 years), where scores might be affected by the age and experience of the athletes. As outlined in the Introduction, doping can be understood as a coping strategy (Petróczi and Aidman, 2008) for dealing with multiple risks arising from the interaction between the environment and the individual (Petróczi, 2013; Petróczi et al., 2017). In this respect, age is important because perceived risks change with age. Likewise, given that elite sport is an exceptional and sometimes risky environment, in which drug use behavior is influenced by specific social and cultural factors and their complex interactions and interdependencies (at different levels in the sport figuration), athletes' reactions (and pressures) may change when facing new working conditions, for example (Overbye, 2018). Thus, it seems likely that perceptions of risks and pressures may change with age over the course of a sporting career. While it seems likely that functional literacy would have even higher scores among adult athletes who regularly receive anti-doping information and education, further research is needed to assess whether scores for interactional literacy are affected by age based on the arguments delineated above. Even though our tool was developed with youth athletes, we are confident in its applicability to samples of older athletes.

Impact of Education on Trust and Legitimacy

The overall trust scores (combined scores for the items on capability to fulfill the role, taking care of members and keeping

promises) were between 3 and 4 on the Likert scale, and clearly showed that only comprehensive education significantly increases the level of trust of federations (IOC, WADA, NADO, International and National Federation), as perceived by athletes. If trust plays a role in literacy and compliance in anti-doping (Dreiskämper et al., 2016) as important as that which it plays in health science, there is a need for comprehensive anti-doping education. Similar results (and conclusions) were found for legitimacy; however, this concept needs to be discussed in more detail. As defined by Tyler (2006), perceived legitimacy requires that a system operate in a proper, just, and appropriate manner. Following Woolway et al. (2020), the current research distinguished normative legitimacy from two types of procedural legitimacy (fair outcome and fair process), as outlined in the methods section and used in other studies [e.g., a qualitative study by Qvarfordt et al. (2021); for details, refer to the **Supplementary Material 2**].

Athletes who received comprehensive education scored significantly higher on normative legitimacy (system perceived to be appropriate) components, and on one component of procedural legitimacy (system being perceived to be proper), compared to those only receiving information-based education or no education. These findings are especially important in terms of the concept of appropriateness, as there is evidence that the effectiveness of the system is still considered weak (Woolway et al., 2020). Athletes around the world agreed that anti-doping organizations are doing the right things (i.e., proper) but not always in the right way (i.e., [in]appropriate), which is highly relevant to compliance with the system according to the athletes themselves. Woolway et al. (2020) suggested that promoting the results of anti-doping authorities might improve perceived appropriateness. The findings of the current study highlight the importance of comprehensive education (including value-based education), because information-based education does not appear to significantly improve perceptions of the system as proper or appropriate compared to no education.

The second component of procedural legitimacy (perceiving the system as just), however, was not affected by the kind of education received. Scores were lowest for this component, and were not significantly different among the groups of athletes who received no education, information, or comprehensive education. The lower scores on this component compared to the other two were expected, given that previous research showed that most elite athletes have low trust in the equal implementation of doping controls globally (Bourdon et al., 2014; Overbye and Wagner, 2014; Efverström et al., 2016; Overbye, 2016). However, the average score (i.e., >3.5 on a Likert scale) cannot be considered low. It seems likely that the relatively high levels of trust in our cohort might be related to their young age; samples with older and more experienced elite athletes may have lower scores (i.e., higher levels of distrust regarding equal and fair implementation of anti-doping measures globally). For example, studies showed that trust in specific parts of the anti-doping system were higher among younger athletes, but decreased with age (Overbye, 2016). Moreover, athletes with personal experience of specific anti-doping measures/procedures showed lower trust in their functioning (Overbye and Wagner, 2013, 2014). Athletes' trust may change during their sporting career; in particular, negative experiences (e.g., of system errors) can lead to distrust in the anti-doping system (Overbye, 2016). Also, the review of Woolway et al. (2020) outlines how athletes generally support anti-doping measures because they agree that they are necessary. However, even though included athletes in the study of Woolway et al. (2020) articulated high levels of trust in their own anti-doping system, they also expressed concerns about the global fairness of the process and its outcomes. Linked to the experience of athletes, Woolway et al. (2020) showed that athletes only appreciate the issue of global fairness once they start competing internationally and thus accrue first-hand experience with how anti-doping rules are followed in countries other than their own. Woolway et al. (2020) suggest that low trust in the implementation of anti-doping measures might also arise due to a lack of knowledge about the anti-doping activities of different organizations and countries. Information about anti-doping activities is not part of most education-based prevention measures (Gatterer et al., 2020), which might help to explain why the scores for the just concept (perceived procedural legitimacy) did not differ by education level in this study. Importantly, knowledge about the implementation of anti-doping activities should correspond to reality (i.e., what is actually offered), which underscores the importance of improving compliance with and implementation of doping rules across the world. Studies illustrating that unequal or inappropriate implementation can also undermine non-doping athletes' trust in anti-doping further support this (Overbye, 2016; Shelley et al., 2021). The latter (as mentioned earlier) may ultimately be associated with rule compliance and acting on the DAL (Woolway et al., 2020). We hypothesize that DAL with high levels of perceived trust and legitimacy would not only improve athletes' ability to make informed decisions, but also to *want* to make them, as they would perceive the anti-doping system as legitimate, and the organizations entrusted with it as trustworthy.

Impact of Educational Incongruence on Doping Awareness Literacy Stages, Perceived Trust, and Legitimacy

The results of both phase one and two indicated significant incongruence between what athletes should have received in terms of anti-doping education and what they in fact received. On the one hand, there were athletes who indicated receiving comprehensive education even though they resided in countries in which NADOs only offered information-based education, according to Gatterer et al. (2020). An explanation for this positive incongruence may simply be that the athletes received education from other providers, as already discussed in phase one. However, the study also identified negative incongruence: athletes not receiving education despite residing in countries whose NADOs provide it. This latter finding merits attention [see also Gatterer et al. (2021)], especially because the results of phase two clearly illustrate that comprehensive education had significant effects on DAL. As discussed above, scores for all DAL stages were highest among athletes who received comprehensive education, but information-based education also improved

scores compared to no education. Regarding translation of this finding into practice, it might not matter what kind of education the responsible organizations provide to their athletes (with comprehensive education leading to high DAL, trust, and legitimacy) but, regarding DAL, whether the athletes are aware that they received this education is important. None of these points were applicable to the concepts of trust and legitimacy.

LIMITATIONS AND FUTURE RESEARCH

This research was not free of limitations. The first set of limitation addresses the tool itself, whereas the second set addresses more generic limitations. Even though the development of the survey followed a strict and systematic approach, final items were chosen based on consensus of the research group. Bias based on wording and/or the fact of including some and not including other items that as well might have reflected the latent construct cannot be fully excluded but were mitigated against by striving for consensus in the research group and experts. Furthermore, the knowledge questions used to supplement the perceived and test knowledge that underpons Functional Literacy covered knowledge about the strict liability principle, rights and responsibilities during doping controls, possible ADRVs and the whereabout system. These questions were thus driven by anti-doping rule violation (as it was the time with the 2015 Code) and did not cover all possible knowledge areas, as for example knowledge of the prohibited list. We decided to opt for a more generic knowledge that is applicable to all athletes. Because drug specific knowledge is sport specific, no athlete (or athlete support personnel for that matter) can reasonably be expected to know about all drug classes in the Prohibited List. Even though we believe that the items chosen reflect Functional Literacy and we could show that education impacted this specific knowledge, GRADE-IT could and should be validated with a different set of knowledge questions. Further facilitating this is the need that the current set of knowledge questions must be updated for the World Anti-Doping Code that came into effect in 2021, because ADRVs and athletes' roles and responsibilities changed. Another limitation that is worth noting is the stem of the questions in regard to perceived knowledge. One could argue that "how well you know" and "how well do you feel informed about" are not the same as one could feel well informed (the information is out there or has been provided, or they have access) but one is not particularly knowledgeable. Thus, this question might be formulated too imprecise and future research using the tool might want to consider changing the wording. To be consistent with the literacy approach, that reflects the capability to solve a situation rather than knowing an answer to every question, we would suggest to only use "how well do you feel informed about."

In terms of more generic bias, we were only able to compare cohorts of athletes with different anti-doping education experiences to demonstrate the utility of our tool as a cross-sectional retrospective design was used. Thus, we cannot confirm that anti-doping education causes or changes the DAL stages; a prospective cohort study is needed to validate the tool. Additionally, although GRADE IT is available in 23 languages, a language bias cannot be ruled out, where some athletes might have misinterpreted items due to a language barrier. Furthermore, as doping, trust and legitimacy are sensitive issues, socially desirable responding cannot be excluded. Also, the mean values may have been higher than what would be expected in a sample of older athletes, and we assume that most of the athletes were not doping (as discussed earlier). Additionally, there might have been a selection bias, whereby the participating athletes may have had a generally positive attitude toward anti-doping education and perceived the system as trustworthy and legitimate. Importantly, even though the mean values for most of the constructs were high, they still differed among the assessed groups and ceiling effects seem unlikely. In terms of the representativeness of the sample, 23.5% of all athletes who attended the four events participated in the study, i.e., we did not receive information from every athlete. As the survey was not sent out to all athletes, we tried to reach as many as possible through various channels; consequently, we cannot confirm the true response rate. It was not feasible to collect data from all attending athletes, because some of them did not have contact with us, others did not have the time, and still others did not spend their free time in the communal spaces where we provided the tablets. Finally, some of the athletes did not want to participate because of the sensitivity of the topic. We tried to counter these difficulties by providing the link through as many channels as possible (as outlined in the methods section), and by ensuring complete anonymity. Unfortunately, it is not feasible to evaluate whether or not the missing values were at random. As stated earlier, the positive educational incongruence was most likely due to Gatterer et al. (2020) only analyzing NADOs, even though there are other organizations that provide anti-doping education. However, as we showed that comprehensive education is important for DAL, as well as for trust and legitimacy, we expect that the inclusion of other organizations would not alter this finding, as these organizations also mostly provide information-based education (Hurst et al., 2020). With respect to the negative incongruence, it is possible that some athletes who indicated that they had not received any kind of education were not aware that they had in fact received such education. Finally, the label of "comprehensive education" included all education initiatives going beyond providing only information on what is prohibited or listed as rules and responsibilities under the WADC. We did not further differentiate between the content (e.g., checking whether values-based education was part of it). The self-report nature of the data on the education received by the athletes is a further limitation.

We believe that developing a valid and reliable instrument for evaluation is an iterative process, often with series of empirical testing not just by the developers but the broader research community, and in many cases with feedback from practical implementation. What we present here is a starting point for this process, not the ultimate product. Thus, future research should apply our tool in a setting in which the education provided is controlled and can be classified more precisely. This would provide additional important information on the role of values-based education in the development of DAL, for example.

Interactive Literacy		Baseline	Afte Education Received	Reference
Explicit Pressure		4,05	4,1	4,35
Implicit Pressure		3	3,67	3,3
Physical Limitations		4	4,23	4,3
Psychological and Emotional Limitations		3,85	3,94	4,15
Life/Career Defining Events		3,95	3,99	4,25
Actions in the Role of Elite Athlete		4,49	4,49	4,79

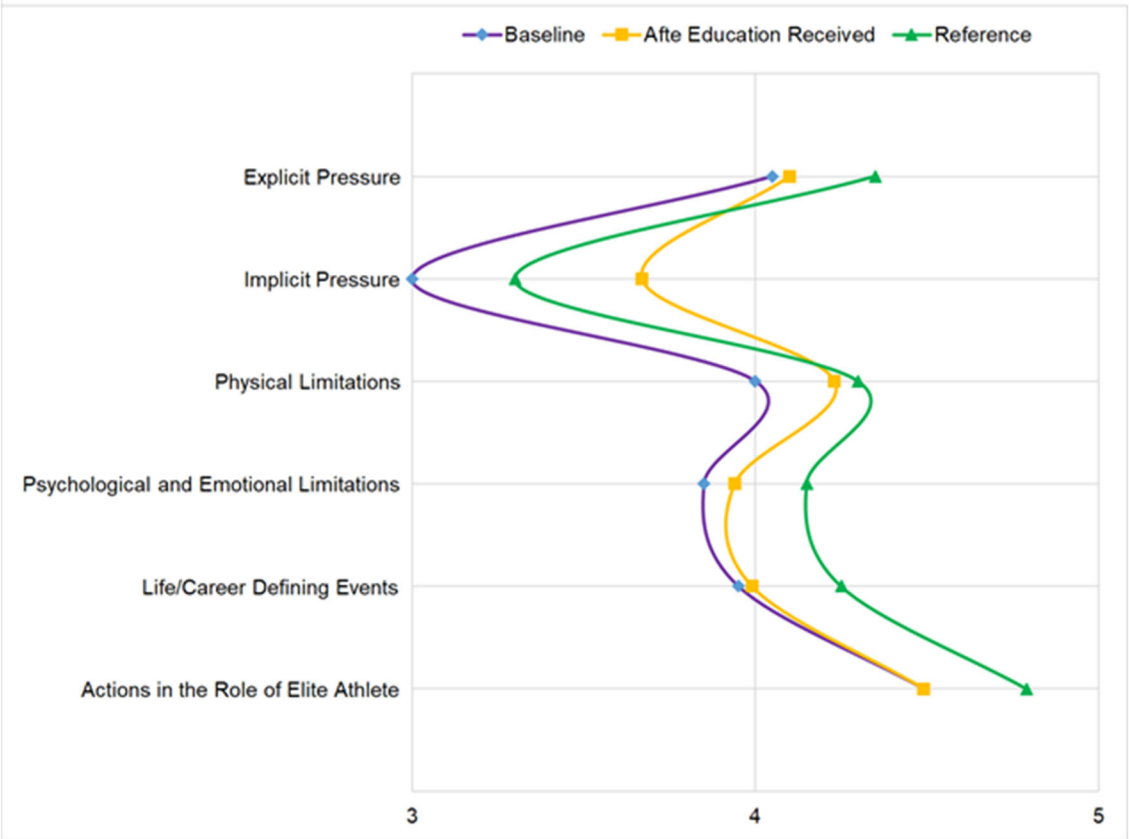

FIGURE 8 | Illustrative example of profile graph (excel template) for organizations.

PRACTICAL IMPLICATIONS

The two main findings of this study were as follows: (a) we were able to develop a reliable assessment tool, GRADE IT, which includes relevant markers with sufficient sensitivity to detect changes in DAL stages, perceived trust and legitimacy; and (b) differences were identified in almost all these parameters according to the anti-doping received. The focus needs to be on the importance of comprehensive education because, as the highest level of anti-doping education (also requested by the ISE), it has the greatest effects on Functional Literacy and Critical Literacy, as well as on trust and aspects of perceived legitimacy. Unfortunately, research has shown that comprehensive education is the least well-implemented type of education by NADOs worldwide, even though some of them erroneously believe that they do in fact provide it (Gatterer et al., 2020). Additionally, considering that elite athletes will always be operating in a high-pressure environment that can itself be considered a risk factor for doping (Whitaker et al., 2017; Gatterer et al., 2019), a high level of DAL in all aspects, as well

as clean sport culture, might promote resilience to pressure. In the context of the finding that comprehensive education impacts positively on Critical Literacy, implementation of the ISE and all four components [values-based education (awareness-raising, information and anti-doping education)] is expected to lead to closer alignment between education content and intended outcomes, which is currently lacking (Woolf, 2020). Additionally, we call for additional research on intervention activities provided by organizations other than NADOs.

A further practical implication of this research pertains to the need to enforce the awareness-raising ISE component (World Anti-Doping Agency, 2021b), not only in the context of doping-related issues but also in the context of why athletes must take specific anti-doping classes. This seems important because negative educational incongruence significantly impacted DAL. Additionally, promoting the results of anti-doping authorities, and knowledge and awareness of the anti-doping and education of different organizations and countries, might also have a direct effect on perceived legitimacy (i.e., enhance perceptions of the system as appropriate and just). These are particularly important aspects of perceived legitimacy, because it is hypothesized that these are associated with compliance with the system (Woolway et al., 2020).

Finally, we invite researchers to use GRADE IT (it is available online in 23 languages, at osf.io/vjtrz) to collect additional data to: (a) determine whether our results can be replicated in other samples, (b) assess if other variables such as culture, sport and level of competition are effect modifiers, (c) build a database to identify if changes in doping prevention policies have a delayed effect on the concepts of DAL, perceived trust and legitimacy, and (d) assess if these concepts are associated with "making the right decision" (this is likely to be the most challenging task). WADA's ISE requests organizations delivering anti-doping education to develop evaluation strategies to assess its effectiveness. To support this, we welcome organizations to use GRADE IT as evaluation tool. There is an Excel Template provided at osf.io/vjtrz that will allow the organization to enter its own data to receive representative figures that are similar to the ones presented in this paper. To make full use of the tool and the profile map (see **Figure 8** for an illustrative example), organizations using the GRADE-IT should collect baseline data first in order to have the first line in the figure representing mean values of the current levels of DAL, perceived trust and legitimacy. Then, to add a second line where they asses the mean values achieved after receiving anti-doping education. The third line serves as the reference line which is set by the organization as the minimum target. With these profile graphs, representing group means instead of individual assessments, organizations will have a valuable visual tool to evaluate their anti-doping program.

CONCLUSION

In conclusion, there is a need for performance-based evaluations of anti-doping education mandated by the International Standard of Education. With GRADE IT, we offer an evaluation tool that is available in 23 languages and focuses on athletes' capabilities to make the right decision as it pertains to clean sport behavior context. We showed that the tool worked well when applied to a sample of elite adolescent athletes. Before implementation of the tool, further work is warranted (i.e., validation in an adult athlete population, and application in different settings where anti-doping education is not self-reported but established independently). Future research could focus on applying the tool longitudinally to examine whether changes in doping prevention policies have a delayed effect on DAL stages, perceived trust, and legitimacy.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Research Committee for Scientific Ethical Questions (RCSEQ), UMIT - Private University for Health Sciences, Medical Informatics and Technology. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

CB and AP: conceptualization and supervision. CB, KG, MO, WS, BS, and AP: methodology and writing—review and editing. CB and KG: formal analysis and investigation. KG: data curation and project administration. CB, KG, and AP: writing—original draft preparation. CB: funding acquisition. All authors have read and agreed to the published version of the manuscript.

FUNDING

This study received funding from the Anti-Doping Research Grant of the International Olympic Committee (IOC).

ACKNOWLEDGMENTS

We would like to thank the members of the expert panel who supported us in developing and critically discussing GRADE IT. Furthermore, we would like to thank all of the participating athletes. Finally, we would like to thank all of the research assistants who supported us with the data collection.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fspor.2022.842192/full#supplementary-material

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Conflict of Interest: WS was employed by Tirol Kliniken GmbH.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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frontiers in Sports and Active Living

OPINION
published: 18 March 2022
doi: 10.3389/fspor.2022.841033

Philosophical Perspectives on Doping Sanctions and Young Athletes

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Keywords: youth doping, doping sanctions, minors, privacy, autonomy, children in sport

INTRODUCTION

Several recent legal and ethical analyses of drug testing in sport (e.g., McNamee and Møller, 2011; Veber, 2014; Dimeo and Møller, 2018; Murray, 2018; Haas and Healy, 2019) build on the foundational philosophical arguments presented by Brown (1984), Fraleigh (1984), and Schneider and Butcher (2001). However, these cogent analyses largely focus on autonomous adults who freely choose to participate in sport knowing what the anti-doping system requires of them. Whether young people who break the rules outlined in the World Anti-Doping Code can and should be treated any differently than their adult peers and competitors is unclear. A vast body of research literature confirms that the use of performance-enhancing substances and methods extends far beyond the scope of high-performance sport, and many non-athletic populations regularly use performance-enhancing substances and methods for alternative purposes (Katims and Zapata, 1993; Yesalis and Bahrke, 2000; Miller et al., 2002; Lorente and Grelot, 2003; Laure and Binsinger, 2007; Muller et al., 2009; Ntoumanis et al., 2014; Andreasson and Johansson, 2021; Gleaves et al., 2021). For over two decades, research teams have reported that doping is not restricted to adult athletes (Komoroski and Rickert, 1992; Melia et al., 1996; Goulet et al., 2002; McNamee, 2009; de Hon et al., 2015). These studies highlight and confirm that some young people engage in doping practices, and doping is not restricted to adult athlete populations.

Media coverage of young people committing anti-doping rule violations is also increasingly common. For example, two anti-doping rule violations occurred at the first Youth Olympic Games (YOG), held in August 2010 in Singapore. At the YOG, which currently feature athletes between the ages of 15 and 18, all medal winners as well as randomly selected athletes are required to undergo doping control procedures. At the inaugural YOG, two 17-year-old wrestlers returned positive doping tests, were disqualified, and were required to return their participation certificates and the medal one athlete was initially awarded (Associated Press, 2010). Both were suspended from sport for 2 years, and their names were entered into the public doping registry of the Fédération Internationale des Luttes Associées (FILA; now known as United World Wrestling) despite their status as legal minors (FILA, 2010).

The Olympic movement has long held the position that doping rules are firm, and an athlete's age is irrelevant. This stance is best illustrated with the case of 16-year-old Romanian artistic gymnast Andreea Răducan losing the gold medal at the Sydney 2000 Olympics over taking cold medicine given to her by her team physician. Her appeal to the Court of Arbitration for Sport's *ad hoc* division, on the basis she was not responsible for the anti-doping violation, was unsuccessful. Arbitrators ruled that her status as a minor did not negate the fact a banned substance was found in her urine sample (Teetzel and Mazzucco, 2014). IOC Executive Board member, Dr. Jacques Rogge, who was appointed president of the IOC a year later, acknowledged to reporters the injustice of the situation: "This is one of the worst experiences I have had in my Olympic life. Having to

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Edited by:
Angela Jo-Anne Schneider, University of Western Ontario, Canada

Reviewed by:
Ian Ritchie, Brock University, Canada

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Specialty section:
This article was submitted to Anti-doping Sciences, a section of the journal Frontiers in Sports and Active Living

Received: *21 December 2021*
Accepted: *22 February 2022*
Published: *18 March 2022*

Citation:
Teetzel S (2022) Philosophical Perspectives on Doping Sanctions and Young Athletes. Front. Sports Act. Living 4:841033. doi: 10.3389/fspor.2022.841033

strip the gold medal from the individual gymnastic champion for something she did not intentionally do is very tough. But the rules are the rules" (BBC Sport Online, 2000). The Court of Arbitration for Sport's acting secretary general at the time, Matthieu Reeb, also acknowledged the injustice, noting, "The panel is aware of the impact of its decision on a fine, young, elite athlete" (BBC Sport Online, 2000). Răducan's disqualification aligned with a decision at the 1972 Summer Olympics to disqualify 16-year-old swimmer Rick DeMont of the USA following his gold medal performance in the 400 m freestyle, after his doping control sample tested positive for ephedrine. All involved in the case understood that the ephedrine found in his sample came from his prescription asthma medication, and that his team physician had made an error in not disclosing the athlete's required use of the medication, yet the disqualification stood (Hunt, 2011).

Concerns about youth doping were amplified at the 2022 Olympic Winter Games in Beijing following the news between the team figure skating finals and scheduled medal award ceremony that 15-year-old figure skater Kamila Valieva, representing the Russian Olympic Committee, had tested positive for the banned substance trimetazidine. The delayed news of her positive test, which was collected on December 25, 2021 at the Russian Figure Skating Championships in Saint Petersburg, but not released until February 8, 2022, the day after the team figure skating finals, raised many questions and resulted in considerable speculation. Despite objections from the World Anti-Doping Agency, International Olympic Committee, and the International Skating Union, the Russian Anti-Doping Agency (RUSADA) Disciplinary Committee lifted the mandatory provisional suspension applied to Valieva and argued before an emergency meeting of the *ad hoc* division of the Court of Arbitration for Sport that Valieva should be permitted to continue competing at the Winter Olympics in the upcoming women's event. WADA quickly clarified in a press release that the World Anti-Doping Code does not allow exemptions from mandatory provisional suspensions for anyone, including minors who, like Valieva, fall under the relatively new category of "protected persons" (WADA, 2022). As per the WADA Code, WADA defines protected persons as athletes who are under 16 years (or under 18 if the athlete is not part of a registered testing pool or competed at international events) or "for reasons other than age has been determined to lack legal capacity under applicable national legislations" (WADA, 2021, p. 174). The Code also stipulates that mandatory public disclosure is not required when a protected person commits an anti-doping rule violation, but it does not prohibit media reporting on the athlete. Specifically, the Code notes, "Any optional Public Disclosure in a case involving a Minor, Protected Person or Recreational Athlete shall be proportionate to the facts and circumstances of the case" (WADA, 2021, p. 102).

With the introduction of the protected persons category in recent years, WADA has recognized that young athletes require protection. Indeed, much of the resulting vitriol and outrage at the decision to allow Valieva to continue competing at the Winter Games, pending her B sample results and appeal process, was directed at her controversial coach, Eteri Tutberidze, and the Russian sport system, generally, not at the 15-year-old athlete herself. Consensus emerged quickly that the adults influencing and controlling Valieva were the ones to blame. Unlike with past cases, more people are recognizing that youth cannot fully comprehend the implications of taking a banned substance or providing a doping sample, particularly if coercion or parental pressure is involved. To highlight the additional ethical concerns that are present when young athletes commit anti-doping rule violations, this paper examines the concepts of childhood, autonomy, and privacy from a philosophical perspective focusing on how each relates to young athletes who dope. Conceptual clarification at the metaphysical level is always beneficial before attempting to address any ethical issue in sport (Kretchmar, 1983). After analyzing how influential conceptions of childhood, privacy, and autonomy apply to young athletes, I argue that legitimate expectations of privacy and autonomy in the context of doping are not being recognized in sport. This vulnerable athletic population, by definition, has not developed the capacity to make rational, independent decisions and therefore should not be held to the same level of fault or face the same consequences as adult athletes who commit anti-doping rule violations. In summary, age ought to matter more than it currently does.

SPECIAL CONSIDERATIONS OF CHILDHOOD

The American Academy of Pediatrics' (2005) policy on performance-enhancing drugs acknowledges that children are the most vulnerable population affected by doping. However, children have not always been considered such a vulnerable population, in sport or in everyday life. As the history and philosophy of childhood literature establishes, the division between childhood and adulthood, and the time in between these descriptors, is hard to categorize and is culturally conditioned (Cole and Cole, 1996; Schapiro, 1999; Matthews and Mullin, 2020). Developmental psychologists recognize adolescence as the transitory period between childhood and adulthood where individuals reach a level of maturity and personal identity. However, as Neil Postman's work on the history of childhood demonstrates, the view of childhood as a social structure dates back only to the sixteenth century. Arguing that increased literacy associated with the Renaissance led to the recognition children require protection stemmed from conceptualizing the "adult world" as one that excluded children. With this recognition, people had to develop skills and "earn" adulthood, not just grow older; as a result, illiterate older people began to be grouped with children in the category of non-adults. Literacy and education motivated societal understanding of the importance of childhood when adulthood came to be marked by "the requirements of a fully literate culture: the capacity for self-restraint, a tolerance for delayed gratification, a sophisticated ability to think conceptually and sequentially, a preoccupation with both historical continuity and the future, a high valuation of reason and hierarchical order" (Postman, 1994, p. 99).

Fast forwarding to the Victorian era, the concept of childhood evolved to be considered a time of innocence protected from the demands of labor (Mayall, 2000). Despite that recognition,

a clear distinction between childhood and adulthood has not ever been fully embraced in the literature, in public policy, or around the world, and the terms "youths," "minors", and "adolescents" continue to be used interchangeably to describe the period between childhood and adulthood. For example, youth as per the Youth Olympic Games eligibility criteria, are people aged 15-18. The United Nations (UN) uses age 18 as the start of adulthood, stipulating in Article 1 of the Convention on the Rights of the Child that children represent "every human being below the age of 18 years unless under the law applicable to the child, majority is attained earlier" (UN, 1989). In addition, the United Nations consider "youth" to be people aged 15–24, recognizing member states may apply different definitions or age ranges for individuals considered to be youth (UN, 2021). WADA sets the limits of 16 years of age for "protected persons" in most situations, but also clarifies "minors" otherwise refers to people under 18 years of age (WADA, 2021, pp. 171, 174).

The arbitrariness of these definitions is clear in sport. While the Convention on the Rights of the Child suggests age limits for engaging in paid labor, it does not address elite sport participation and training (Farstad, 2007). Moreover, international standards addressing children's rights are not adopted by all governments, making compliance unenforceable globally (Mazzucco, 2012). Similarly, protections that stem from research ethics boards with respect to children's involvement in non-therapeutic research do not extend into completion and training for sport either (Schneider and Butcher, 2001). As a result, child labor, child trafficking for sport, and the treatment of child athletes are among the most pressing issues in sport (Tymowski, 2001; Grenfell and Rinehart, 2003; Donnelly, 2008). Outside of sport, children are considered a vulnerable population requiring care and consideration to ensure they are protected from harm. However, a substantial number of young athletes have risen to the top of their sports and achieved remarkable success quite early in their lives and careers. For example, using the UN recommendations, diver Fu Mingxia of China was a child when she won the 10 m platform diving event at the Barcelona 1992 Summer Olympics at age 13, and much further back Aileen Riggen was 14 years old when she won the women's diving event at the 1920 Olympics in Antwerp, while figure skater Sonja Henie was a mere 11-year-old child at the time of her Olympic debut. Romanian gymnast Nadia Comaneci was 14 when she achieved the first perfect 10 in Olympic gymnastics, and swimming sensation Michael Phelps was 15 when he competed in his first Olympic Games in 2000 and set his first world record in the 200m butterfly. These legendary Olympians were children at the time of their success according to most countries' laws. In terms of physical, intellectual, and moral development, these young athletes were girls and boys, not women and men. However, complicating the distinction between child and adult, children mature at different rates and some 14-year-olds, for example, might be more mature than an immature 20-year-old opponent.

With recognition of the arbitrariness of doing so, this paper focuses on young athletes in the age range 15–17 who are developing the ability to make decisions in their own best interests. These athletes are eligible to compete at the YOG (pending their IF not stipulating a different age range within the 15–18 range, as the IOC permits IFs to do) yet fully within the UN's definitions of children and youth. While resisting the idea that one's 18th birthday magically makes a person a competent adult, in this paper the legal age of adulthood in most countries is used as the onset of adulthood, and adult athletes are considered in what follows as athletes who are 18 years of age and older.

PHILOSOPHICAL CONCEPTIONS OF AUTONOMY

Discussions of autonomy in sport are prevalent with respect to participants' ability to consent to participate in the so-called violent sports, or in activities like cockfighting and rodeo (Dixon, 2016). Other areas where arguments from autonomy feature prevalently relate to risk and athletes' decisions to engage in risky recreational pursuits like BASE jumping and big wave surfing (Creyer et al., 2003). When arguing in favor of eliminating the current doping bans in elite sport, some of the most convincing arguments used by sport philosophers, including Brown (1984) and Tamburrini (2000) appeal to athletes' autonomy and right to make independent decisions about matters pertaining to their bodies. However, the legitimacy of the restrictions outlined in WADA's World Anti-Doping Code are also based on athletes' autonomy, but in this case their abilities to choose to voluntarily accept the conditions of participating, including that they cannot consume or use banned substances or methods without consequences. On both sides of the issue, the philosophical concept of autonomy features prominently in guiding our collective thoughts on moral issues in sport. The idea of autonomy as self-rule has been debated by philosophers for centuries and described in numerous ways; as a result, myriad conceptions of autonomy can be found in the philosophy literature. Regardless of whose definition is used, there are commonalities among what we mean when we declare someone is or is not autonomous, which matter in evaluating youth athletes' abilities to make independent decisions in sport.

Western historical sources trace discussions of autonomy back to the Ancient Greeks, referring often to the self-rule enjoyed by several Greek city-states, not by individuals. The Ancient Greek origin is evident in the word itself, which divided into its roots, *Autos* (self) and *Nomos* (meaning rule, governance, and law), results in the concept of self-rule. A consensus on what the idea of "self-rule" really means today in the twenty-first century is not as clear. An autonomous individual is often defined as a person whose moral principles are one's own; however, this does not tell us what autonomy is or why we should value it and work to protect it, particularly in sport. The view that autonomy is a necessary value is found in many foundational ethical theories, including Kant's (1785/1983) moral philosophy as well as Mill's (1859/1975) liberal utilitarianism, and autonomy is often a central virtue in both virtue ethics and ethics of care (Christman, 2020). Autonomy can be conceived of as a moral, political, and social ideal to make sense of intuitions and normative claims (Dworkin, 1988). The concept is always context dependent, lacks an essential definition, and may not be met with universal approval.

One reason autonomy is difficult to define is its similarities with other philosophical concepts, such as dignity, freedom, independence, individuality, integrity, responsibility, self-determination, and sovereignty. Other descriptors connected to autonomy highlight the connection between autonomy and independent action, including the ability do as we please, the capability to intentionally self-initiate actions, freedom from obligations imposed by others, and the absence of coercion, deception, or force. Finally, kindred concepts related to self-reflection and self-knowledge connect deeply to many definitions of autonomy, which include the capacity to make decisions rationally and freely, awareness of your own best interests, and the voluntary pursuit of projects that form your identity. Together these positively and negatively defined descriptors characterize people who act autonomously.

Berlin's (1969) influential essays on positive and negative liberty attempt to answer two central questions: (1) in what area(s) should people be left without interference by others? and (2) how far can government(s) interfere with individuals? Berlin argued that freedom is obedience to a law that one prescribes to oneself, noting: "I am free because, and in so far as, I am autonomous. I obey laws, but I have imposed them on, or found them in, my uncoerced self" (1969, p. 136). These ideas surrounding a necessary recognition of an uncoerced self are present in subsequent analyses of autonomy that emphasize critical self-reflection. For example, according to Dworkin, autonomy is:

> A second-order capacity of persons to reflect critically upon their first-order preferences, desires, wishes, and so forth and the capacity to accept or attempt to change these in light of higher-order preferences and values. By exercising such a capacity, persons define their nature, give meaning and coherence to their lives and take responsibility for the kind of person they are (1988, p. 20).

What Dworkin refers to as "second-order capacities" can be understood as our preferences about our preferences, or the ability to think about our reasons for holding a certain preference that we hold. Similarly, "first-order preferences" are those at the most basic level, which are similar to instincts, such as obtaining food and water, whereas "higher-order preferences and values" are those that align with one's principles rather than one's whims or immediate needs. The ability to perform critical self-reflection to recognize your higher-order preferences is an important component of being an autonomous person and making autonomous decisions.

McLeod (2005) summarizes some of the intricacies in discussing the concept of autonomy, arguing:

> Autonomy is mostly a philosophical term of art, one that philosophers use in a myriad of ways…(none of us grew up with it surely, unless perhaps we are children of philosophers) we have no pre-theoretical intuitions with which to evaluate how philosophers use it, or so some might claim. But would one be right? I do not think so. 'Autonomy' represents a phenomenon with which people do have some experience and on which they could comment in a pre-theoretical way. The phenomenon itself is that of self-government or self-rule, as opposed to government or rule by others (p. 1).

With respect to sport and athlete autonomy, McLeod's succinct definition, "When we govern our own actions and choices we are autonomous; when someone else does so, we are not" (p. 10) is helpful. Feminist views of autonomy acknowledge that autonomy has practical value in understanding gender oppression and objectification (Govier, 1993), while recognizing that oppressive practices undermine and diminish a person's autonomy (Stoljar, 2018).

Bioethicists Tom Beauchamp and James Childress's identification of respect for autonomy as a core principle of biomedical ethics emphasizes the importance of autonomy in matters pertaining to our health and wellness. Their understanding of autonomy as a core principle includes the idea that a practical understanding of autonomy is "not excessively individualistic, not excessively focused on reason (neglecting the emotions), and not unduly legalistic (highlighting legal rights and downplaying social practices)" (2001, p. 57). In an applied ethics setting, Beauchamp and Childress advocate analyzing autonomous actions by whether an individual can make decisions and act intentionally, with understanding, and without any controlling influence. What is relevant here with respect to youth doping is whether youth athletes can undergo this type of reflection, free of coercion from those invested in their athletic success.

Applying the concept of autonomy in sport requires the blending together of the elements of liberty, independence, and critical self-reflection that can be found in the philosophical works described above. Acting paternalistically often involves violating other people's autonomy by seizing their decision-making powers, which is often the case when a parent or coach acts on behalf of a young athlete (Dixon, 2007). Examples include choosing a sport for a youth to specialize in or deciding how many hours per week youth athletes will train. A recurring theme in the philosophical literature on both autonomy and privacy is the uncertainty regarding how much of each a person can expect and demand.

A RIGHT TO PRIVACY?

Privacy discussions in the law and ethics literature often start with Warren and Brandeis's (1890) definition of privacy as "the right to be let alone." Since then, the difficulties involved in producing a universally accepted definition of privacy have led many philosophers to acknowledge that a precise definition may be impossible because of the lack of consensus on both if and why we may have a right to privacy (Alfino and Mayes, 2003). Given the differing emphasis on privacy around the globe and among different cultures, debates continue on whether privacy ought to be considered a basic human right.

Putting aside the question of privacy's inclusion on the list of human rights, privacy is valuable for several reasons, including that "it protects what people deem important in life, such as the intimate sphere or the conditions for autonomous judgment" (Beckman, 2005, p. 98). Privacy includes a measure of protection:

> Privacy shields us not only from interference and pressures that preclude self-expression and the development of relationships, but also from intrusions and pressures arising from others' access to our persons and the details about us. Threats of information leaks as well as threats of control over our bodies, our activities, and our power to make our own choices give rise to fears that we are being scrutinized, judged, ridiculed, pressured, coerced, or otherwise taken advantage of by others. . . Loss of privacy leaves us vulnerable and threatened (DeCew, 1999, p. 249).

The threat of constant observation by others can cause people to censor their movements and behaviors, which WADA's whereabouts program draws on as a component of the anti-doping system in sport. In sport, discussions of privacy and autonomy often intersect.

The link between respecting privacy and treating people as autonomous beings worthy of respect is a central principal of bioethics, with many recognizing privacy as a moral rule necessary for researchers and medical professionals to respect (Beauchamp and Childress, 2001). Violating a person's privacy denies that person the power to control who has access to privileged information about their self and body. Children are frequently denied this right, which is instead bestowed upon their legal guardian(s) tasked with making decisions for them in their best interest with the intent of ensuring they maintain an open future (Miah and Rich, 2006). As children mature at different rates, it is difficult to pinpoint the time that young athletes should be entitled to the same expectations of privacy that adults receive. Some critics of the current doping policies and rules note that the whereabouts program requirements and sample collection methods impinge upon athletes' right to privacy.

The Privacy Commissioner of Canada in a report on drug testing and privacy bluntly acknowledged that drug testing is an invasion of privacy. Specifically, the report noted: "the principal privacy issue flowing from drug testing is not whether testing is intrusive. It is. Urinalysis is particularly intrusive, requiring as it may either a pre-test physical search, the direct observation of an intimate bodily function, or both. The principal issue is in what circumstances the intrusions occasioned by testing are justified" (Privacy Commissioner of Canada, 1990, p. 22). In Canada, the privacy officer deems drug testing to be defensible on utilitarian grounds when public interest is at stake, explaining, "while there is no doubt that drug testing infringes personal privacy in a profound sense, one must not be blind to the need to protect the public interest" (p. 3). Public safety supersedes individual privacy for pilots, corrections officers, and some medical personnel, as people in these occupations are subject to drug testing as a condition of their employment. But the same argument is weak when applied to sport. The right to privacy is made more complex when genetic information is at stake (Privacy Commissioner of Canada, 1992). How children fit into the equation is not addressed; yet this problem is magnified when the athletes in question are considered children incapable of making decisions of this nature. In the context of doping, detection tests require athletes to consent to provide access to their personal information via the "data" contained in their blood and urine even though accessing this type of information violates privacy rights in many areas of the world (Teetzel, 2007).

ETHICAL CONSIDERATIONS IN YOUTH ATHLETES' RIGHTS TO AUTONOMY AND PRIVACY IN THE CONTEXT OF DOPING IN SPORT

When young athletes use banned substances or methods to increase their performance, additional ethical concerns arise beyond those associated with adult doping (McNamee, 2009; Mountjoy et al., 2015). Most obviously, the stigma of a positive doping conviction can haunt young athletes for the rest of their careers, and even their lives. For example, when Polish athlete Igor Walilko tested positive for nikethamide and received an anti-doping rule violation and subsequent 2-year ban from the Federation Internationale de L'Automobile, his family hired a lawyer to challenge the decision. As Walilko was only 12 years old at the time of the incident, his lawyer argued he could not be considered criminally liable for doping as he was too young to even compete at the Youth Olympic Games (Carmichael, 2011). Despite his age, and the banned substance being traced back to an energy bar, the Court of Arbitration for Sport only recommended reducing his WADA-imposed ban from 2 years to 18 months, calling it "excessive and disproportionate" but agreeing the athlete was not too young for the anti-doping rules to apply. Accordingly, his lawyer noted, "He was very famous in Poland and, 1 day after, he was a criminal child" (Hyde, 2011).

Long-term stigmas and lifelong repercussions can impact any athlete found to have cheated with banned substances or methods. For example, after Ben Johnson tested positive for an anabolic steroid at the 1988 Olympic Games, his reputation never recovered, and his name remains synonymous with cheating and doping in sport. Johnson was 27 years old when he was caught doping in Seoul, but his use of anabolic steroids is thought to have started much earlier, and his disqualification has negatively impacted his subsequent opportunities for employment and sponsorship. Unable to capitalize on his image or attract new sponsorship opportunities, years later Johnson agreed to be featured in a television commercial for the sports drink Cheetah Power Surge where he participated in a staged race against a cheetah, and responded to the question, "Ben, when you run, do you Cheetah?" emphatically noting, "Absolutely, I Cheetah all the time." The ad ends with him recommending to consumers to "go ahead and Cheetah" (YouTube, 2012). Johnson serves as a cautionary tale to athletes considering using banned substances or methods (Moore, 2012). The duration of the shame, and onset during the time an adolescent is maturing and entering adulthood, may have even more lasting consequences on self-image and future prospects.

Paternalistic interventions in sport are accepted in recognition of children and youth's vulnerability and susceptibility to coercion and exploitation, with recognition that young athletes are not yet mature legally, morally, or physically (Tymowski, 2000). As Gabriela Tymowski argues, "the moral responsibility ought to be on adults to protect children rather than on

children to be precocious in the ways of the world before they are truly ready to meet those challenges" (2000, p. 81). The rules governing participation in high-performance sports allow national and international anti-doping agencies to test athletes competing under their jurisdiction for the use of performance-enhancing substances or methods. Athletes selected for tests must declare their whereabouts, submit to the testing, and provide the requested blood or urine sample under observation. Refusing to do so is taken as an admission of guilt and an anti-doping rule violation. It is easy to see that there is no room to opt out of taking a doping test on the grounds that doing so constitutes an invasion of privacy. Advocates of privacy rights might maintain that this system does not respect the privacy that athletes, as human beings, are entitled to receive, but this claim is contestable as no one is forced to participate in sport at the high-performance level (Kayser et al., 2007).

No matter their age, athletes are prohibited from using substances banned by the World Anti-Doping Code, and tests are needed to ensure anti-doping rules are followed. This creates a problem for respecting autonomy and privacy rights because current tests to detect doping violate youth athletes' justifiable expectations of privacy and autonomy, and it is unclear if they can consent to this violation. This problem is magnified when the athletes in question are youths because it is not obvious to what extent the notions of autonomy and privacy apply to people who have yet to reach adulthood. Legal guardian consent to analyze a youth's blood or urine is sufficient in the context of health and medicine when a person's life or wellbeing is at stake, but sport is a voluntary pursuit. Arguments that support paternalistic decision making in the best interest of the child do not seem as effective in sport as they do in healthcare examples.

The degree of privacy and autonomy a young athlete can expect in the sporting world is debatable due to the prerequisite conditions sport-governing organizations require athletes to adhere to in order to opt in to participate. Parents and coaches make the majority of decisions for young athletes because, in the majority of societies, youth are not considered able to adequately foresee the consequences of their behaviors and make truly informed choices until they reach a level of maturity. Doping control procedures utilized in sport are justified on utilitarian grounds that a "clean" sport system outweighs any indignities providing a sample produces, and that athletes voluntarily agree to participate in this system in order to ensure their competitors compete fairly (Schneider, 1993). The challenges that athletes face as a result of drug testing programs in sport create an interesting case study to analyze the different societal expectations placed on youth athletes in their roles as athletes compared to their entitlements as children.

The sociohistorical literature that addresses youth and doping often returns to the experimental doping studies undertaken during the Cold War, which subjected a large but unknown number of young people to untested drugs, particularly anabolic androgenic steroids, to gain insight into how to enhance performance with drugs. In most cases, athletes did not consent to their inclusion in these experiments, and many faced long-term negative consequences from their forced participation (Dimeo and Hunt, 2012). While public opinion continues to associate the era of state sponsored systemic doping with the German Democratic Republic (East Germany), teenaged athletes from many countries were required to take part in similar experimental protocols (Franke and Berendonk, 1997). Translated documents from the former Soviet Union suggest that adult coaches, trainers, and medical researchers provided performance-enhancing drugs to children as young as seven and eight years old who showed promising athletic potential (Waddington and Smith, 2009).

Beyond steroids, documented cases exist of adults intentionally doping minors with human growth hormone, as well as laxatives and diuretics, to either accelerate growth or delay the onset of puberty in athletes competing in the aesthetic sports. Joan Ryan, known for her advocacy for safe sport, quotes a gymnastics coach explaining the necessity to delay puberty in girls to facilitate athletes maintaining the desired physique, noting: "gymnasts don't so much retire as expire" (Ryan, 1995, p. 34). As a result of investigations like Ryan's, the American Academy of Pediatrics. (2005) acknowledged that consumption of these drugs and others by healthy youth is dangerous given most have not developed the skills to reason accurately and recognize their long-term interests when presented with short-term gains.

As Matti Häyry and Tuija Takala have noted, individuals can consent to waive their rights to "privacy, confidentiality, non-discrimination, and autonomous decision making," (Häyry and Takala, 2001, p. 403) which is why WADA and other anti-doping agencies can attain and test blood and urine samples from athletes without creating much controversy, and why many athletes willingly provide the samples. However, when applied to young athletes, who are on their way to becoming autonomous but remain immature, the coercive elements that underlie an athlete's agreement to forgo his or her rights in sport are important but are often ignored. When the only options available to athletes are to adhere to the WADA code or not compete in any WADA-sanctioned events, the consent given by athletes may not be truly voluntarily or freely given. Autonomous athletes can reflect on their choice to waive their rights to medical privacy and freely agree to provide their urine or blood for testing to be eligible to participate, even with recognition that doing otherwise implies guilt and will result in a suspension from competing at the elite level of sport. If Adam Moore is correct that, "controlling who has access to ourselves is an essential part of being a happy and free person" (Moore, 2000, p. 105) then serious ethical implications arise when requiring young athletes to participate in the doping control process. A parent or guardian could counter this concern noting that they can provide consent on behalf of their child to allow anti-doping officials to test their child's urine or blood. The expected assent children must provide alongside their legal guardian's consent to participate in research is often not a focus (Kopelman, 2000).

The utilitarian argument that the rewards of social justice outweigh the costs and consequences of potential privacy and autonomy violations can be very persuasive (Farrelly, 2002). Some young athletes and their legal guardians may conclude that clean sport offsets the violations of privacy that the doping control system creates. For an athlete committed to

excellence, taking part in the anti-doping system can be a mere inconvenience or a necessary step to moving forward in their athletic pursuits. But this non-critical approach may stem from a culture of obedience that discourages critical self-reflection and contemplation of one's values and beliefs. Many, but not all, high performance athletes are taught over their many years of intensive training to follow the orders of their coaches and sport-governing bodies and to not question the rules. A young athlete in this category might become accustomed to adhering to rules without first engaging in critical self-reflection or considering the implications of his or her actions outside of the sporting world. Dworkin's second order reflections are likely rarely utilized.

Former WADA director Richard Pound explains how the rules work in sport, and why impartiality and consistency are essential for fairness. Regarding the need for the anti-doping system, Pound reflected in 2004, in a compelling statement no longer available on WADA's website:

> [Sport] is governed by rules that, however artificial or arbitrary they may be, are freely accepted by the participants. Why a race is 100 or 200 or 1,500 meters does not really matter. Nor does the weight of a shot or a discuss [sic], the number of members on a team, or specifications regarding equipment. Those are the agreed-upon rules. Period. Sport involves even more freedom of choice than participation in society. If you do not agree with the rules in sport, you are entirely free to opt-out, unlike your ability to opt-out of the legal framework of society. But if you do participate, you must accept the rules. You are not entitled to use a 10-pound shot instead of the 16-pound shot used by your fellow competitors. You are not entitled to start the race before the other competitors, just because you may be a bit slower than they are.[1]

The anti-doping system only exists because people (presumably athletes, sponsors, and fans) want doping-free sport, and athletes can agree to participate for any number of positive or negative reasons: because they value clean sport, because they do not want to get caught, because they do not want to risk damaging their reputation, because they believe their doping will go undetected, and so on.

Coercion can affect young athletes in many ways. The power of coaches, parents, and the athlete entourage can push reluctant youth to use performance-enhancing substances or methods in order the please their mentors, or because they lack support in saying no, as a "coercive environment can inhibit an athlete's autonomous choice to reject the use of performance-enhancing substances" (Miah, 2005, p. 875). The consent that athletes give to anti-doping agencies to have their blood and urine analyzed is not without coercion in the majority of cases (Munthe, 2005). When uncoerced autonomous adults opt to waive their right to privacy and voluntarily accept the rules of sport in order to participate, the resulting restriction of freedom is not a limitation of privacy or autonomy.

[1]This passage was published on the World Anti-Doping Agency website under the title "Remarks by WADA President Richard W. Pound at AAAS annual meeting." The link to the page is no longer active but was previously available at http://www.wada-ama.org/en/t3.asp?p=41275&x~=1&a=88937.

Testing is necessary to ensure compliance with the anti-doping rules, but serious ethical concerns arise regarding young athletes' ability to consent if the detection protocol infringes their rights to privacy and autonomy. Pound's argument that athletes can opt out of participating if they do not agree with the rules does not address the objection that children cannot consent to undergo doping control, particularly when we recognize the known pressures that young athletes face and the considerable coercion that coaches and the entourage may be exerting. It is uncertain at what age any individual develops the capacity to understand the implications and potential lifelong health and reputational damage that doping may create. It is equally unclear if it is possible for a young athlete to decide to participate in the anti-doping system, free of coercion, without undue pressure from parents, coaches, and members of the athlete entourage.

Dworkin's account of autonomy, which rests on a person's capacity to reflect critically on first order preferences and accept or attempt to change them in light of higher-order preferences and values, seems missing in sport. Youth athletes accustomed to following the directions and orders of their coaches, trainers, and parents might find this task close to impossible without plenty of prior education. The culture of obedience demanded in sport seems at odds with critical self-reflection and choosing to accept or change one's actions. Of course, there are numerous athletes who have critically evaluated the pros and cons of adhering to the rules set by WADA, the IOC, and their respective IFs, and then made an informed choice to adhere. Blind adherence, without that level of critical reflection, is problematic given the high stakes pressure and coercion known to occur in sport.

CONCLUSION: AGE MATTERS

Age requirements have a long history in sport. At the Ancient Olympic Games, where only boys and men were permitted to participate, rather than require that each participant appear in Olympia with proof of his age, the judges "trusted to their eyes and their common sense, instead, with the aim of preventing blatant mismatches" (Finley and Pleket, 1976, p. 62). Boys' events were restricted to competitors who appeared to be between the ages of 12 and 18, but it is possible that tall boys who had not yet turned 12 years of age competed as well. Judges could use their discretion in moving up a well-developed boy to compete in the men's competition if he looked strong enough to contend against the older participants (Finley and Pleket, 1976). Currently, at the Olympic level, the rules stipulated in the Olympic Charter allow each IF to impose age restrictions. Specifically, Rule 42, "Age Limit," demonstrates that the IOC acknowledges that age matters, stating: "There may be no age limit for competitors in the Olympic Games other than as prescribed in the competition rules of an IF as approved by the IOC Executive Board" (International Olympic Committee, 2021, p. 81). While the IOC does not set age limits on participation as an eligibility rule, responsibility is handed down to the IFs to decide if competitors' age matters. Some IFs have decided that age matters and impose minimum age restrictions for Olympic participation, varying from 13 years of age set by fencing IF and 14 by the IFs for taekwondo and

bobsleigh, to 17 years of age set by the IFs for wrestling, cycling, and weightlifting, and 20 years of age for the endurance athletics events governed by World Athletics. The vast discrepancy among disciplines allows 14-year-old divers and bobsled athletes to plunge headfirst into water from heights of 10 meters, or hurl down an ice track wearing minimal protective gear, but not participate in relatively less-risky disciplines. For the young athletes excluded from participating because they do not meet a minimum age limit, the inconsistencies among the rules can seem both arbitrary and unfair (Teetzel, 2010). What is relevant here is that IFs can and do implement minimum age requirements, seemingly in recognition that a certain degree of growth and maturity is needed to compete safely.

The IOC's introduction of the YOG as "a multi-sport, cultural and educational event for young people and driven by young people" (International Olympic Committee, 2007, p. 3) highlights the organization's recognition that age matters in sport. Each IF participating in the Youth Olympic Games sets the age range for eligibility (within the parameter that all competitors at the YOG now must be a minimum of 15 and maximum of 18 years old). As a result of these rules, some youth athletes are eligible to compete at both the YOG and the Olympics, while other young high-performance athletes are eligible for only one or the other, or neither.

There are several good reasons for age restrictions in sport, most of which focus on avoiding early specialization, minimizing the risks of major injuries, and allowing youth athletes to enjoy their youth without undue pressure to excel athletically (Dixon, 2007). These reasons seem equally applicable for determining different levels of culpability when young people dope. The strict liability approaches that are part of the anti-doping movement directly contradict how other spheres recognize the importance of applying age restrictions to protect child and youth athletes.

From exploring the ethical question of whether youth can comprehend fully the implications of taking a banned substance or providing a doping control sample, particularly if coercion or legal guardian pressure is involved, from a philosophical perspective the current system seems unjust. Young athletes have not matured legally or morally, and therefore they should not be subjected to the same punishment and consequences as autonomous adults found to have committed an anti-doping rule violation. What a youth doping sanction would look like remains to be seen, and we must recognize that if there were to be different consequences for doping based on age, then child athletes would be ripe for even further exploitation by unethical coaches and sports clubs. However, a first step is advocating that WADA and the Court of Arbitration for Sport more readily consider an athlete's age and competency when applying the rules that an anti-doping rule violation trigger. Just as IFs are given leeway to choose which age of athletes compete at the YOG, more space to recognize age as a variable in determining the consequences or sanctions after assessing if an anti-doping rule violation has occurred seems warranted.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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Conflict of Interest: The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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ORIGINAL RESEARCH
published: 31 March 2022
doi: 10.3389/fspor.2022.829940

Studies of IGF-I and Klotho Protein in Relation to Anabolic-Androgenic Steroid and Growth Hormone Administrations

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It has been suggested to longitudinally monitor Insulin-like growth factor I (IGF-I) as a biomarker for the detection of recombinant growth hormone (GH). Subsequently, it is of interest to understand any confounders of endogenous IGF-I. Herein we have studied if serum IGF-I concentration is affected by the intake of anabolic androgenic steroids (AAS) and the potential connection between IGF-I and klotho protein. Moreover, the usefulness of klotho as a biomarker for recombinant GH intake was assessed in healthy male volunteers. An ongoing administration of AAS did not affect the levels of IGF-I. Klotho protein was ∼30% higher in men with an ongoing AAS use compared to those with previous (>2 months ago) AAS use, and the serum klotho protein correlated negatively with luteinizing hormone (LH) ($r_s = -0.38$, $p = 0.04$) and follicle stimulating hormone (FSH) ($r_s = -0.35$, $p = 0.05$) levels. Serum IGF-I and klotho concentrations showed no correlation in the AAS using population but showed a strong negative correlation in healthy volunteers ($r_s = -0.86$, $p = 0.006$). The intake of recombinant GH did not affect the serum concentrations of the klotho levels. In conclusion, IGF-I was not affected by supra-physiological AAS doses in men. Interestingly, an association between AAS intake and serum klotho was seen. The usefulness of klotho as an androgen biomarker warrants further studies, whereas klotho can be discarded as a promising biomarker for GH doping.

Keywords: doping, anti-doping, IGF-I, klotho, anabolic androgenic steroid, growth hormone

OPEN ACCESS

Edited by:
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Specialty section:
This article was submitted to Anti-doping Sciences, a section of the journal Frontiers in Sports and Active Living

Received: *06 December 2021*
Accepted: *28 February 2022*
Published: *31 March 2022*

Citation:
Lehtihet M, Stephanou C, Börjesson A, Bhuiyan H, Pohanka A and Ekström L (2022) Studies of IGF-I and Klotho Protein in Relation to Anabolic-Androgenic Steroid and Growth Hormone Administrations. Front. Sports Act. Living 4:829940. doi: 10.3389/fspor.2022.829940

INTRODUCTION

Anabolic-androgenic steroids (AAS) are used among athletes and in society for their muscle building and performance-enhancing effects (Bhasin et al., 1996). In addition to AAS, recreational and elite athletes may co-use recombinant growth hormone (GC; recGH) and insulin-like growth factor I (IGF-I) for the lipolytic and muscle-enhancing effects noted after GH substitution therapy (Chikani and Ho, 2014). To detect recGH doping, the GH2000 score, including serum IGF-I and procollagen type III N-terminal peptide (P-III-NP) biomarkers, is used in World Anti-Doping Agency (WADA) accredited labs. This population-based score can detect high doses of recGH (Guha et al., 2014), whereas detection of lower doses delivers poor results (Lehtihet et al., 2019).

Lately, it has been discussed that IGF-I could be longitudinally monitored, with or without P-III-NP, in an endocrine passport module to increase the true positive rate (Lehtihet et al., 2019; Marchand et al., 2019). Subsequently, it is of interest to understand how the administration of different drugs, including other doping substances, such as AAS, influences the production of IGF-I. In fact, previous studies on exogenous androgen's effect on IGF-I production in healthy individuals are scarce, but indicate that testosterone administration may lead to an increase in IGF-I serum levels (Hobbs et al., 1993; Veldhuis et al., 2005). However, to our knowledge, IGF-I has not been investigated in relation to the supra-physiological doses often used among athletes engaged in e.g., bodybuilding.

Klotho protein has been proposed as a clinical biomarker for GH/IGF status, i.e., in the diagnosis and treatment of acromegaly (Sze et al., 2012; Neidert et al., 2013). It is believed that klotho inhibits insulin and IGF-I pathways (Shahmoon et al., 2014), but the correlation between serum klotho and IGF-I in humans has been inconclusive. These differences may be due to the different populations studied (age, disease status) and the kit used for the IGF-I and klotho analyses (Heijboer et al., 2013; Bidlingmaier et al., 2014). Exogenous recGH therapy has been shown to induce klotho concentrations in some healthy subjects (Adema et al., 2018), indicating that klotho protein could act as a putative marker for GH doping. Moreover, a relationship between klotho and androgens has been suggested as klotho gene promoter includes an androgen receptor element (ARE) and testosterone upregulates the messenger RNA (mRNA) and protein klotho expression in kidney cell lines (Hsu et al., 2014). But to our knowledge, the association of supra-physiological doses of androgens and serum klotho has never been studied.

Here we have studied IGF-I and serum klotho protein in relation to AAS administration in men self-reporting an ongoing or previous AAS use. Moreover, to investigate if serum klotho levels can function as a longitudinal biomarker for GH doping, the klotho protein was studied in relation to GH administration.

MATERIALS AND METHODS

Study Populations

Two cohorts were included in this study: cohort 1 included healthy volunteers administered with recGH and cohort 2 included self-reporting AAS users.

The study population of cohort 1 has been described earlier and included nine healthy male volunteers aged 32–45 years (Lehtihet et al., 2019). The participants were administered with Somatropin (Genotropin®, Pfizer Innovations AB, Strangnas, Sweden) daily for 2 weeks (1 or 4 IU/day) with the primary endpoint to study biomarkers of GH doping. This dose regimen mimics doses reported among AAS users (cohort 2) (Borjesson et al., 2020) and athletes (Marchand et al., 2017). The exclusion criteria for participating in the study included cardiovascular diseases, diabetes, hormonal treatment, being under the influence of abused substances (AAS, opioids, cannabis, cocaine, and amphetamine), malignancy within the last 5 years, or being a member of a sports federation. Three blood samples were collected daily for 3 days prior to recGH administration, and two samples were collected during the treatment period: after 7 and 13 days, respectively. Post-samples were taken 1.5, 3, 24, and 48 h after the last injection. All samples were collected in the morning (7.30–10.30). The study was approved by the Ethics Review Board in Stockholm and written informed consent was obtained from all participants before inclusion in the studies.

Cohort 2 consisted of 30 male individuals self-reporting an AAS use within the last year, aged between 20 and 63 years old. They were recruited from our Anti-Doping Hot-Line *via* the snowball sampling approach and the population has been described elsewhere (Borjesson et al., 2020). Participation was commenced after oral and written informed consent and the study was approved by the Ethics Review Board in Stockholm. At inclusion, blood and urine samples were taken, and the weight in kilograms and height in meters were measured to calculate the body mass index (BMI) (kg/m^2). The participants sat down for 10 min prior to blood sampling, and blood samples were collected from an antecubital vein in serum tubes. Serum was obtained within 4 h by spinning the serum tubes for 10 min at 2,000 g and immediately frozen at −80°C. Testosterone, luteinizing hormone (LH), and follicle-stimulating hormone (FSH) were measured as described and reported previously. The participants were grouped into current AAS users (<2 months) and former AAS users (last AAS intake 2-12 months ago).

Serum Analyses IGF-I

The IGF-I for the GH administration study was analyzed in our previous report (Lehtihet et al., 2019) and IGF-I analyses of the subjects self-reporting AAS use were quantified with the same WADA accredited method. Briefly, serum IGF-I was measured by a commercially available sandwich-type immunoassay, the Immunotech A15729 IGF-I IRMA (Immunotech SAS, Marseille, France). Six calibrators with different concentrations were used to plot a standard curve. Quality control (QC) samples, QC low and QC high, were used to check the performance of the analysis. Human serum obtained from Sigma Aldrich, ref: H4522, was used as QClow, which gives IGF-1 concentration <200 ng/ml, and QC high was prepared by spiking the same serum with recombinant human IGF-I obtained from Invitrogen, ref: PHG0071, which gives concentration >500 ng/m. A sample volume of 50 µl was applied to the antibody-coated tubes. After the incubation, radioactivity was counted for 5 min with a gamma counter 1282 Compugamma (LKB Wallac). The data were analyzed with spline function curve fitting to determine the concentration of IFG-1 in the samples. To take the age into account, the age-corrected formula calculated from the regression of IGF-I values of healthy adult subjects determined in Hilding et al. (1999) was applied.

Serum Analyses Klotho

The commercial Human KL(Klotho) ELISA Kit (Catalog Number EKH4368) (Nordic Biosite AB, Täby, Sweden) based on sandwich enzyme-linked immune-sorbent assay technology was used for klotho quantification. To pre-coated anti- klotho

antibody wells, standards (7.8–500 pg/ml) and samples of interest were added followed by a biotin-conjugated anti-klotho antibody as detection antibodies. Horseradish peroxidase (HRP)-Streptavidin was added, and unbound conjugates were washed away with wash buffer. Tetramethylbenzidine (TMB) substrates were used to visualize HRP enzymatic reaction. TMB was catalyzed by HRP to produce a blue color product that changed into yellow after adding an acidic stop solution. The O.D. absorbance was read at 450 nm in a microplate reader (SpectraMax® Plus 384 Microplate Reader, Molecular Devices, LLC, San Jose, CA, USA) and the concentration of klotho was calculated from the standard curve (best-fit-purpose) and multiplied by the dilution factor using the SoftMax Pro Software v1.01. (Molecular Devices, LLC, San Jose, CA, USA). All samples were analyzed in duplicates. The kit has been validated regarding recovery (97–102%) and precision (intra-assay CV < 8%, inter-assay CV < 10%) by the manufacturer (Nordic Biosite, Täby, Sweden). The serum volume used in the ELISA reaction was recommended by the kit provider to be empirically tested. Different serum volumes of 1, 10, 50, and 100 ul were tested from two subjects. For the serum results, 75 ul (1:1.33 dilution) was chosen for the serum analyses as this shows linearity and is within the range of the standard curve. For two participants, one with ongoing AAS use and one with previous AAS use, the klotho levels were far above the standard curve and therefore not included in data analyses. Occasional samples from one of the participants in the GH administration study were outside the standard curve and hence this subject was excluded.

Data Analyses

The statistical analyses were performed using GraphPrism Software version 8 (San Diego, CA, USA). IGF-I and klotho were normally distributed (Shapiro-Wilk test), and the student *t*-test test was used for comparison between ongoing and previous AAS users, whereas the gonadotropins showed non-normal distribution and the Mann-Whitney *U*-test was applied. For the correlation analyses, Spearman rank-order correlation or Pearson's correlation analyses were done depending on the distribution. The coefficient of variation (CV%) was calculated by dividing the SD by the mean value to show intra-individual stability. Differences were considered significant at $p \leq 0.05$ (2-sided test).

RESULTS

AAS Administration and IGF-I

There was no difference in age and BMI between the ongoing and former AAS users, whereas LH and FSH were significantly lower in those with ongoing AAS use (**Table 1**).

The IGF-I concentrations (range 55–360 ng/mL) were negatively correlated with age ($r = -0.54$, $p = 0.0006$). Therefore, the age-corrected IGFSD values were also applied when comparing IGF-I levels between the groups. There were no significant differences in neither IGF-I and IGFSD between AAS users and former AAS users (**Table 1**). IGF-I and IGFSD did not correlate with circulatory levels of the gonadotropins (data not shown).

An ongoing use (i.e., within the last two months) of potential interacting substances, such as insulin ($n = 1$), and GH/IGF-I ($n = 1$), displayed IGF-I values of 160 and 279 ng/ml and IGFSD values of −0.30 and −0.59, respectively.

AAS Administration and Klotho

A significant correlation between serum klotho levels and age was noticed, increasing klotho concentrations with age, $r = 0.45$, $p = 0.01$, **Figure 1**.

Klotho serum levels in relation to the time of last AAS intake revealed significantly higher klotho levels in current AAS users compared to those who reported AAS intake longer than 2 months ago, $p = 0.04$, **Table 1**.

Negative correlations between FSH and LH with klotho serum levels were observed $r_s = -0.353$, $p = 0.05$ and $r_s = -0.38$, $p = 0.04$.

GH Administration Study

Klotho protein was quantified in serum from eight volunteers from our previous study. Serum samples include samples obtained before recGH administration ($n = 3$/subject) during the treatment period (day 7 and 13) and post GH treatment (+1.5, 3, and 24 h). There were no differences in serum klotho

TABLE 1 | General characteristics, and hormone values in men with an ongoing AAS (<2 months) and previous AAS (2–12 months).

	Current AAS users ($n = 17$)	Previous AAS users ($n = 14$)	*P*-value
Age	31.5	33.5	ns
BMI	27.3 + 2.7	29.4 +3.6	ns
LH (IU/LH)	0.10 ± 1.8	5.3 ± 2.6	$p < 0.0001$
FSH (IU/L)	0.14 ± 1.5	3.2 ± 3.0	$p < 0.0001$
IGF-I (pg/mL)	201 ± 84.1	157 ± 41.7	ns
IGFSD	−0.41 1.5	−1.0 0.9	ns
Klotho (pg/mL)	68.4 ± 20.8	49.3 ± 51.5	$p = 0.04$

Values presented as median ±SD. For comparison between groups, Whitney U-test or student T-test were applied depending on the distribution.
BMI, body mass index; LH, luteinizing hormone; FSH, follicle stimulating hormone; IGF-I, insulin growth factor 1.

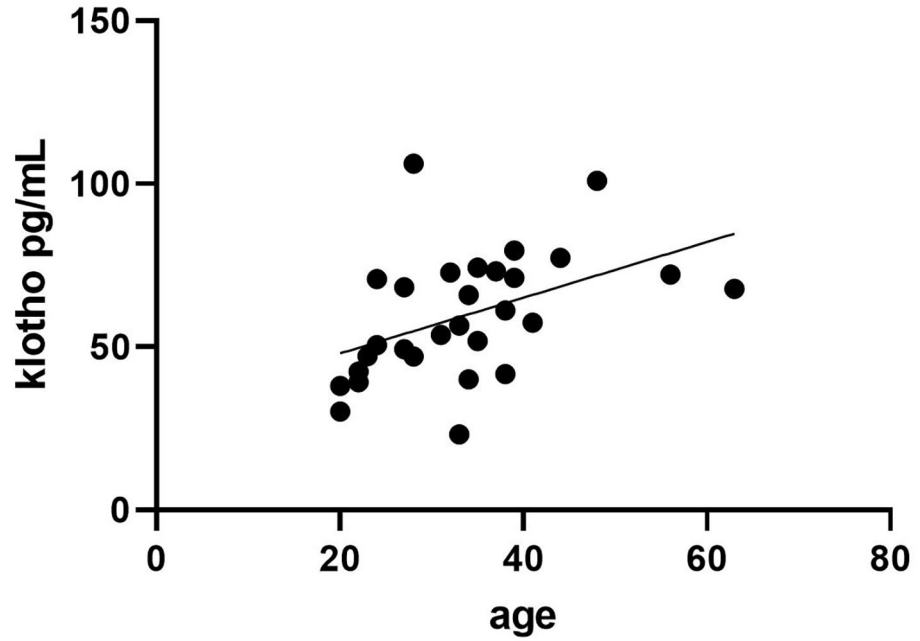

FIGURE 1 | Correlation between age (years) and klotho serum concentrations in 29 male individuals using anabolic androgenic steroids (AAS) within the last year.

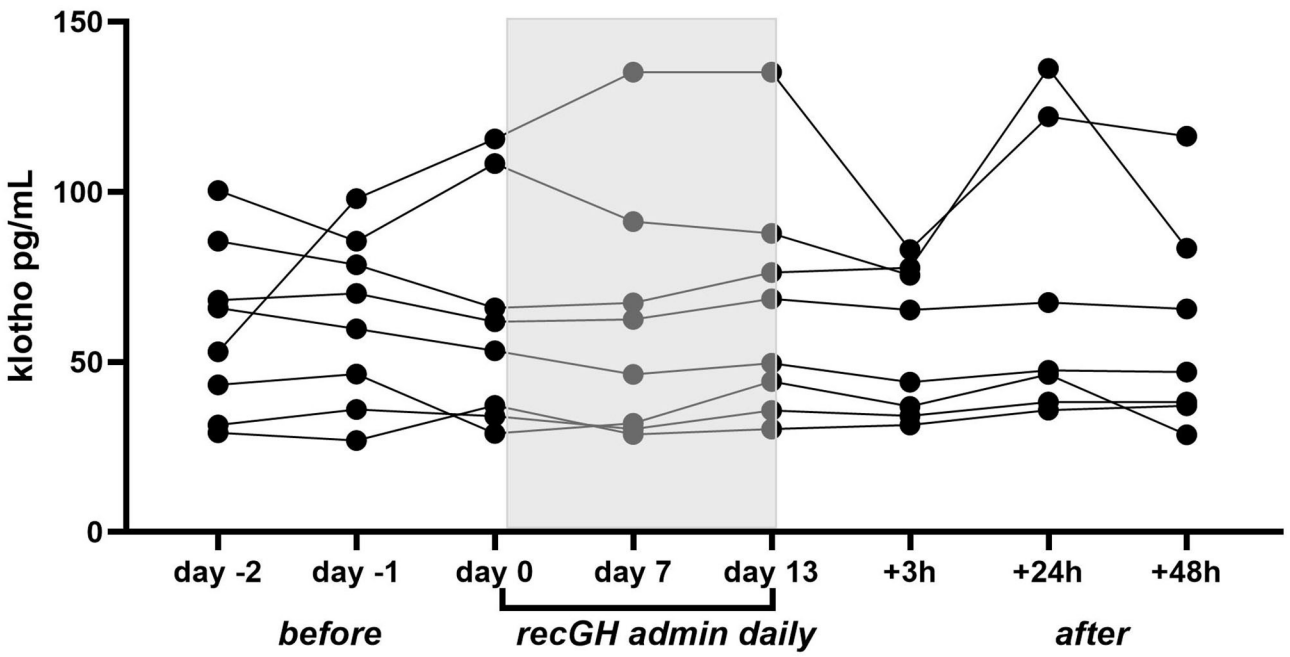

FIGURE 2 | Klotho serum levels in eight participants administered with recGH (0.008–0.051 IU/kg body weight/day) for 2 weeks. Serum samples were analyzed prior to the treatment period (day−2, day−1, and day 0), during treatment (day 7 and 13), and 3, 24, and 48 h post-treatment.

levels between the different time points investigated ($p = 0.33$, Friedman test), **Figure 2**. The intra-individual variations of the baseline values were lower (range 4.4–26.5% CV) than the inter-individual variation (range 38–59% CV). The klotho levels showed a strong negative correlation to IGF-I concentration before GH administration ($r = -0.86$, $p = 0.006$), **Figure 3A**. Also, after GH administration, a similar correlation remained ($r = -0.86$, $p = 0.006$), **Figure 3B**.

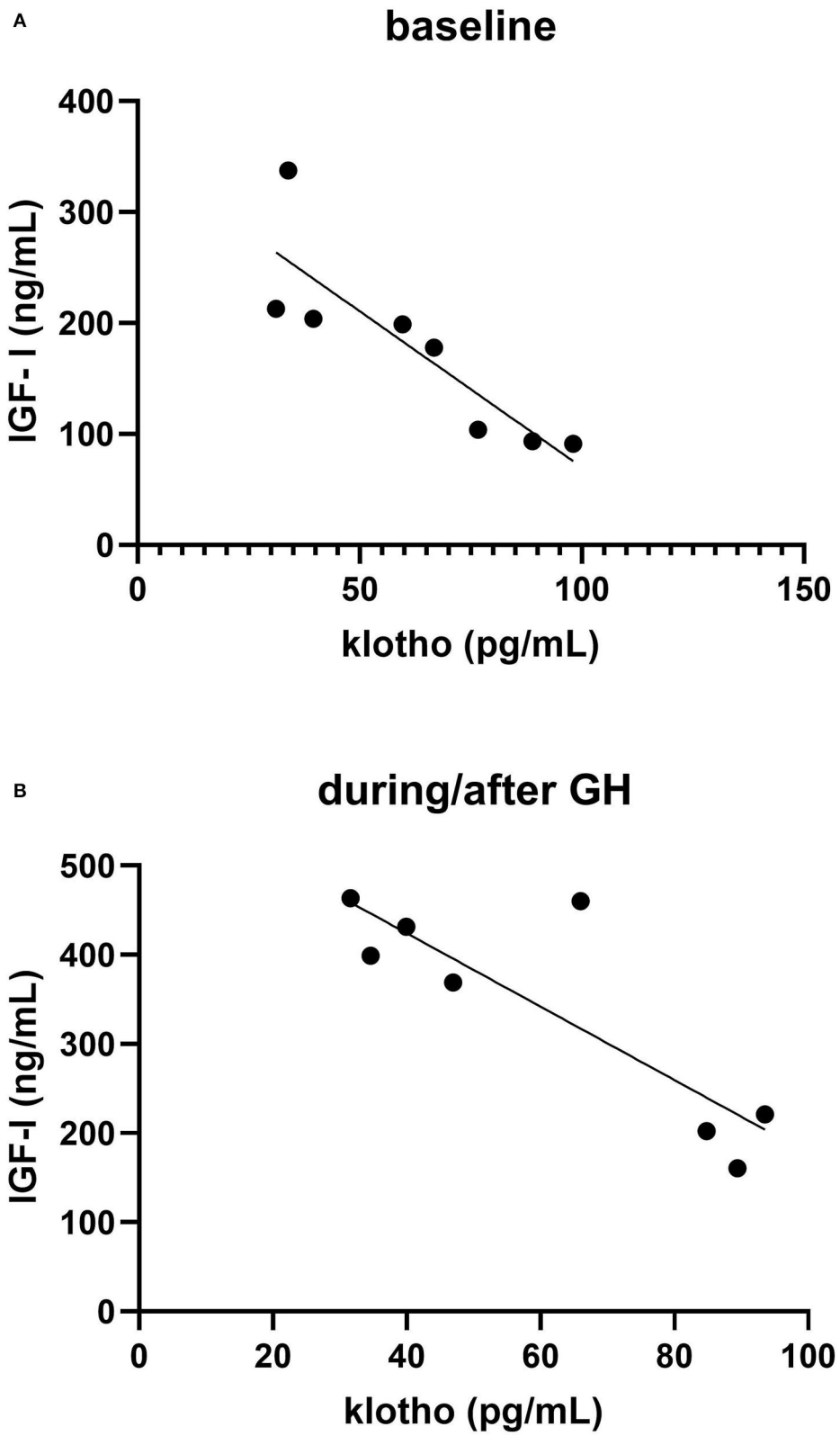

FIGURE 3 | Correlation between IGF-I and klotho in eight healthy volunteers **(A)** mean of three baseline values **(B)** mean of four samples taken during (day 7 and 13) and after (+3 and 24 h) recombinant growth hormone (recGH) administration.

DISCUSSION

This is the first study assessing IGF-I and klotho levels in AAS users. It was shown that the intake of supra-physiological doses of AAS was not associated with circulatory IGF-I levels i.e., there was no difference in IGF-I levels between those with current and former AAS use. Previous studies indicate that androgens increase IGF-I secretion *via* GH (Bondanelli et al., 2003) and it is possible that AAS-induced hypopituitarism abrogates GH responsiveness of androgens. This is in line with clinical studies in men with hypopituitarism where co-administration with GH was needed to obtain an increase in IGF-I after testosterone administration (Gibney et al., 2005).

We did not see any elevated klotho levels in the AAS user with ongoing use of recGH, and to further strengthen the finding that serum klotho is not affected by GH administration, klotho was analyzed in healthy male volunteers that were administered with recGH for 2 weeks. The intra-subject variation in klotho levels was small (4–26 CV%) and the individual values were not perturbed by recGH administration. The result is in line with Adema et al. who did not observe any significant effects on serum klotho on a group level when a similar recGH dose was administered, even if klotho elevation was noted in a few subjects (Adema et al., 2018). So, it is likely that klotho protein cannot function as a valuable biomarker for doping with recGH. Notably, low levels of klotho may also be detected in urine, particularly in patients with GH excess (Schmid et al., 2013) and it is possible that a different response to recGH would have been observed in urine.

A novel finding was that the ongoing use of AAS was associated with higher serum klotho concentrations. Also, the AAS-induced hypogonadism as reflected by LH and FSH repression correlated to klotho levels. Supra-physiological doses of androgens are known to suppress gonadotropins with fast response (Jarow and Lipshultz, 1990). The degree of suppression and the ability to recover after an AAS cycle depends on the duration of AAS use and the cumulative dose (Tan and Scally, 2009) with most being normalized within 6 months, even though in some cases, it may take up to 1 year as seen in our participants (Borjesson et al., 2020) and elsewhere (Sader et al., 2001). It is possible that AAS activates the ARE and influences the expression of the klotho gene resulting in elevated protein levels as has been seen in mice (Hsu et al., 2014). Two AREs have been identified *in silico* in the human klotho promoter region (Hsu et al., 2014) which may explain the higher klotho protein levels in the granulosa cells from women with Polycystic ovary syndrome (PCOS) and hyperandrogenism compared to controls (Mao et al., 2018). Furthermore, a correlation between circulatory T and DHEA and klotho levels in healthy sedentary middle-aged adults has been observed (Dote-Montero et al., 2019). The connection between klotho and androgens in humans warrants further studies.

We noted a strong negative correlation between klotho and IGF-I in the healthy volunteers, whereas in the self-reporting AAS subjects, correlations between klotho and IGF-I/IGFSD could not be discerned. A negative association between klotho and IGF-I is in agreement with the hypotheses that klotho exerts inhibitory effects on the IGF-I pathway as seen in several animal studies (Abramovitz et al., 2011; Shahmoon et al., 2014). A negative association between IGF-I and klotho has been found directly after exercise in healthy subjects (Saghiv et al., 2017). However, in adults with acromegaly positive correlations between IGF-I and klotho have been reported (Sze et al., 2012). Several hypotheses have been proposed for the connection between klotho and the GH/IGF-I pathway, extensively reviewed by Rubinek and Modan-Moses (2016).

The IGF-I and IGFSD values in the AAS users showed large inter-individual variations but were within ranges previously reported in Swedish healthy men (Unden et al., 2002). It is well-known that IGF-I decreases with age and a negative correlation between age and IGF-I were seen among the AAS users. The opposite age pattern was found for klotho, i.e., a strong positive correlation between age and serum klotho concentrations in the AAS users. This is contrary to previous findings where serum klotho levels significantly decreased with age (Koyama et al., 2015). The discrepancy might be that our participants are younger and most of them do not suffer age-associated diseases.

In previous studies it has been observed that athletes display higher IGF-I concentrations than sedentary controls, being highest in athletes engaged in power sports (Eklund et al., 2021). But herein, no differences in IGF-I levels between healthy volunteers and the AAS population were observed. Nor were any differences in serum klotho concentrations between the healthy volunteers and the AAS users noted, but regrettably, both cohorts exhibit lower klotho concentrations that are seen in other studies, including healthy subjects (Dote-Montero et al., 2019). The reason for this may be that the samples have been stored (−80°C) for 3 years and the klotho protein has partly been degraded. However, during method testing, we also included freshly prepared control serum that did show klotho levels in the same range. It is possible that the kit used herein exerts lower sensitivity for klotho than the kits used in other studies, as has been discussed previously (Heijboer et al., 2013). It is possible that only the alternative spliced secreted klotho presents in the circulation (and not the membrane-bound form that has been shredded into the circulation) is detected herein.

There are some limitations with our study that needs to be addressed. Firstly, we only included men in our study populations, and it is possible that gender differences in IGF-I and Klotho response to AAS and GH administration exist. Moreover, regarding the AAS self-reporting population, the timing of the last AAS intake may not be correctly stated. In addition to AAS, several other drugs were used e.g., additional performance-enhancing drugs and drugs taken to eliminate AAS-induced side effects, that might interfere with the results. However, studies of populations self-reporting AAS use is the only way to perform studies of doses often used among bodybuilders, since it is not ethically or medically justified to conduct controlled studies with such doses (60–3,800 mg/week). Another limitation is that the samples were not taken after overnight fasting but rather at different time points to mimic a doping test situation. IFG-I is known to increase after food intake, particularly proteins. Many of the AAS users eat large amounts of proteins as well as dietary supplements which may be confounder herein.

In conclusion, it has been shown that supra-physiological doses of AAS do not affect circulatory IGF-I concentrations. Instead, the AAS exposure was associated with elevated klotho serum levels and the klotho as a biomarker in relation to androgens deserves further investigation. Klotho levels were not influenced by the administration of recGH and suggested not to be a promising biomarker for GH doping.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Review Board, Stockholm. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

LE and ML were involved in the concept/design of the GH administration study. LE, ML, and AB were involved in the concept/design of the AAS study. LE, HB, and CS performed the quantification of IGF-I and klotho. LE, CS, and AP were responsible for the acquisition of data. LE wrote the first manuscript draft. All authors were involved in the critical revision of the article. All authors listed met the conditions required for full authorship. All authors contributed to the article and approved the submitted version.

FUNDING

Grants for performing the rhGH administration study and the collection of samples from AAS users were previously supported by WADA and the Swedish Research Council for Sport Science, respectively, and the analyses herein were supported by the Doping Control Laboratory, Karolinska University Hospital.

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frontiers | Frontiers in Sports and Active Living

ORIGINAL RESEARCH
published: 24 May 2022
doi: 10.3389/fspor.2022.839976

Prevalence of Prohibited Substance Use and Methods by Female Athletes: Evidence of Gender-Related Differences

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To achieve optimal sports performances, women and men may show specific doping practices because of the physiological and psychological gender differences, but there are few data on this topic. Here, we report the apparent use of prohibited substances and methods by female athletes based on analyses of the doping tests collected by the French Anti-Doping Agency from 2013 to 2019. We compared the frequency of use and the ergogenic and side effects to those of their male counterparts. The results revealed lower use of prohibited substances in female vs. male athletes, with significantly fewer anabolic agents, hormone and metabolic modulators, and cannabinoids. Gender specificity in utilization of substance classes was also shown. Relatively lower use of hormone modulators and cannabinoids and higher use of beta-2 agonists, diuretics and glucocorticoids were found in the woman cohort compared with men cohort, combined with the different choice of substances, possibly because of the altered ergogenic and/or side effects. However, no impact due to gender regarding the sports disciplines was observed, with both women and men showing similar use of anabolic agents, mainly in the anaerobic sports, and EPO and corticoids, mainly in endurance or mixed sports. Further studies are needed to put these French data into a global perspective, comparing uses across countries and exploring possible new developments in the fight against doping in women.

Keywords: doping, woman, anabolic agents, cannabinoids, beta-2 agonists

OPEN ACCESS

Edited by:
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Reviewed by:
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Specialty section:
This article was submitted to Anti-doping Sciences, a section of the journal Frontiers in Sports and Active Living

Received: *20 December 2021*
Accepted: *04 April 2022*
Published: *24 May 2022*

Citation:
Collomp K, Ericsson M, Bernier N and Buisson C (2022) Prevalence of Prohibited Substance Use and Methods by Female Athletes: Evidence of Gender-Related Differences. Front. Sports Act. Living 4:839976. doi: 10.3389/fspor.2022.839976

INTRODUCTION

Women were first allowed to participate in the Olympic Games in the early 1900s, but only in a limited number of sports, such as archery, lawn tennis, figure skating, and swimming (Lal and Hoch, 2007). Since then, their inclusion in other sports has continued, but several reviews (Lepers, 2008; Thibault et al., 2010; Bassett et al., 2020) have noted that the significant gaps between women and men in terms of sports records persist, with an overall 10% average higher performance in men. This gap due to gender is essentially explained by physiological, psychological, and sexual characteristics, directly or indirectly linked to gonadal hormone secretion, i.e., estrogens and progesterone in women and testosterone in men (Bassett et al., 2020).

Compared with men, women are smaller and lighter, and they have more body fat and lower skeletal muscle mass with shorter fiber lengths and cross-sectional areas (Haizlip et al., 2015; Trevino et al., 2019). In parallel, they have less bone mass and greater joint laxity (Nieves et al., 2005). All these factors mean not only lower force production and anaerobic capacity, but also a greater risk of bone fracture (Doherty et al., 2014; Wolf et al., 2015). Respiratory and cardiac functions are also lower in women during exercise because of a smaller respiratory tract and lungs coupled with a smaller heart and lower maximal cardiac output (Wheatley et al., 2014; LoMauro and Aliverti, 2018). The addition of lower blood volume, red blood cell number, and hemoglobin level leads to a significantly lower aerobic capacity compared with men, which is partially offset by a higher contribution of fat oxidation, lower fatigability, and higher recovery capability (Dasilva et al., 2011; Bassett et al., 2020). Last, sex steroid hormones influence cognitive function and emotional processing. According to the "sexually dimorphic" theory, men perform better in visuospatial skills, whereas women outperform men in verbal skills, and the impact of sex hormones at every level of the central nervous system to the muscle itself suggests a potential effect due to gender on balance and motor control (Castanier et al., 2021).

These sexual characteristics could lead to differences in doping behaviors and practices to achieve optimal performance. Since 2004, the World Anti-Doping Agency (WADA) (WADA prohibited list, 2022) has been updated at least once a year. It includes the classes of substances (S) and methods (M) prohibited at all times (in- and out-of-competition, only in-competition and in particular sports (P) (**Supplementary Material** section). To our knowledge, only one study (Mazzeo et al., 2019) conducted on Italian professional athletes, and focused on a direct comparison of substance use based on the results of a WADA-accredited anti-doping laboratory. In order to complete the results of this first descriptive study, we present here the larger scale findings on the detected use of banned substances and methods in samples from mostly elite athletes collected by the French Anti-Doping Agency (AFLD). The samples were analyzed by WADA-accredited laboratories in accordance with the WADA International Standard for Laboratories (WADA ISL, 2021). In parallel to the frequency of use, we reviewed the documented ergogenic and side effects for each substance class in women, in order to try to understand the differences in use between the genders, if any. We refer to female athletes based on their biological gender reported by the doping control officer.

METHODS

The data used for this study were based on test results obtained for doping controls (from the AFLD) performed between 2013 and 2019. The year 2020 was excluded from this study since fewer controls were performed, and many competitions were canceled due to COVID-19 pandemic. Data were extracted from the WADA Anti-Doping Administration & Management System (ADAMS) platform with AFLD consent. For each test result, the following information was collected: discipline, gender, test result [negative, adverse analytical findings (AAF, test results were prohibited substance or method have been confirmed) or atypical findings (ATF, test results where it is not possible to conclude as negative or AAF)], substance detected, substance or method class, sample type (urine or blood), and year of collection. As it was impossible to know the therapeutic use exemption (TUE) obtained by the athletes, all the AAF results reported by the laboratory, which followed the WADA International Standard for Laboratories (WADA ISL, 2021) in force along the selected years, were considered in this study, as in WADA's annual statistical report. This may be a study limitation, first, because some prohibited substances/methods are not currently detectable and, second, because there is a slight overestimation of the number of violations, particularly for beta-2 agonists and glucocorticoids that can be covered by a TUE. However, as shown in the article of Vernec and Healy (2020), this did not constitute a bias because the same prevalence of TUEs was observed for both genders, whatever the pharmacological class involved. In the same manner, due to the anonymization of the data, it was not possible to know if an athlete has been tested on different occasions but the same doping control logistics was followed by the AFLD regardless of the gender of the athletes. Finally, only one substance was reported when the drug and its metabolites were found in the same sample.

SPORTS CLASSIFICATION

As there is a clearly sport-specific use of doping substances (Aguilar-Navarro et al., 2020), the sports were divided into the following categories: Category A: anaerobic sports (strength, power, and speed); Category B: aerobic sports (endurance); Category C: mixed aerobic/anaerobic sports; and Category D: combat sports and others. Team sports were included in Category C and sports with weight categories were included either in Category A (weightlifting, powerlifting, etc.) or Category D (boxing, judo, karate, etc.).

STATISTICS

Standard descriptive statistics were performed in the R programming environment (version 4.1.1) and a Fisher exact test was used to compare the frequency distributions of: (i) use of substance classes relative to the number of samples per gender; (ii) use of substance classes relative to AAFs; and (iii) use of substance classes relative to sports categories. Due to the smaller number of samples taken from women vs. men, the statistical conditions were not fulfilled for some substances, for which it was therefore not possible to carry out the analysis of comparison. Similarly, S0 (non-approved substances), P1 (beta-blockers) and M2 (prohibited methods) were not processed due to the too small number of AAFs, i.e., 0 for S0, 5 for P1 (3 men; 2 women) and 1 for M2 (1 woman). The null hypothesis was rejected at $p<0.05$.

TABLE 1 | Number of controls (NC) for blood (B) and urine (U) and number of controls with AAF in males and females from 2013 to 2019.

		Females		Males	
		NC	**AAF**	**NC**	**AAF**
2013	B	78	0	634	1
	U	1817	30	5209	107
2014	B	98	1	342	1
	U	1537	24	5448	73
2015	B	101	0	451	0
	U	1578	26	5018	100
2016	B	136	0	554	9
	U	1572	18	5196	131
2017	B	93	0	764	2
	U	1085	31	4645	127
2018	B	38	0	438	4
	U	1487	18	5714	117
2019	B	89	1	346	1
	U	1527	11	5420	56
% of samples leading to AAF		**1.42%**$^{++}$		**1.81%**	

$^{++}p < 0.01$, *gender difference in % of samples leading to AAF.*

RESULTS

Number of Controls, AAFs, and Substances by Gender

The total number of urine and blood samples over the 7 investigated years (**Table 1**) was lower for women compared with men (22% of the total number of controls, $p < 0.001$). The number and percentage of AAFs related to the number of samples collected by the biological gender were also significantly lower in women vs. men when we compared the number of samples leading to AAFs (1.42 vs. 1.81%, $p < 0.01$) and the total number of substances identified in these samples (1.98 vs. 2.88%, $p < 0.001$). Compared to men (**Table 2**), significantly fewer anabolic agents (S1, $p < 0.001$) were reported from female samples (S1, $p < 0.001$), with lower values for both exogenous and pseudo-endogenous anabolic-androgenic steroids (AASs) ($p < 0.001$). In parallel, fewer hormone and metabolic modulators (S4, $p < 0.001$) and cannabinoids (S8, $p < 0.001$) were found in women vs. men, with no change in the other classes or methods. Last, there was a combined use of S1 (anabolic agents) and S4 (hormone and metabolic modulators) substances (71% of S4 substances associated with S1 substances) in men but not women.

Gender Specificity in Percentage of Class Utilization

There was a significant difference due to gender in the relative percentage of use of the prohibited substance classes and methods (**Figure 1**). Indeed, compared to their male counterparts, female athletes used significantly fewer substances from S4 ($p < 0.05$) and S8 ($p < 0.001$) and more S3 ($p < 0.05$), S5 ($p < 0.05$), and S9 ($p < 0.01$), with a trend toward fewer S1 substances ($p = 0.06$). No difference due to gender in the % of use was found for the other classes.

Gender Specificity in Substance Utilization

Significant differences due to gender were also found for some of the substances (**Table 2**). Among S1 substances, female athletes used relatively fewer endogenous AAS ($p < 0.05$) and more other anabolics ($p < 0.01$) like clenbuterol ($p < 0.05$) than men. In S3, the number of terbutaline uses relative to the number of controls was greater in women than in men ($p < 0.05$). In S5, furosemide was predominately detected in woman vs. man samples ($p < 0.05$). In S6, there was a preferential use of heptaminol in women (relative: $p < 0.001$; absolute: $p < 0.01$), with a significantly lower use of cocaine ($p < 0.05$) compared with men. In S9, the absolute and relative percentage of prednisone and prednisolone use was greater in women ($p < 0.05$ and $p < 0.01$, respectively), whereas the use of triamcinolone was significantly lower ($p < 0.01$). In S2, women exclusively used recombinant EPO, in contrast to men, in whom hGH, LH-releasing factors, and growth factors were detected. Similarly, in S4, only anti-estrogenic substances such as tamoxifen were found in women, although they were only used by half the men, who combined them with aromatase inhibitors and metabolic modulators such as meldonium.

Gender Specificity in Sports Categories

No gender difference emerged in class use regarding the sports categories (**Figure 2**). Indeed, in both female and male athletes, S1 class was mainly used in anaerobic sports and S2 class in aerobic sports. S5 class was mostly found in weight-category sports in both women (Category A: 53%; Category D: 14%) and men (Category A: 40%; Category D: 19%), whereas S9 class was mainly reported in endurance and mixed sports.

TABLE 2 | Number and % per class for the most used substances (>3%).

Class	Females: 223 (1.98%)$^{\&\&\&}$	Males: 1157 (2.88%)
Substances: Number and % per class for the most used substances (>3%)		
S1	**70 (0.62%)** $^{\&\&\&}$	**440 (1.09%)**
	• 38 exogenous AAS$^{\&\&\&}$: stanozolol (39%), oxandrolone (15%), drostanolone (13%) • 14 pseudo endogenous AAS$^{\&\&\&*}$: 19-norandrosterone (47%), testosterone and related compounds$^{\&}$ (26.5%), boldenone$^{\&}$ (26.5%) • 18 other anabolics** (26%): clenbuterol*(83%)	• 244 exogenous AAS: stanozolol (29%), trenbolone (13%), drostanolone and metanedienone (11%) • 142 pseudo endogenous AAS: 19-norandrosterone (46%), testosterone and related compounds (24%), boldenone (30%) • 54 other anabolics (12%): clenbuterol (94%)
S2	**6 (0.05%)**	**41 (0.10%)**
	• 6 rhEPO (100%)	• 29 rhEPO (71%) • 10 peptide hormones and releasing factors (24%) • 2 growth factors and growth factor modulators (5%)
S3	**14 (0.12%)***	**35 (0.09%)**
	• 12 terbutaline$^{\&}$ (85.7%) • 2 others: salmeterol, vilanterol (14.3%)	• 19 terbutaline (54%) • 16 others: higenamine, salbutamol, salmeterol (46%)
S4	**5 (0.04%)** $^{\&\&\&*}$	**69 (0.17%)**
	• 5 anti-estrogenic substances: tamoxifen (60%), raloxifene (20%), clomiphene (20%)	• 33 anti-estrogenic substances: tamoxifen (38%), raloxifene (9%) • 22 aromatase inhibitors: letrozole (9%), anastrozole (10%), androstatrienedione (11%),... • 14 metabolic modulators: meldonium (17%),…
S5	**32 (0.28%)***	**106 (0.26%)**
	• 13 furosemide$^{\&*}$ (41%) • 10 canrenone (31%) • 2 hydrochlorothiazide (6%) • 7 others: other thiazides,…(22%)	• 23 furosemide (22%) • 20 canrenone (19%) • 23 hydrochlorothiazide (22%) • 40 others: other thiazides (8%), dorzolamide (6%),…
S6	**29 (0.26%)**	**131 (0.33%)**
	• 15 heptaminol$^{\&\&***}$(52%) • 6 amfetamine and derivates (21%) • 6 tuaminoheptane (21%) • 1 cocaine$^{\&*}$(3.0%) • 1 ephedrine and derivates (3.0%)	• 20 heptaminol (15%) • 45 amfetamine and derivates (34%) • 17 tuaminoheptane (13%) • 27 cocaine (21%) • 16 ephedrine and derivates (12%) • 6 others (5%)
S7	**9 (0.08%)**	**34 (0.08%)**
	• 8 morphine (89%) • 1 other: buprenorphine	• 29 morphine (85%) • 5 others: methadone (12%),...
S8	**3 (0.04%)** $^{\&\&\&***}$	**120 (0.30%)**
	• 3 cannabis$^{\&\&\&}$(100%)	• 120 cannabis (100%)
S9	**52 (0.46%)****	**178 (0.44%)**
	• 40 prednisone/prednisolone$^{\&**}$(77%) • 3 triamcinolone$^{\&\&**}$ (6%) • 9 others: budesonide (11%), fluticasone (6%)	• 93 prednisone/prednisolone (52%) • 44 triamcinolone (25%) • 41 others: betamethasone (8%), budesonide (8%), …
P1	**2 (0.02%)**	**3 (0.01%)**
	• 2 propanolol	• 1 propanolol • 1 bisoprolol • 1 nebivolol
M2	**1 (0.01%)**	**0**
	• 1 tampering	

$^{\&\&\&}p < 0.001$; $^{\&\&}p < 0.01$; $^{\&}p < 0.05$, gender difference in class and substance use relative to number of controls.

****p < 0.001; **p < 0.01; *p < 0.05, gender difference in substance use relative to AAFs per class.*

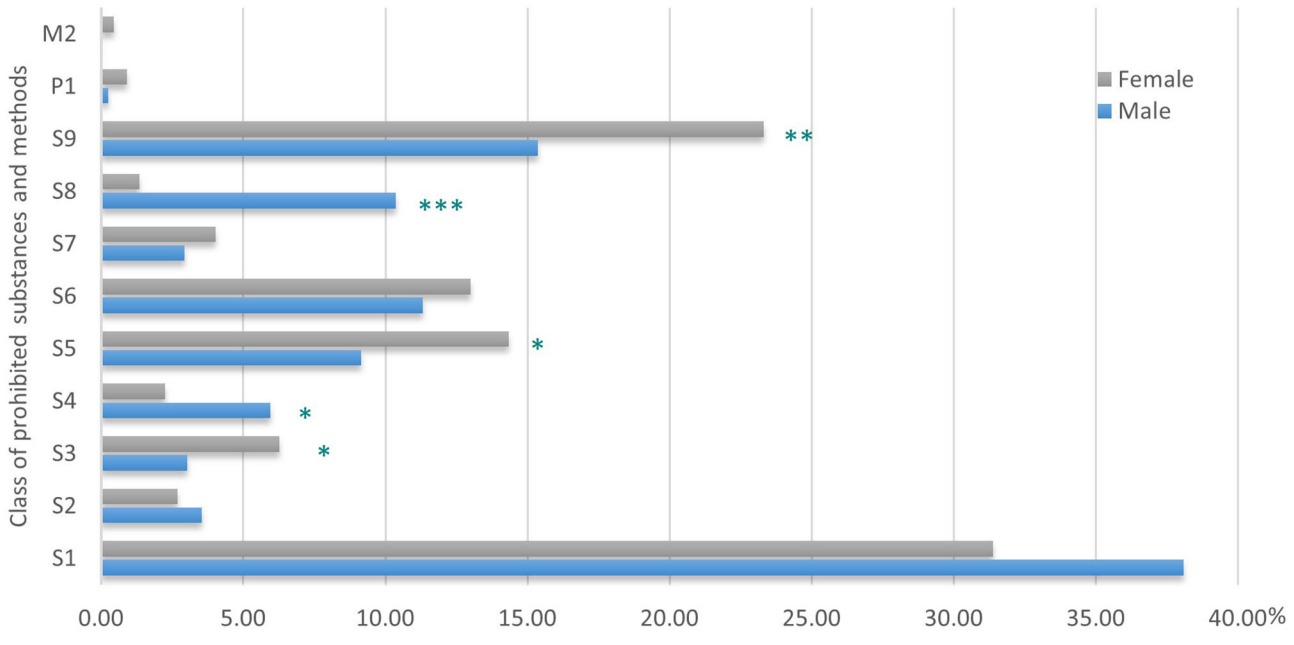

FIGURE 1 | Distribution of classes of prohibited substances and methods (in %) in female and male athletes. ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$, gender difference in distribution of class of substances and methods.

DISCUSSION

The main results of this study of female vs. male athletes were the following: (i) lower use of prohibited substances/methods for females, with fewer anabolic agents, hormone and metabolic modulators, and cannabinoids; (ii) specific use of substance classes and prohibited methods, including a relatively lower use of cannabinoids and hormone modulators for females, and also higher use of beta-2 agonists, diuretics, and glucocorticoids; (iii) a different choice of substances, possibly due to altered ergogenic and/or side effects; and (iv) an identical class use according to the sports categories, with anabolic agents and diuretics mainly found in anaerobic sports, and peptide hormones and glucocorticoids in endurance or mixed sports.

Our data showed a lower number of tests (22%) in female than male athletes, which partly reflects the lower number of elite French female athletes (39%) (French Ministry of Sports, 2021), and a lower percentage of AAFs, because of fewer anabolic agents (S1), hormone and metabolic modulators (S4), and cannabinoids (S8). Our data were in accordance with the descriptive study of Mazzeo et al. (2019) on Italian professional athletes from 2007 to 2017, but comparison is difficult because of the smaller cohort in that study. Given the gender differences in class use noted here, we now present the known ergogenic and side effects for each class in women, analyzing, where possible, substance use and effect within those classes.

S1. Anabolic Agents

Our data showed a significant difference in the utilization of S1 substances, with lower use by women vs. men, because of the significantly lower number of both exogenous and pseudo-endogenous AAS adverse cases. Short-term administration of anabolic substances improves male anaerobic performance through an increase in muscle strength and power (Hartgens and Kuipers, 2004), but it does not improve aerobic performance (Baume et al., 2006). The few studies performed in women seem to show, as in men, a significant increase in muscle mass combined with a significant improvement in anaerobic performance (Franke and Berendonk, 1997; Fitch, 2008; Huang and Basaria, 2018), which may explain the predominant use of S1 class in anaerobic sports for both women and men. It was interesting to note, however, the relatively greater use by females of "other anabolic agents." AAS induce abnormal endogenous hormone secretion, producing such reversible or irreversible damage as acne vulgaris, androgenic alopecia, hypertrichosis, liver cancer, cardiovascular risks, renal failure, and increased tendon ruptures (Hartgens and Kuipers, 2004). AAS are also known to induce psycho-behavioral disorders leading to violence or depression, with more aggressive responses in men (Gruber and Pope, 2000; Chegeni et al., 2021). AAS also induce gender-specific side effects, with either gynecomastia, testicular atrophy, azoospermia, and infertility in men or amenorrhea, uterine atrophy, and clitoral enlargement in women (Liu and Wu, 2019). There is a consensus that the use of classic AAS such as testosterone and nandrolone esters is associated with greater physiological adverse effects in females than male athletes, with hirsutism, voice deepening, and menstrual disturbances, though this depends on the molecule (Franke and Berendonk, 1997; Fitch, 2008; Huang and Basaria, 2018). Use of other AAS considered to be steroid precursors, such as DHEA, has been less documented in a young healthy population but seems to

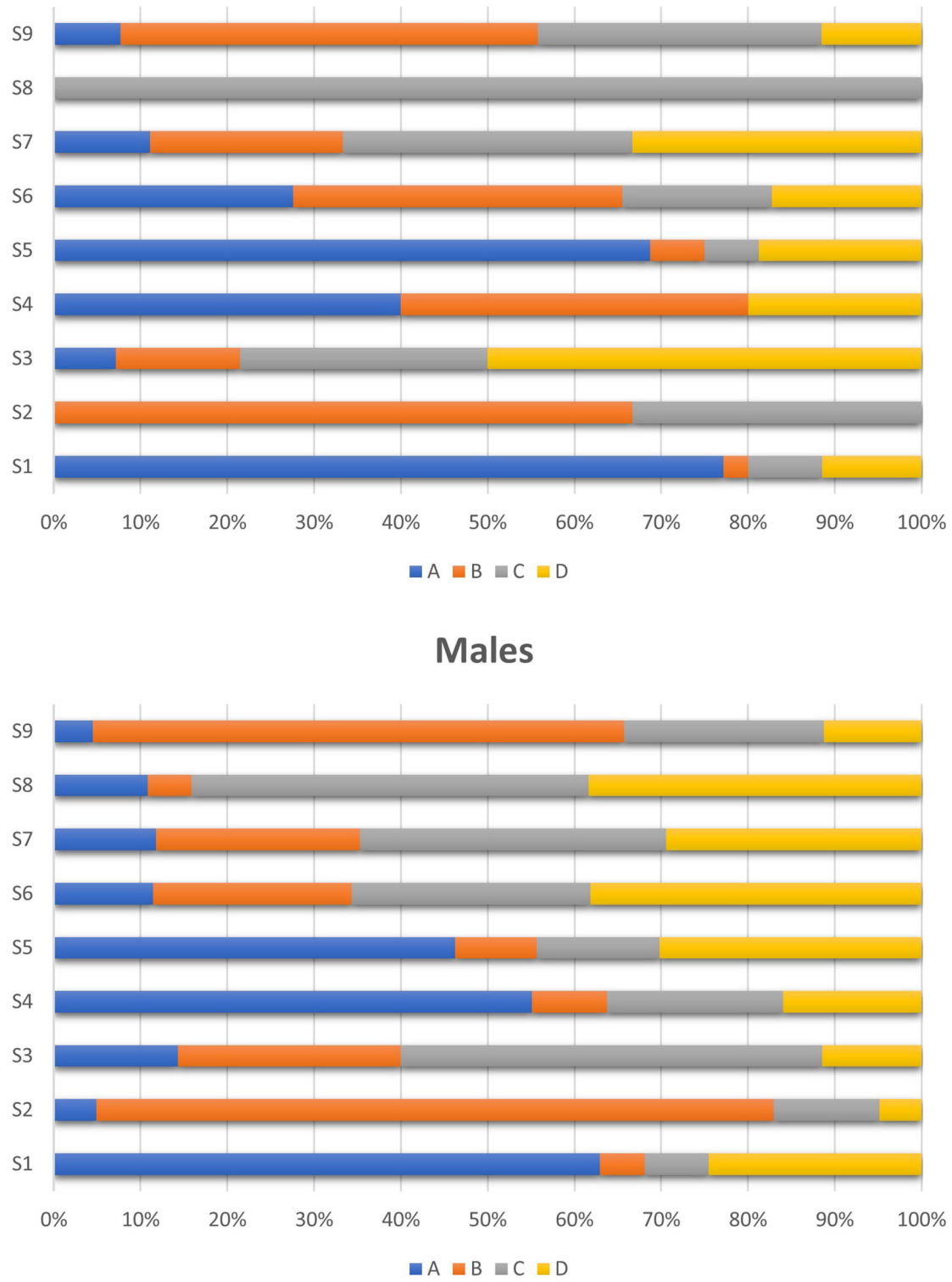

FIGURE 2 | Class use by women and men regarding the sports discipline. Group A: anaerobic sports (strength, power, and speed); Group B: aerobic sports (endurance); Group C: mixed aerobic/anaerobic sports; Group D: combat sports and others. S0, P1 and M2 were not represented, due to the too small number of AAFs, i.e., 0 for S0, 5 for P1 (3 men, 2 women) and 1 for M2 (1 woman).

induce fewer ergogenic, physiological and psychological side effects in recreationally trained female athletes (Gravisse et al., 2018). However, the physiological side effects of other non-androgenic anabolic agents such as clenbuterol appear to be more limited than those of AAS in female athletes. Despite the lack of studies in woman, the absence of androgenic effects of this type of substance could explain its greater use by female athletes demonstrated here.

S2. Peptide Hormones, Growth Factors, Related Substances, and Mimetics

No significant difference in the use of the S2 class between women and men was observed in our data. Short-term use of rhEPO markedly improves endurance capacity in male athletes, and this is identified by a significant increase in VO_2 max or maximal aerobic power in running or cycling trial performances (Salamin et al., 2018; Sgrò et al., 2018; Haile et al., 2019). For this reason, rhEPO analyses focus on aerobic sports and, unsurprisingly, we found all rhEPO cases in either endurance or mixed sports. It is generally assumed that the main part of performance improvement with rhEPO administration is related to blood adaptations that enable higher oxygen transport. Unfortunately, to our knowledge, no study on performances in female athletes has been conducted, even though their lower blood volume, red blood cell number, and hemoglobin level probably modulate the stimulating effect on erythropoiesis. Regarding the side effects, they appear to be much more limited in the short term since the advent of micro-dose administration, but here again, data exist only for male athletes (Salamin et al., 2018). In a study on young healthy sedentary volunteers, however, Gambardella et al. (2016) suggested that the rhEPO effects might be confined to the vascular wall in males, with stabilization of the thrombi, whereas its effects in females can be observed in the peripheral circulation, with possible high blood thrombogenicity that merits more careful medical attention to female athletes. Nevertheless, rhEPO accounted for all the AAF in females for this S2 class, contrarily to males. Caution is warranted here in view of the small number of analyses carried out, but it could be suggested that the other S2 substances used by male athletes, i.e., hypoxia-inducible factors, GH, LH and their releasing factors, may induce either less ergogenic or more marked side effects in women. Given the difficulty of obtaining approval from the Ethics Committees for the administration of rhGH in athletes, few studies have investigated its ergogenic effects in trained subjects (Berggren et al., 2005; Marchand et al., 2019), with only one in females (Berggren et al., 2005). The authors reported no change in maximal oxygen uptake or maximum power output during exercise with rhGH use (Berggren et al., 2005; Marchand et al., 2019), and also increased body weight that was attributed to fluid retention and not muscle mass (Berggren et al., 2005). Despite these results, the rhGH impact on both anaerobic and aerobic performance is not in doubt, due to its direct and indirect anabolic (Holt and Sönksen, 2008; Siebert and Rao, 2018) and lipolytic effects (Healy et al., 2006) with, in terms of IGF-1, a greater response to rhGH treatment in men (Giannoulis et al., 2005). Although it remains unknown whether the cardiovascular, metabolic, and neuropsychiatric side effects reported in patients with chronic GH treatment occur in athletes (Siebert and Rao, 2018), short-term supra-physiological rhGH treatment was shown to induce central hypothyroidism in both male and female recreationally trained athletes from various team sports, but with distinct gender-related patterns, probably due to modulation of gonadal steroids on the GH-IGF-1 axis (Sgrò et al., 2016). Last, it should be recalled that, given the small number of GH analyses and the very short elimination half-time of rhGH (Giannoulis et al., 2005), the number of positive cases probably greatly underestimates actual use by athletes, irrespective of gender.

S3. Beta-2 Agonists

This study highlighted relatively greater use of beta-2 agonists in women vs. men, with a higher use of terbutaline. The effects of beta-2 agonists on aerobic performance have been investigated in both male and female athletes after acute therapeutic inhalation of salbutamol (Koch et al., 2015, 2016) and terbutaline (Molphy et al., 2019), with no performance change noted whatever the gender (Koch et al., 2015, 2016; Molphy et al., 2019). However, acute salbutamol intake induced a significant increase in both anaerobic peak power and capacity in women (Le Panse et al., 2007), whereas only improvement in peak power was reported in men (Collomp et al., 2005). After short-term oral salbutamol administration, maximal anaerobic power but not capacity was improved, irrespective of the gender or training status, with no change in body composition (Le Panse et al., 2005, 2006). Other studies performed only in men showed various results after salbutamol or terbutaline inhalation or intake, with change or no change in aerobic (Collomp et al., 2000) and anaerobic performances, coupled or not to anabolic effects (Hostrup et al., 2014; Jessen et al., 2021). Women may have greater sensitivity to beta-2 receptor stimulation (Kneale et al., 2000), but in view of the same TUE prevalence for beta-2 agonists in female and male athletes (Vernec and Healy, 2020) and the lack of studies on the pharmacokinetics and the ergogenic, physiological, and psychological terbutaline effects in women, it is difficult to speculate on the higher number of terbutaline cases found in female athletes. Last, in the abovementioned studies, some participants of both genders experienced mild and similar adverse physiological side effects, whereas psychological repercussions were not explored.

S4. Hormone and Metabolic Modulators

Lower use of this class by women was clearly shown in this study. Over the 7 years investigated, the most frequently used substance by both genders was tamoxifen, which is an estrogen antagonist prescribed for the breast cancer in women that stimulates testosterone secretion in men but not women. Tamoxifen's effect on athletic performance remains unknown (Matich, 2007), but its estrogen effect seems to be mostly used by men to limit the gynecomastia induced by AAS administration, as most samples of men with S4 substances also contained S1 substances.

S5. Diuretics and Masking Agents

Our data showed a relatively greater use of the S5 class by the women, with a higher number of furosemide cases in this population. S5 substances have no ergogenic effect and are used to mask the use of other prohibited substances by diluting the urine, or methods, to induce rapid weight loss or treat hypertension. The majority of these cases was thus found, regardless of gender, in the anaerobic and combat sports that have weight categories. It can be suggested that the relatively higher use by women may be related to the greater variations in body weight because of the fluctuations in hormonal status during the menstrual cycle (Ryan et al., 2021).

S6. Stimulants

The data did not show gender-specific effects for the S6 class but did show gender specificity for the substances, with less cocaine and more heptaminol in women vs. men. Several studies have shown that amphetamine and cocaine administration improves aerobic and anaerobic performances in humans (Wyndham et al., 1971; Chandler and Blair, 1980; Clarkson and Thompson, 1997), with a tolerance and withdrawal effect when taken chronically, but no studies have been conducted in woman. For ephedrines, a correlation clearly exists between the dose administered and its ergogenic effects (Trinh et al., 2015). Some studies have been performed in females (Clemons and Crosby, 1993; Chait, 1994), with one showing a better mood response to ephedrines in male subjects (Chait, 1994). In this study, the lower number and % of female samples containing cocaine metabolites compared with male samples suggest that females use fewer illicit drugs than male. Regarding the higher number of samples containing heptaminol in women and the lack of studies on the ergogenic and side effects of this substance in either gender, it can only be hypothesized that women tend to use more supplements, with many of them containing heptaminol.

S7. Narcotics

As for the S6 class, the data showed no impact of gender on the absolute or relative use of substances from the S7 class. Morphine, a major analgesic and metabolic of codeine, accounted for most of the cases of this class in both women and men.

S8. Cannabinoids

It appears clearly from our data that the use of cannabis is more limited in women. These data are in line with the various studies carried out by questionnaire (Lorente et al., 2005), showing a lower use of "recreational drugs" for women compared with men, even outside the sporting context. As there is no consensus at present about the ergogenic effect of cannabis, the lower use in women probably reflects a healthier lifestyle. Last, it should be noted that most of the cannabis cases in male athletes were found in mixed sports, including team sports and combat sports.

S9. Glucocorticoids (GCs)

The data showed a relatively higher use of glucocorticoids by women vs. men, with a greater number of prednisone and prednisolone samples and a lower number of triamcinolone samples. Only systemic and not local (Kuipers et al., 2008) short-term administration of corticoids produces significant ergogenic effects during exercise lasting more than 40 min in both man (Arlettaz et al., 2007; Collomp et al., 2008) and woman (Le Panse et al., 2009) recreationally trained athletes, with a similar gender performance improvement, whereas GC ergogenic effects appear more variable in brief exercise (Nordsborg et al., 2008; Casuso et al., 2014; Zorgati et al., 2014). This was clearly evident in our data by the predominance of GCs in endurance and mixed sports, regardless of gender. The duration of hypothalamic-pituitary-adrenal (HPA) axis inhibition with oral therapeutic doses of prednisone/prednisolone was also found to be similar in women and men (Jollin et al., 2010; Collomp et al., 2014). However, as no hyperglycemia has been reported in female athletes after short-term prednisone treatment (Le Panse et al., 2009), contrarily to their male counterparts (Arlettaz et al., 2007), it could be suggested that women are less sensitive than men to the insulin resistance induced by GCs. This may be an argument for the preferential use of GCs in women, as similar TUE prevalence for GC was reported in elite athletes of both genders (Vernec and Healy, 2020).

LIMITATIONS

First, the prevalence of drug use was estimated from the detection in anti-doping tests. This is an extrapolation, but the preferred approach for estimating the prevalence of illicit drug use in different populations, as the results from toxicological analyses of biological matrices are much more conclusive than the use of questionnaires, which leads to underestimation (Tavella et al., 2020).

Second, it was assumed that the detection of substances was identical in women and men. Most drugs currently in use were approved based on the clinical trials conducted only on men, despite the fact that pharmacokinetics may be gender specific, as it was recently shown for anti-inflammatory drugs, antidepressants, and anti-cancer drugs (Zucker and Prendergast, 2020) with, in general in women, higher blood concentrations inducing higher risk of adverse effects, reduced clearance and longer elimination times, that may potentially increase AAF female cases in an anti-doping context.

Third, it cannot be ruled out that women may be using drugs with shorter half-lives, and hence less frequent detection, than men, or *vice-versa*, for all the prohibited classes.

At last, considering the fewer samples collected from women than from men, a conservative test for unequal sample sizes was selected, but it was unfortunately not possible to statistically compare the gender-related use for all the detected substances.

Therefore, in order to definitively and more sharply establish the gender-specific doping prevalence, it seems necessary to set up a new anti-doping approach better targeted on female athletes, according to their hormonal status if possible.

CONCLUSION AND PERSPECTIVES

In conclusion, despite the smaller number of controls carried out for women compared with men, the present data highlight the apparent lower use of prohibited substances by women vs. men athletes. We also found gender-related differences in the use of substances and classes of substances. However, no gender difference related to the type of sport was observed, with anabolic agents mainly found in the anaerobic sports, and rhEPO and corticoids in endurance or mixed sports. Further studies are required to collaborate these French data into a global perspective, comparing uses across countries and opening discussions on possible new developments in the fight against women doping. Areas for discussion include increasing the number of tests in this population and the need for further study of the pharmacokinetics and the physiological, psychological, and side effects of many of the substances that remain unknown in woman athletes.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding authors.

AUTHOR CONTRIBUTIONS

KC and CB: study conception, data analyses, and manuscript writing. ME and NB: data analyses and manuscript writing. All authors agreed to the published version of the manuscript and formed a consensus on the resulting conclusions and recommendations.

ACKNOWLEDGMENTS

The authors would thank the French Anti-Doping Agency (AFLD) for its permission to use test results obtained for doping controls performed in France. The authors would also thank Cathy Carmeni for her expert assistance.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fspor.2022.839976/full#supplementary-material

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BRIEF RESEARCH REPORT
published: 27 May 2022
doi: 10.3389/fspor.2022.858730

Every Young Athlete Counts: Are Tailored Doping Prevention Programs Necessary in Young Elite Sports?

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Conclusions from doping prevention literature recommend tailored anti-doping education for athletes' specific needs. Newer approaches like the International Standard for Education of the World Anti-Doping Agency recommend a needs assessment before implementing measures. The International Standard for Education refers to the type of sports and its associated risk for doping. Following this idea, elite athletes from different types of sports should differ in their prerequisites for doping prevention. Consequently, the guiding research question focused on exploring the doping-prevention-related background of young athletes as a particular group for prevention efforts. Sixty young elite athletes (58.3% male) took part in a cross-sectional online survey, which was quantitatively analyzed. Participants included 26 athletes from a sport with low doping prevalence (sailing) and 34 athletes from a sport associated with high doping prevalence (wrestling). Sailors and wrestlers differed concerning the perceived resistance against doping temptations ($p = 0.031$, $r = 0.31$) and the estimated actual doping prevalence regarding sports in general (national frame: $p < 0.001$, $r = 0.60$; international frame: $p = 0.013$, $r = 0.43$). No differences between the two types of sports occurred, referring to doping attitudes, tendency to disengage morally, or topics athletes wish to learn about during doping prevention measures. All results indicated a good baseline for doping prevention with young elite athletes at the beginning of their careers. There is no sport-specific needs profile that could be used as a base for tailored measures. However, the data suggest that a differentiated consideration of gender could be helpful in the planning of doping prevention measures.

Keywords: anti-doping education, young elite athletes, individualization, evaluation, gender

OPEN ACCESS

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Specialty section:
This article was submitted to Anti-doping Sciences, a section of the journal Frontiers in Sports and Active Living

Received: *20 January 2022*
Accepted: *06 May 2022*
Published: *27 May 2022*

Citation:
Pöppel K and Büsch D (2022) Every Young Athlete Counts: Are Tailored Doping Prevention Programs Necessary in Young Elite Sports? Front. Sports Act. Living 4:858730. doi: 10.3389/fspor.2022.858730

INTRODUCTION

Peak performance is appreciated inside and outside elite sports. For this reason, some athletes try to gain an advantage by prohibited means, commonly known as doping. Highlighting the complexity, Petróczi(2021, p. S16) describes the phenomenon as follows: "When strategies for boosting performance employ substances or methods specifically outlawed by a governing body, such as the World Anti-Doping Agency (WADA), the practices become doping." Besides outlawing doping offenses, WADA aims to prevent doping by developing and implementing doping prevention measures (World Anti-Doping Agency, 2021b). Therefore, athletes should be qualified to make informed decisions as part of the management of their sports performance.

Understanding doping prevention as a learning process, this brief research report aims to specify a natural baseline level of characteristic variables of young athletes involved in talent development programs of different types of sports prior to doping prevention.

Doping prevention aims to support athletes to refrain from doping and arrange a fair and clean sports environment. Different prevention approaches were published recently to support athletes in resisting doping and maintaining the spirit of sport. For example, WADA's International Standard for Education (ISE, World Anti-Doping Agency, 2021b) pictures the shift from deterrence-based (e.g., Goldberg et al., 1991) to skill-oriented and values-based doping prevention or the protection of clean athletes (Petróczi et al., 2021). The ISE refers to a multifaceted handling of doping prevention: It strives for an early and global implementation of anti-doping education, offers constructive handling of doping prevention, and introduces ideas for interactive learning in the cognitive and affective domain, including values-based education. The ISE aims to enable a tailored application built upon an evaluation of the general setting and an additional needs assessment. The needs assessment should consider the specifics of sports, participants' learning needs as "a good first step to planning education," and the risk for doping in different types of sport (World Anti-Doping Agency, 2021b, p. 34). Even before the publication of the ISE, ideas for increasing the individualization of doping prevention measures have emerged.

Models of doping behavior guide the understanding of athletes' behavior and influence how prevention is implemented (Hauw and McNamee, 2015). Numerous publications on doping and prevention refer to the theory of planned behavior (Ajzen, 1991; Pöppel, 2021). They emphasize the impact of positive doping attitudes and perceived social norms as correlates of doping intentions and behavior or extend the theoretical model by adding the use of supplements or self-efficacy to resist doping (Ntoumanis et al., 2014). However, the focus on this theory is critically discussed (Petróczi et al., 2017). Nevertheless, many doping prevention studies use these variables to evaluate the effectiveness of interventions (Pöppel, 2021). Mainly newer approaches highlight the importance of ethics, moral disengagement, or resistance against doping temptations as target variables and broaden the prevention perspective (Elbe and Brand, 2016; Hurst et al., 2020; Kavussanu et al., 2021). According to these studies, doping attitudes, moral disengagement, and self-regulatory effectiveness represent variables of interest in the context of doping prevention. Irrespective of the concrete configuration of doping prevention, researchers increasingly demand scientific monitoring and evaluation of these measures to understand better the effect (Boardley et al., 2021; Pöppel, 2021).

Recommendations for doping prevention tend to be literature-based (e.g., Backhouse et al., 2012), developed by expert consensus (Boardley et al., 2021; Petróczi et al., 2021), or based on conclusions from empirical data (e.g., Elbe and Brand, 2016). These recommendations involve individualizing prevention measures, including online options, protecting clean athletes, and empowering informed decision-making (e.g., Backhouse et al., 2012; Pöppel, 2021). Hence, the request for tailored approaches includes the assumption that individual requirements of athletes exist. In 2017, for example, the German Nationale Anti-Doping Agentur (2020) launched the *Together Against Doping* program (German: *Gemeinsam gegen Doping*), which offers athletes a choice of different thematic units as part of a modular system. The content areas range from basic questions about doping to optimizing performance through nutrition. The idea of tailored approaches corresponds to the ISE's ideas of a prior needs assessment and the focus on target groups with a high risk for doping, which should be prioritized in education (World Anti-Doping Agency, 2021b). Therefore, this study aims to conduct a baseline level of variables characteristic of potential doping behavior and relevant to doping prevention.

Following official laboratory data, doping appears to be a comparatively rare phenomenon. Thus, World Anti-Doping Agency (2021a) reported a doping prevalence of 0.7% for sports overall. The prevalence considering Olympic sports ranged from 0% in sailing to 1.2% in weightlifting. However, the number of athletes using prohibited aids seems more comprehensive. Presumably, we face many unreported cases and difficulties in specifying an approximate value (Gleaves et al., 2021). According to their review data, the reported prevalence rates ranged from 0 to 73%. Facing the immense interval, the authors criticized a weak database of the underlying studies and referred to specifics of the population examined, like sports, gender, or geographic differences. While laboratory data underestimate the actual doping prevalence, individuals inside and outside elite sports assume that sports are more polluted than these official data indicate. Additionally, we face a more optimistic view of the situations in one's country. Coaches or fans, for example, estimated the prevalence in international competitive sports to be significantly higher than in the national setting (Solberg et al., 2010; Pöppel and Büsch, 2019).

A suspicion of doping can have severe consequences for athletes, including a competition ban or a withdrawal of achievements (World Anti-Doping Agency, 2021c). Therefore, athletes who engage in doping generally avoid doping-related disclosures. One can assume that response bias, like social desirability, influences athletes' answers concerning doping behavior and associated variables (Gucciardi et al., 2010; Petróczi and Nepusz, 2011). For this reason, researchers recommend a further application of indirect measures (Petróczi, 2016).

Gatterer et al. (2021) concluded that almost 75% of young elite athletes had received anti-doping education prior to the publication of the ISE (World Anti-Doping Agency, 2021b). These athletes rated the trust in the measures and the usefulness of this education as good. Considering that confidence in the fight against doping is decreased among older elite athletes due to negative experiences in doping controls and thus their socialization in elite sports (Petróczi et al., 2021), this good starting position should be used. Despite attempts to achieve international standardization, geographical differences concerning doping knowledge, beliefs, and attitudes can be found in young elite athletes (Königstein et al., 2021). The authors highlight the existence of a sound knowledge base as a valuable basis for doping prevention, influencing other variables such as

attitudes or beliefs. A sound knowledge might provide direction, also in the gray areas as the borderline between prohibited and not prohibited substance use is blurred.

Doping prevention should start early, like in preadolescence, and adolescent athletes are a favorite target group as they still develop their understanding of sports and enable most likely a primary prevention approach (Nicholls et al., 2017; Königstein et al., 2021). Additionally, we face an early onset of doping behavior as even under-10-years-olds reported doping (Nicholls et al., 2017). It is to assume that this age group is not aware of the consequences of harmful behavior yet and needs support to reflect on doping. Therefore, it is even more crucial to constructively equip young elite athletes for informed-decision making.

To gain a deeper insight, participants in this study included athletes with a high competition level, as this level corresponds to a high pressure to perform and a natural confrontation with doping topics. Furthermore, athletes should compete in types of sports which represent *extreme groups* concerning the risk for doping based on the respective doping prevalence according to World Anti-Doping Agency (2021a), which encompasses all elite athletes from junior to senior level. Referring to extreme groups might enhance the probability of differences in athletes' needs. Additionally, preferably young athletes should be included, as they have a favorable position for doping prevention (e.g., Backhouse et al., 2012; Königstein et al., 2021).

RESEARCH QUESTIONS

From a scientific perspective, recommendations for doping prevention include tailored measures for specific groups and an early onset (e.g., Backhouse et al., 2012). They rather represent a top-down position based on theoretical deductions (Boardley et al., 2021; Petróczi et al., 2021; Pöppel, 2021). An empirical needs assessment of the respective target groups prior to doping prevention is lacking. According to the idea of tailored doping prevention, differences should appear regarding the athlete's prerequisites and needs (e.g., depending on the different types of sports). The article is guided by the research question: How is the doping prevention-related background constituted in young elite athletes? And more specifically: Are sport-specific differences already apparent at the beginning of a career in the highest performance level in sports? In contrast to elite sports in general, it covers specifically the entrance in the high-performance level.

Approaches on the evaluation of anti-doping education represent a retrospective view (e.g., Hurst et al., 2020; Gatterer et al., 2021). This research report takes a forward-looking perspective and aims to provide an empirical baseline of young elite athletes' prerequisites concerning upcoming doping prevention. The analysis is based on variables discussed in the literature as relevant. Athletes should differ concerning:

1. the perceptions of the extent to which doping is prevalent in sport (cf. Pöppel and Büsch, 2019);
2. their doping attitudes (cf. Elbe and Brand, 2016);
3. their willingness to morally disengage (cf. Kavussanu et al., 2021);
4. their resistance against doping temptations (cf. Kavussanu et al., 2021);
5. their content-related requests for doping prevention (cf. World Anti-Doping Agency, 2021b).

METHODS

Study Design, Sample, and Recruitment

To answer the research questions, a cross-sectional online survey (survey tool: LimeSurvey) was conducted. The authors addressed extreme groups of athletes according to World Anti-Doping Agency's (2021a) report on doping prevalence to compare athletes with a comparable competition level but different sport-specific socialization. As representatives of the extreme groups for Olympic sports, this study addressed young athletes involved in talent development programs from sailing (*low* doping prevalence: 0%) and wrestling (*high* doping prevalence: 1.1%). They were included in this study representing young elite sports. The sports directors coordinated the data assessment within their federation by obtaining informed consent of the participants or their parents in case of minors and disseminating the invitation and the link to participate in the survey. The study was conducted following the recommendations of the Carl von Ossietzky University of Oldenburg, Germany, and the local committee approved the protocol for research assessment and ethics. All subjects gave their written informed consent in accordance with the Declaration of Helsinki. Data assessment took place in March 2020 (sailing) and September 2021 (wrestling).

Procedure

The online survey was primarily based on existing and validated questionnaires applied in a German translation. The athlete's attitude toward doping was assessed by the short version of the Performance Enhancement Attitude Scale (PEAS-S; Vargo et al., 2015). The scale indicated adequate reliability for a short form (Cronbach's $\alpha = 0.72$, Widaman et al., 2011). Participants indicated their agreement on a 6-point Likert scale (1 = strongly disagree to 6 = strongly agree), which led to a sum value (scores 8–14: strongly disagree, 15–21: disagree, 22–28: slightly disagree, 29–35: slightly agree, 36–42: agree, 43–48: strongly agree). High values indicated a more lenient doping attitude. Their moral perspective was assessed by the short version of the Doping Moral Disengagement Scale (DMDS-S; 7-point Likert scale from 1 = strongly disagree to 7 = strongly agree; Boardley et al., 2018). Its psychometric properties can be rated as weak in the underlying sample (Cronbach's $\alpha = 0.60$, Widaman et al., 2011). Additionally, the athlete's resistance against doping was evaluated based on the Doping Self-Regulatory Efficacy Scale (DSRES; Boardley et al., 2018). The participants indicated their confidence to resist on a 5-point Likert scale from 1 (no confidence) to 5 (complete confidence). According to Widaman et al. (2011), the scale's reliability is acceptable (Cronbach's $\alpha = 0.89$). DMDS-S and DSRES were interpreted based on the mean. Higher values corresponded to a critical doping representation.

The three short questionnaires were embedded by estimations of the actual national and international doping prevalence at the beginning of the survey, and a prioritization of topics of

the doping prevention program *Together Against Doping* of the German Nationale Anti-Doping Agentur (2020), as well as questions concerning the athlete's supplement use at the end of the survey. Finally, participants conveyed demographic data, including age, gender, squad status, and information concerning doping, doping prevention, and supplements.

Analysis

Data were analyzed applying the following software packages: IBM SPSS Statistics 27; JASP statistic software, version 0.16 (JASP Team, 2021); as well as G*Power, version 3.1.9.7 (Faul et al., 2020) to perform sensitivity analyses. Shapiro-Wilk tests carried out in advance showed a deviation from normality for the estimation of the doping prevalence, doping attitudes, moral disengagement, and self-regulatory efficacy. For this reason, non-parametric tests were applied to compare the two types of sport and a subsequent exploratory data analysis comparing male and female participants. As the logic of the different tests is based on rank data, medians (*Mdn*) and median absolute deviations (*MAD*) were reported in addition to means (*M*) and standard deviations (*SD*).

RESULTS

Altogether 60 athletes representing the highest levels of elite sports in Germany ($n = 34$ wrestling, $n = 26$ sailing) completed the survey, whereby two participants skipped conveying demographic information. The participant's mean age was 18.14 years ($SD = 2.24$), and 58.2 % ($n = 35$) of the sample was male (see **Table 1**). The participants of the two types of sports did not differ concerning age [$t_{(56)} = 0.63$, $p = 0.529$] or previous experience concerning doping prevention measures [$t_{(56)} = 1.28$, $p = 0.206$]. Most participants (68.3 %, $n = 39$) took part in one or two doping prevention measures. Thus, the baseline level evaluated here was heterogenous concerning prior prevention experience. Sixty percent of the participants ($n = 36$) indicated that they did not search for information on doping themselves.

The prevalence estimation showed substantial perception heterogeneity, indicated by the differences between the standard deviations. Regardless of this fact, many participants estimated the prevalence of doping to be considerably higher than the official laboratory data indicated (see **Table 2**).

Comparing the two types of sports, sailors perceived doping as more widespread in international and national elite sports in general (see **Table 2**). The heterogeneity of the participants' perception was apparent in the confidence interval of the effect sizes, which varied between a small to strong effect (international) and a medium to strong effect (national elite sports; Cohen, 1988). There were no differences between sailors and wrestlers concerning the perception of the prevalence of doping in their sport.

TABLE 1 | Characteristics of the sample.

		Sailing ($n = 26$)	Wrestling ($n = 34$)	Overall ($N = 60$)
Gender	Male	42.3 % ($n = 11$)	70.7 % ($n = 24$)	58.3 % ($n = 35$)
	Female	57.7 % ($n = 15$)	23.5 % ($n = 8$)	38.3 % ($n = 23$)
Age (years)	*M* (*SD*)	18.35 (1.36)	17.97 (2.78)	18.14 (2.24)
	Range	15–20	15–30	15–30
Squad	Perspective squad		14.7 % ($n = 5$)	8.3 % ($n = 5$)
	Youth squad 1	73.1 % ($n = 19$)	32.4 % ($n = 11$)	5% ($n = 30$)
	Youth squad 2	11.5 % ($n = 3$)	47.1 % ($n = 16$)	31.7 % ($n = 19$)
	Federal state squad	15.4 % ($n = 4$)		6.7 % ($n = 4$)
Style	Single-handed	42.3 % ($n = 11$)		
	Double-handed	57.7 % ($n = 15$)		
	Greco-roman		6.7 % ($n = 4$)	
	Freestyle		46.7 % ($n = 28$)	
Participation in doping prevention measures	0	23.1% ($n = 6$)	38.2% ($n = 13$)	31.7% ($n = 19$)
	1	34.6% ($n = 9$)	17.6% ($n = 6$)	25.0% ($n = 15$)
	2	1% ($n = 4$)	26.5% ($n = 9$)	21.7% ($n = 13$)
	3	15.4% ($n = 4$)	8.8% ($n = 3$)	11.7% ($n = 7$)
	4	3.8% ($n = 1$)		1.7% ($n = 1$)
	5			
	More than 5	7.7% ($n = 2$)	2.9% ($n = 1$)	5.0% ($n = 3$)
Own search for doping information	Yes	53.8% ($n = 14$)	23.5% ($n = 8$)	36.7% ($n = 22$)
	No	46.2% ($n = 12$)	70.6% ($n = 24$)	60.0% ($n = 36$)
Supplements use	Yes	34.6% ($n = 9$)	26.5% ($n = 9$)	30.0% ($n = 18$)
	No	65.4% ($n = 17$)	67.6% ($n = 23$)	66.7% ($n = 40$)
Application Cologne list	Yes	61.5% ($n = 16$)	61.8% ($n = 21$)	61.7% ($n = 37$)
	No	38.4% ($n = 10$)	29.4% ($n = 10$)	33.3% ($n = 20$)

Perspective squad: former B- and C-squad for athletes with outstanding performance perspective, second highest squad; youth squad 1: third highest squad, youth squad 2: fourth highest squad, federal state squad: lowest national squad level according to the German Olympic Sports Confederation.

TABLE 2 | Comparison of athletes from sailing and wrestling concerning their prevalence estimations as well as doping attitudes (PEAS-S), moral perspective (DMDS-S), and resistance against doping (DSRES).

Analysis section		Sailing *M* (*SD*) [*Mdn*, *MAD*]	Wrestling *M* (*SD*) [*Mdn*, *MAD*]	Mann-Whitney test
1	International elite sports overall	39.1 % (18.6) [40.0, 10.0]	25.5 % (20.0) [22.5, 12.5]	$U = 148.50$, $z = -2.48$, $p = 0.013$, $r = 0.43$ [95% CI: 0.19, 0.66]
	National elite sports overall	25.8 % (14.9) [25.0, 9.0]	11.8 % (19.1) [5.0, 4.0]	$U = 103.00$, $z = -3.50$, $p < 0.001$, $r = 0.60$ [95% CI: 0.33, 0.78]
	International elite sports own sports	9.6 % (9.3) [5.0, 4.0]	17.3 % (14.8) [16.5, 7.5]	$U = 177.00$, $z = -1.86$, $p = 0.064$, $r = 0.32$ [95% CI: −0.59, 0.01]
	National elite sports own sports	5.4% (8.26) [2.0, 2.0]	7.3 % (16.3) [1.0, 1.0]	$U = 245.00$, $z = -0.34$, $p = 0.734$
2	PEAS-S (Sum)	13.31 (4.05) [12.50, 3.50] Range: 8–20	13.24 (4.86) [12.00, 2.50] Range: 8–28	$U = 414.50$, $z = -0.41$, p =0.680
3	DMDS-S	2.40 (0.70) [2.50, 0.50]	2.40 (0.74) [2.50, 0.50]	$U = 439.00$, $z = -0.05$, p =0.964
4	DSRES	4.33 (0.80) [4.67, 0.33]	4.55 (0.88) [5.00, 0.00]	$U = 305.50$, $z = -2.15$, $p = 0.031$, $r = 0.31$ [95% CI: −0.55, −0.02]

Generally, the participants indicated a strongly rejective attitude toward doping ($M = 13.27$, $SD = 4.49$, $Mdn = 12.00$, $MAD = 3.00$). Nevertheless, the participants' attitudes showed a heterogeneous picture and included athletes who indicated solely a slightly rejective doping attitude. No statistical difference emerged between sailors and wrestlers (see **Table 2**, analysis Section Research Questions).

Participants generally indicated a low willingness to morally disengage in doping concerns ($M = 2.40$, $SD = 0.72$, $Mdn = 2.50$, $MAD = 0.50$). This tendency was independent of the type of sports participants competed in (see **Table 2**, analysis Section Methods).

Considered first in general and independent of sport, most participants indicated to be very confident to resist doping temptations ($M = 4.46$, $SD = 0.85$, $Mdn = 4.83$, $MAD = 0.17$). Comparing the two types of sports, wrestlers indicated to be even more resistant than sailors, including a medium effect size (Cohen, 1988; see **Table 2**, analysis Section Results).

No sport-specific profile emerged concerning the topics participants would like to address in an anti-doping measure (see **Figure 1**, the significance of the Mann-Whitney test comparing sailing and wrestling ranged from $p = 0.160$ to $p = 0.811$). Regarding six of the 10 contents offered, participants exploited the full range of rank options: a topic rated as most important by one participant was rated as the least important by another.

Deviations and heterogeneity of the data suggest the existence of subgroups beyond a differentiation by type of sports. Since the literature points to doping-related gender differences (Gleaves et al., 2021), a subsequent exploratory data analysis was conducted comparing male and female participants irrespective of the type of sport. Considerable differences can be seen in **Figure 2**. The analyses showed that young female elite athletes assumed a greater prevalence of doping in national and international sports in general. In addition, their attitudes toward doping were less negative, and they were less confident to resist doping temptations.

DISCUSSION

Generally, the study cannot identify sport-specific differences for a subsequent prevention planning tailored to these sports within the setting of young elite sports. One must keep in mind that the prevalence logic regarding a high and a low risk for doping was transferred from sports in general to young elite sports. Due to a lack of comparative data from senior elite sports, we cannot assume that sport-specific differences become apparent in the course of the career and socialization in a type of sport with a low or high risk for doping. Instead, all young elite athletes who participated indicate a good baseline for doping prevention. Thus, no indicators can be found why athletes from a sport with a high risk for doping should be prioritized in education in this age group (cf. World Anti-Doping Agency, 2021b).

Athletes perceive doping to be more widespread than laboratory data suggest. Their data support studies that have explicitly dealt with the determination of doping prevalence and assume a significantly higher prevalence of doping (Gleaves et al., 2021). Comparable to coaches' perception (Pöppel and Büsch, 2019), athletes perceive foreign countries to be more *doping-polluted*. Thus, athletes have the impression that cleaner competitions are more likely to occur in the national setting than in the international setting. It is noticeable that there is a more substantial discrepancy in how athletes perceive the situation within their sport. Although athletes should be more familiar with the situation in their sport, one can assume that questions about the prevalence of doping in one's sport trigger the fear of negative conclusions. The data suggest that athletes expect

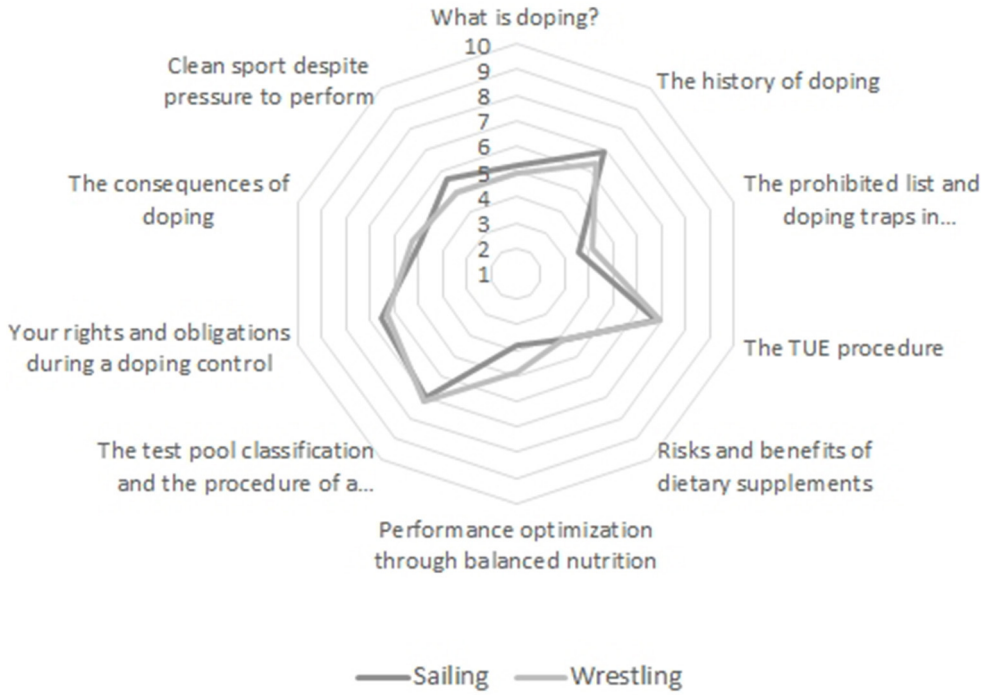

FIGURE 1 | Content preferences regarding German doping prevention program *Together Against Doping*.

more doped opponents in the international arena. Therefore, the national space should be a good starting point for constructive doping prevention to protect clean athletes early (cf. Petróczi et al., 2021).

Regardless of the type of sports, both groups of athletes appear to be in a favorable starting position, with a negative attitude toward doping. This critical attitude is a typical phenomenon regarding self-reported doping attitudes (e.g., Vargo et al., 2015; Pöppel and Büsch, 2019). However, the heterogeneity of data regarding doping attitudes (see **Figure 2**) indicate that individual athletes with a slightly negative attitude perish in the group analysis. In particular, for these individuals, doping prevention must be tailored to their needs and needs to address issues, which supports athletes to develop a more reluctant attitude.

Overall, athletes reject morally disengaging behavior. Again, this result is independent of the type of sports. Nevertheless, athletes indicate room for improvement regarding a moral consideration of doping. Individual items allow for external attribution when dealing with doping behavior (e.g., pressure from team members). Therefore, tendencies to relativize one's misconduct should be considered early. In this context, dilemma discussions (e.g., Elbe and Brand, 2016) could be helpful for a critical reflection. The psychometric properties of the assessment of moral disengagement (DMDS-S) are considerably lower in this sample than in the methodological paper that introduces the scale (Cronbach's $\alpha = 0.86$ and 0.89; Boardley et al., 2018). Therefore, these results need to be interpreted with caution. Considering the width of the confidence interval regarding the effect sizes of the measurement of perceived resistance against doping temptations (DSRES), these results need to be interpreted with caution too (see **Table 2**, analysis Section Results). Athletes from the type of sports in which doping appears to be more widespread express higher confidence to resist doping temptations. As with the other scales, there might be a tendency for socially desirable responses (e.g., Gucciardi et al., 2010; Petróczi and Nepusz, 2011). Thus, data support the need to integrate indirect measures in doping prevention research (Petróczi, 2016).

Finally, athletes indicate no sport-specific differences concerning doping prevention topics. Regardless of the type of sports, the spider web figure (see **Figure 2**) shows that none of the topics was considered particularly interesting or uninteresting. All topics ranked in the middle, with a comparatively high degree of heterogeneity in terms of ranking. Even topics that address the desire to increase performance in sport in a constructive way (e.g., healthy nutrition) do not stand out as being highly valued. It is reasonable to consider preferences at a smaller group or individual level. In addition, the present wording of the topics might be too unspecific and thus does not provide enough clues for a clear expression of interest.

The findings of this study indicate that one should consider additional aspects in young elite sports concerning the doping-specific background of young athletes. Clustering by sport is in line with the usual approach when doping prevention is planned in consultation with sports federations. The findings of this study suggest that additional characteristics need to be considered more in young elite sports than the characteristics of a type of sports when designing tailored doping prevention. In line with the review on doping prevalence by Gleaves et al.

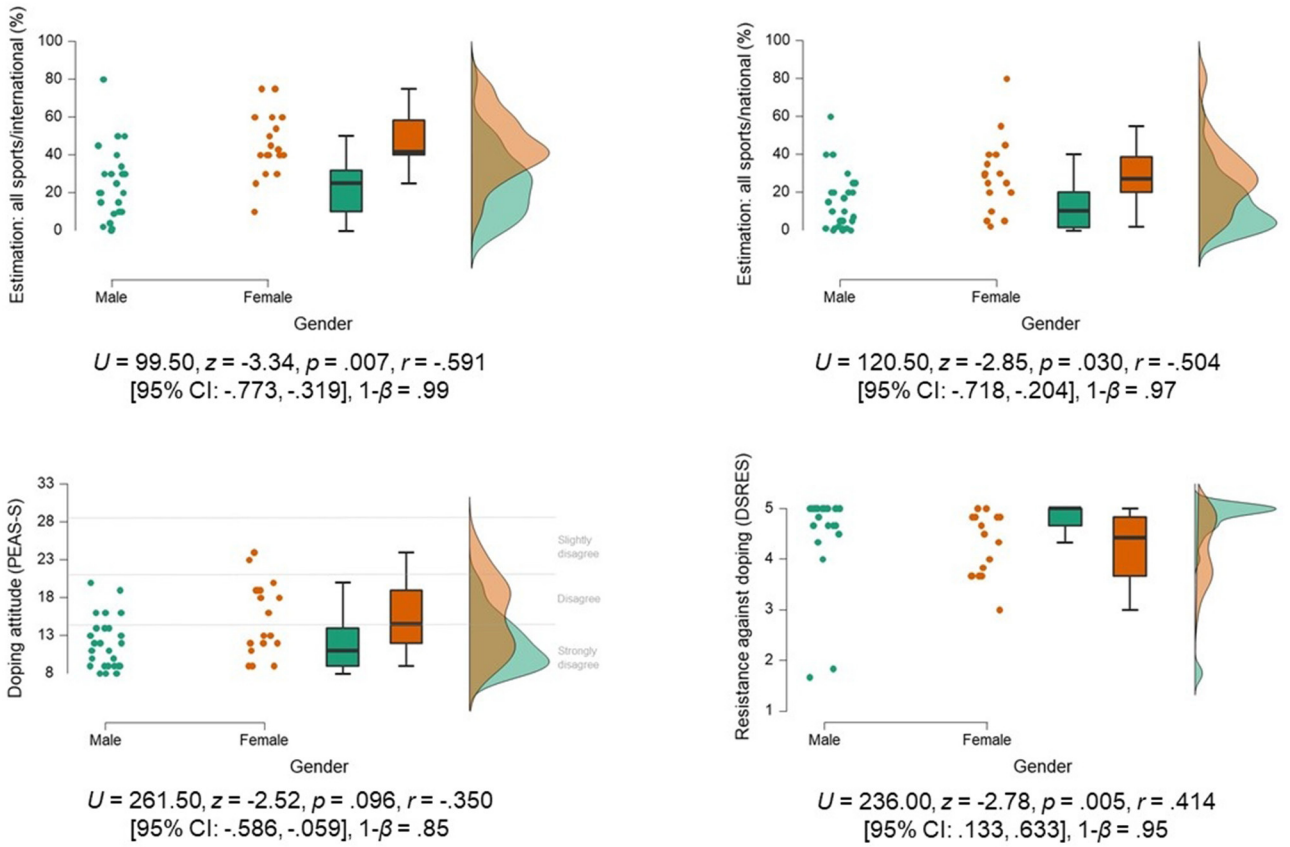

FIGURE 2 | Results of the exploratory data analysis comparing male and female athletes (significance values were adjusted by Bonferroni-Holm procedure for multiple tests).

(2021), the gender of the athletes should be considered as a control variable. The data show that young women indicate a more vulnerable baseline for doping than young men regarding their doping attitudes and a comparably lower confidence to resist doping temptations. These results should be considered in doping prevention specifically. Thus, athletes should profit from a more individualized approach, which considers gender-specifics.

Furthermore, doping prevention should be expanded in the sense of a modular system from which athletes can individually select topics. The description of topics should be more specific and offered in smaller steps than within the *Together Against Doping* program (German Nationale Anti-Doping Agentur, 2020). Expanding the implementation of apps or internet-based prevention components could supplement group measures to increase efficiency. Overall, evaluating (modified) doping prevention is necessary (e.g., Boardley et al., 2021).

Limitations

Methodological limitations concerning certain aspects of this research need to be acknowledged. As we had access to all young athletes involved in German sailing and wrestling talent development programs and thus a high-quality sample, we did not perform a preliminary power analysis to specify the optimal sample size. In order to assess the meaningfulness of results in this small sample and to better evaluate the explanatory power of effect sizes, a sensitivity analysis was subsequently calculated. According to the analysis, an effect size of $r = 0.44$ is needed to strengthen the significance of the results. If we focus on the prevalence estimates, this effect size is exceeded in comparing national elite sports ($r = 0.60$) and approximately achieved in comparing international sports ($r = 0.43$). These values strengthen the significance of the different prevalence estimates in national and international sports between wrestlers and sailors, focusing on elite sports in general. The self-reported resistance against doping fell below this value ($r = 0.31$). However, the upper level of the confidence interval exceeds the effect size according to the sensitivity analysis ($r = 0.44$, see **Table 2**, analysis Section Results). Generally, the sensitivity analysis indicates the significance of the results and the robustness of the sample examined.

Furthermore, assessing doping-related characteristics *via* self-report enhances the probability of response bias (e.g., Gucciardi et al., 2010). The actual values of the variables might be less favorable than reported by the athletes. Future studies should integrate indirect measures and enable a more individualized

view with more robust procedures while protecting the athletes' anonymity and should add a gender-specific perspective. Therefore, the logic in doping prevention should not be one size fits all, but every athlete counts.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because, the anonymity of participants is to protect. Requests to access the datasets should be directed to Katharina Pöppel, katharina.poeppel@uol.de.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Carl von Ossietzky University of Oldenburg, Germany, Local Ethics Committee. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

KP designed the survey in consultation with DB, obtained ethical approval for the intervention, conducted the data coding, transcription, and analysis. DB initiated contact with the federations. All authors contributed to the study design, writing and revision process, and approved the final manuscript.

ACKNOWLEDGMENTS

We thank the German Sailing Federation and the German Wrestling Federation for supporting this study.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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frontiers | Frontiers in Sports and Active Living

ORIGINAL RESEARCH
published: 30 May 2022
doi: 10.3389/fspor.2022.866648

Women's Footprint in Anti-Doping Sciences: A Bibliometric Approach to Research Impact

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Bibliometrics, *via* the exploitation of large-scale publication data, is a facile approach to explore gender-related trends, especially gender equality in academic publishing and authorship. For the first time, this study aims to investigate the gender-related trends in anti-doping sciences to (1) explore the relational structure of gender aspects of authorial, topical, and methodological features, (2) give recognition to women's contribution to anti-doping research, and (3) identify unique "gendered" potentials for advancing anti-doping research. To deliver on these aims, we employed bibliometric tools to publication records in anti-doping. After constructing a database containing academic publications on any aspect of anti-doping with at least one woman among the authors, we applied state-of-the-art methods from bibliometric science mapping and network analysis. The Lotka distribution model showed that the anti-doping research is a closed community with only 70 authors appearing more than once. Male authors being the majority (66.2%), women are under-represented in this field. The most important authorship position in the academic articles is mainly occupied by men, publications with male corresponding authors were in 774 out of 991 anti-doping related papers. The close connection of the top twenty most influential authors, men and women, to the World Anti-Doping Agency in some professional capacity suggest that the Agency have an influence on the anti-doping research beyond directly providing funding. In terms of geographical regions, publications with female authors were dominated anti-doping research in Italy, Romania, and Spain. In research networks to date, women have outperformed male authors in information centrality, which means that women in anti-doping research have had higher level of control over the information flow in the field than their male counterparts. The results of this study confirm the potential of bibliometric approach in the identification of emerging research topics and quantifying gender differentiation in the field of anti-doping. Due to their higher information centrality, women are better positioned for problem-focused multidisciplinary research both within anti-doping community, and with researchers in cognate fields. Bibliometric analyses have proved to be a powerful

OPEN ACCESS

Edited by:
Thierry Zintz, Catholic University of Louvain, Belgium

Reviewed by:
Peter Kokol, University of Maribor, Slovenia
Aurelio F. Bariviera, University of Rovira i Virgili, Spain

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Specialty section:
This article was submitted to Anti-doping Sciences, a section of the journal Frontiers in Sports and Active Living

Received: *31 January 2022*
Accepted: *27 April 2022*
Published: *30 May 2022*

Citation:
Kiss A, Lakner Z, Soós S and Petróczi A (2022) Women's Footprint in Anti-Doping Sciences: A Bibliometric Approach to Research Impact. Front. Sports Act. Living 4:866648. doi: 10.3389/fspor.2022.866648

tool for monitoring and advancing anti-doping research impact via identifying new avenues for multidisciplinary work, better gender representation, and diversity.

Keywords: anti-doping, bibliometric mapping, gender equality, research impact, sport

INTRODUCTION

Analysis of place and role of women in sciences has considerable traditions (e.g., Thistlethwaite, 1959), and it became conventional wisdom, that "*Women scientists [have been] long underrepresented, underpromoted, and underpaid in their fields*" (Vetter 1976, p. 713). Progress have been made toward gender equality. Yet almost half a century later, a comprehensive report by a prominent publishing house still talks of gender inequality in research (Elsevier, 2021). Despite the encouraging signs of improvements, this study showed that women across countries and fields publish fewer papers, are less mobile, and less likely to be involved in international collaborations. On the other hand, the study also found that a slightly larger proportion of the research outputs by women are highly interdisciplinary than scholarly outputs of men. Health, life sciences, and social sciences are among those fields where women have the highest representation, which makes anti-doping research an intriguing field for exploring the presence and solutions for the "genderedness" of academic research, as well as unique "gendered" potentials.

In connection with sport policies and principles of good governance, studies focused on the importance of gender quotas on sport boards or the need for gender equity (e.g., Henry and Lee, 2004; Knoppers and McLachlan, 2018; Moura et al., 2020; Piggott, 2021). Even if gender may not be directly associated with principles of good governance (Parent and Hoye, 2018), gendered perspectives (inequality, standpoint, power) can have an impact on research priorities, agendas, approaches, and interpretations of findings, as well as funding allocations.

Specific to anti-doping research, two competing forces impact gender equality. On the one hand, the "gendered structure" of academic research and publishing tend to make women less visible, their voices less heard, and their career progression stunted (Lundine et al., 2018). On the other hand, anti-doping research—like most applied fields that center on complex issues and span across many subject areas encompassing sciences as well as social science disciplines—is thought to be highly interdisciplinary where inter- and multidisciplinary approaches are encouraged (Petroczi and Naughton, 2011; Viret, 2020). Therefore, in addition to being beneficial for advancing anti-doping, the high degree of inter- and multidisciplinarity of anti-doping research may also promote gender equality at a greater rate than in other fields. Parallel, global sport governing bodies (e.g., the World Anti-Doping Agency, International Olympic Committee, international sport federations) and sport organizations in Western, developed countries are committed to gender equality in terms of representation in committees, expert panels, and working groups (Pollack and Hafner-Burton, 2010; WADA, 2018). If the general gender-gap phenomena are valid for anti-doping related research, this means, that in this field there are considerable intellectual capacities, the better utilization is important to create more equal opportunities for the women scientists (Rosen, 2017), enhancing the spectrum of approaches (Otsubo, 2008), applied to study anti-doping problems, and integrating the possibly partly-utilized intellectual potential.

Bibliometric Approach

Advances in computational social science and the development of different analytical methods—such as bibliometrics, scientometrics, and informetrics—can considerably enhance our knowledge on gender inequality in research, development, and academic publishing. Pioneering the field, Pritchard (1969) defined bibliometrics as "the application of mathematical and statistical methods to books and other media of communication" (1969, p. 348). Thirty years later, Glanzel observed that "bibliometrics is one of the rare truly interdisciplinary research fields to extend to almost all scientific fields" (2003, p. 5). This approach, however, is not to be conflated, or confused, with traditional literature reviews where the aim is to critically review, assess, synthesize, or pool research evidence together for a more robust observation of a phenomenon, and it is often driven by a specific research question about this phenomenon. In contrast, bibliometrics is a field of science, that focuses on quantitative aspects of measurement of scientific research output (Van Raan, 2019). As such, bibliometric methods facilitate the exploration of the conceptual-thematical structure, trends, and dynamism of the field of science by applying mathematical and statistical methods such as statistical-network theoretical modeling of the referencing, text-similarity, and authorial relations of the scientific literature.

Bibliometrics, scientometrics, and informetrics are closely related metric terms. With each of these terms featuring various definitions in the literature, these terms are used to describe similar and overlapping methodologies in science studies (Hood and Wilson, 2001). Bibliometric analyses rely on bibliometric indicators to a specific field of science, thus bibliometric studies apply mathematical and statistical methods to describe the different aspects of scientific communication. During the development of the field of bibliometrics, the main elements of bibliometric analysis have been defined as database compilation, consistency and accuracy of the data, data fields, search options, and analysis and use of metrics (Thompson and Walker, 2015). The application of contemporary bibliometric principles covers three sub-areas, namely methodology research, scientific disciplines, and science policy (Glanzel, 2003).

In the present study, we focus on the applications of bibliometric methods to anti-doping sciences, therefore it could be categorized under the sub-area of scientific disciplines. With bibliometric analyses, we can go beyond perceptions or anecdotal evidence, and formulate adequate methods for improvement, highlighting central points, "hot topics", and best practices.

Bibliometric Approach in Sport-Related Research

Although bibliometric analysis is not completely alien to sport science, it is still far from being fully utilized to advance the field. To date, bibliometric studies have been conducted in several fields of sport science such as factors influencing sport performance (e.g., Bilgiç and Işin, 2022). Its applications have been extended to sport management issues (e.g., Shilbury, 2011; Ciomaga, 2013; Belfiore et al., 2019; Baier-Fuentes et al., 2020), sport economics (Santos and García, 2011), innovation in sport (Ferreira et al., 2020), selected sports (e.g., Ibáñez et al., 2021; Millet et al., 2021), sport and exercise psychology (e.g., Lindahl et al., 2015; Clancy et al., 2017), physical activity and aging (Müller et al., 2016), and sport nutrition (Kiss et al., 2021). Specific to the anti-doping area, only a few bibliometric studies have been completed. The study by Agulló-Calatayud et al. (2008) identified key research centers and authors of scientific articles on anabolic steroids, whereas a working paper by Engelberg and Moston (n.d.) focuses on doping-related papers published in sport management journals.

Women's Share in Academic Publication

Sex/gender disparities in academic productivity were studied based on the application of standard bibliometric indicators (e.g., publication productivity in terms of the number of publications and authors, citations, collaboration patterns, key author positions, and productivity by country) and their distributions (Halevi, 2019). A high number of bibliometric analyses have been conducted in recent years on gender disparities in different fields of sciences, such as women's contribution to science in life sciences (DesRoches et al., 2010), medicine (Pashkova et al., 2013; Henderson et al., 2014), economy (Maske et al., 2003), astronomy, immunology and oceanography (Leta and Lewison, 2003), psychology (D'Amico et al., 2011), and criminal justice and criminology (Snell et al., 2009). From the results and conclusions of academic research, an increasing body of evidence is drawing on women's participation in science. Regarding publication productivity, it is evident that women researchers publish less compared to male researchers, but citation patterns show a more complex picture. There are no differences in the citation patterns between genders in general, but a cross-disciplinary bibliometric study showed that papers with female authors in key positions (sole authorship, first- and last-authorship) are cited less than those with males in key positions (Larivière et al., 2013). The study of Dehdarirad et al. (2015) provides an overview of how research output in the field of women in science, in general, has developed from 1991 up until 2012. They acknowledge the outstanding role of women in education and educational research, psychology, information and library science, computer science, business and economics, and women's studies, but they underline a high degree of multidisciplinarity. The authors emphasize that besides bibliometric indicators, different factors (factors related to gender bias such as family-related issues, sociocultural factors) need to be incorporated when analyzing women's productivity and gender biases in science. Women's higher contribution in multidisciplinary research is also demonstrated by the Elsevier report (2021).

Women in Sport Science Research

A handful of studies on sport sciences focusing on the representation of women in terms of authorship, membership in editorial boards, or academic positions is also available. Studies on gender trends in authorship characteristics in the field of sports science have mixed findings but with an overall trend toward a larger representation of women authors. For example, one study by Mujika and Taipale (2019) examined the gender differences in sport-science authorship. Based on a simple analysis of female and male authors in the first five issues of one sport science journals, the International Journal of Sports Physiology and Performance, published in 2019, they found that only 13% of the authors were women. The authors encourage sports scientists to take sociocultural biases into account during their academic activities (e.g., in selecting speakers for international conferences, reviewers for papers, choosing co-authors and collaborators).

The changing role of women in sport-related medical science is relatively well-investigated. Chang-Yeon et al. (2019) examined the relationship between gender and authorship in orthopedic sport medicine literature between 1972 and 2018 to show how the proportions of female authors in different authors' positions (first, second, middle, and senior authors) are evolved. Altogether, 16.6% of the authors in the sample were female. Whilst it is quite low, the analysis showed that there has been a significant increase in the proportion of female authorship (from 2.6 to 14.7%) in orthopedic sports medicine, the increase of almost 7-fold within the 46-year time frame. Publications with female authors were two-thirds the volume of male authors overall, however, female authors were more likely to be in middle authorship position.

Related to sport medicine, Loder et al. (2021) carried out a bibliometric analysis of the English musculoskeletal literature over the last 30 years. There were gender differences in the first and the corresponding author position, the percentage of female first authors increased from 10.8% in 1985–1987 to 23.7% in 2015–2016, while the percentage of female corresponding authors changed from 8.9% in 1985–1987 to 18.9% in 2015–2016. In addition, differences were shown in the first and corresponding author gender by journal type, specific journal, decade, and geographic region. Notably, female corresponding authors and female first authors were more common in the basic science group compared to the clinical group. The study of Dynako et al. (2020) analyzed the bibliometric and authorship trends in two representative American sports medicine journals, namely the American Journal of Sports Medicine (AJSM), and Arthroscopy in the last 30 years. The average percentage of female first authors was 13.3% for AJSM, increased from 4.7% in 1986 to 19.3% in 2016. For Arthroscopy, the average percentage of female first authors was 8.1%, increased from 2.8% in 1985/1986 to 15.7% in 2016. The AJSM had an overall greater percentage of female authors. To evaluate authorship trends, Ryan et al. (2020) examined articles published in Sports Health journal between 2009 and 2018 for the number of authors, and the presence of

female authorship among others. The percentage of publications with at least one female author increased throughout the study period, from 52% in 2009 to 64% in 2018. The authors highlighted that the Sports Health journal continues to show high rates of female authorship compared with other various journals.

Aims

Overall, the presence and performance of women in science in general and women in sport science, in particular, have increased significantly in recent decades, but gender-related differences still exist and remain a global phenomenon in the field. In the sport science literature, including the anti-doping sciences literature, gender footprint has not been widely investigated in terms of combining and linking the gender-related dimensions of sport science in a structured and systematic way encompassing multiple subject areas and subfields. To our best knowledge, there is no original article that specifically examines the role of women and provides a quantitative analysis aiming at gender differences in anti-doping sciences. With this study we aim to address this gap and—using state-of-the-art scientometric analyses—address the following research questions:

(1) What is the contribution of women to anti-doping research?
(2) What are the characteristic trends in women's contribution to anti-doping research over time?
(3) What is the relational structure of gender aspects of country-related, authorial, topical, and methodological features?
(4) What is the extent of recognition and impact of women in the related literature?
(5) In what way are women "do better" than men in anti-doping research?

MATERIALS AND METHODS

Constructing the relevant literature corpus was challenging in many ways. First, identifying research outputs in and field delineation of the anti-doping research was one of the most important and critical steps, thus data collection and database construction formed the basis of the analysis. Anti-doping is a relatively new and emerging field that spans across multiple scientific fields, with a significant proportion of research being interdisciplinary. The second challenge involved the identification of male and female authors from bibliometric information.

Data Collection

To delineate the anti-doping research field, bibliometrics-aided retrieval was used in line with the methodological paper of Gal et al. (2015). As a first step, a core dataset was created based on a core journal and search terms, then a broader dataset of publications/research outputs was compiled via the use of broad search terms, and finally, citation-based similarity measures between the documents in these datasets were applied in order to gain a final dataset with a high degree of precision.

For data collection and field delineation the Web of Science Core Collection databases were used (including the Science Citation Index, the Social Science Citation Index, and the Arts&Humanities Citation Index). Although many databases are now available for bibliometric analysis (e.g., WoS, Scopus, PubMed, etc.), a standard choice in bibliometric studies involves the WoS dataset as the Gold Standard. Irrespective of coverage issues, which are deeply influenced by indexing policies for these proprietary databases, WoS is usually considered to fulfill the relevant set of criteria for mapping purposes: (1) High-quality standards in indexing, representative coverage, (2) multidisciplinary, and (3) rich characterization of bibliographic records.

The basic documents of the data collection (core dataset) were obtained on one part from the WoS database with a search query of "anti-doping* OR antidoping*" OR "anti-doping"*. The search terms were applied to the title only in WoS. One the other part data were obtained from Acute Topics In Anti-Doping book as one of the core literature. No limitations were placed on the dates of the searches, the final data of data collection has been 20. October 2021. The search resulted in a core set of 572 publications. To extend the information content of the core set, we created a broad search term using the following query: "doping control*" OR "doping prevention*" OR "doping-free sport"* OR "clean sport*" OR "drug-free sport*" OR "anti doping in sport*" OR "fair sport*" OR "WADA*" OR "fair play*" OR "anti-doping*" OR "antidoping*" OR "anti doping*" in (Topic) in WoS database. To identify relevant anti-doping-specific search terms sport science journals, systematic reviews, highly cited research papers, and WADA documents were reviewed. The broad search term set included 2390 research papers. To increase precision, one of the authors who is an expert reviewed the title of publications of a random sample of the broad search term dataset. Publications were excluded from the core and broad search term dataset when the expert excluded the publication or the publication was written related to animals.

Then citation-based similarity measures were applied in the core dataset and the broad search term set, the review of random samples led to the selection of publications of two combined datasets: group I. included papers in the broad search term set citing the core dataset at least twice ($N = 889$). To group II. dataset belonged papers in a broad search term set with at least 10% references among the pooled references of the core dataset ($N = 1{,}594$). Publications from the core dataset and similarities of the core dataset and the broad search term set (group I. or II.) were included in the final set, thus ensuring that only the relevant topics are included. After eliminating duplications, the final set included 1,802 publications, with dates of publication ranging between 1998 and 2021. After excluding studies to which genders cannot be assigned to authors 1,341 studies were included in the analyses. **Figure 1** illustrates the identification workflow of relevant research papers.

The database of funded research projects was constructed from the publicly available records of successful grant applications (https://www.wada-ama.org/en/funded-scientific-research-projects and https://www.wada-ama.org/en/social-science-research-projects-0). At the time of the database construction, applicant details were not available thus we had

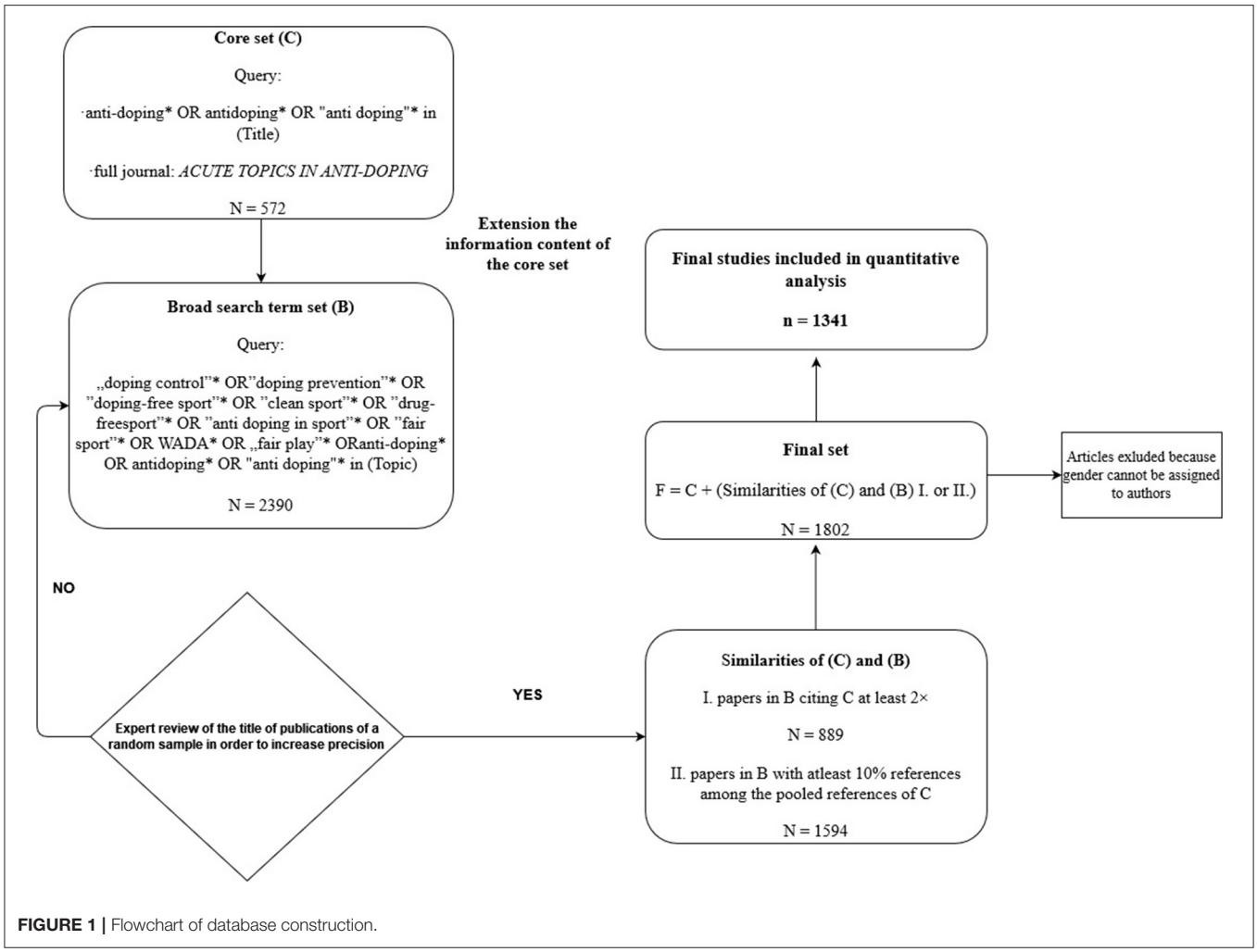

FIGURE 1 | Flowchart of database construction.

to limit the researchers to the principal investigator. Because more details are now available, we will address this limitation in future studies.

Sex/Gender Identification

As a first step toward gender identification, names of authors were cleaned: abbreviations and symbols were removed and abbreviated first names were rewritten in full (first name and last name) form. Middle names were also included in full names. Full author names were retrieved from the bibliographic data downloaded from the WoS databases, which contains a dedicated field for representing the complete name of contributing authors, and used to classify authors into binary categories as male or female. To assign genders we used Gender API (available from https://gender-api.com/en/), which is one of the biggest platforms on the internet to determine gender by a first name or a full name, their database contains 6,084,389 validated names from 191 different countries. Alongside the full name of the authors, we also identified the country assigned to each author from the publications because specifying the queries by adding country code is increase the accuracy of the result. Gender API (value is ranging between 0 and 100) provides an accuracy value in the query result. The final dataset contained 3,628 author names, from which we were able to identify 2,415 full author names. Of these, 2,346 (97%) authors' gender was assigned with an average accuracy value of 93.83. In the case of the missing values, the first name and middle name were abbreviated, and we were not able to resolve these abbreviations. The assigned gender category of the top 70 authors were confirmed by one of the authors who is a senior anti-doping researcher.

We are aware of the high theoretical importance of differentiation between categories of sex and gender (Johnson and Repta, 2012; Tannenbaum et al., 2019). Our studies have been based on sex differentiation of scientists, informed by their first names, that is why our study is sex rather than gender-based. At the same time, we analyze a gender-related problem, using gender-differentiation as a social construct (Kaliyath, 2016), that is why in the current paper the "sex" and "gender" words are used interchangeably.

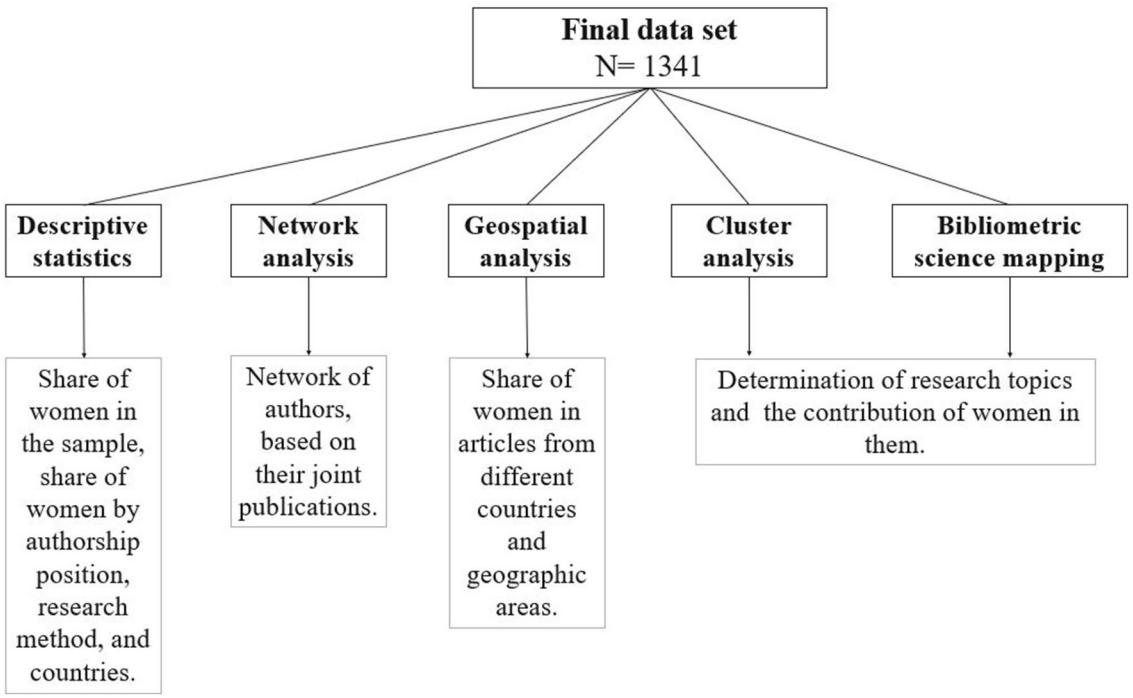

FIGURE 2 | Workflow of the analytical framework.

Data Analysis

Bibliometric analysis of documents, registered on WoS database, classification of different publications on the basis of topics and country, funding information, determination of the role of women in different papers. We have applied a triangulation approach. The use of different methods offered the benefit of analyzing the problems from different angles. Data analysis included geospatial analysis to reveal the contribution of women by geographical areas, cluster analysis to uncover emerging topics as well as the number and authorship position of women in them, and network analysis to create the authorship network and examine the presence and role of women in the network (**Figure 2**).

Topic identification, -or in this case, the clustering of publications into thematic groups- was based on the classical and validated bibliometric method of bibliographic coupling (BC). BC is designed to estimate the cognitive proximity between documents based on the relative amount of their shared references. The main idea behind this approach is that the more references two documents share, the more akin these documents are regarding their thematic focus. The similarity measures of BC usually uncover well-recognizable, specific topics inherent in the discourse. Our procedure consisted of the following steps:

1. Measurement of thematic document similarity. In the first step, we obtained the similarity matrix of documents based on the Jaccard similarity of their reference vectors.
2. Creating a document similarity graph. Upon the matrix, a document similarity graph was generated, with weighted edges representing proximity between them.
3. Graph-based clustering. In the last step, the document graph was subjected to a community detection algorithm (Louvain algorithm), based on modularity optimization. This yielded the densely connected communities (clusters) of papers, that could be deemed the emerging topical clusters of the discourse.

In data analysis, we followed the general workflow of bibliometric studies (Guler et al., 2016), including the calculation the Lotka's Law, which describes the frequency of publication by authors in a given field of science (Lotka, 1926). Bibliometric analysis was carried out by R statistical program (R Core Team, 2020). Cluster analysis as the development of the research field over time has been analyzed based on an algorithm, developed by Van Eck and Waltman (2010), and operationalized in CitNetExploere software.

RESULTS

Anti-Doping Research Within Sport Sciences

Because the current study focuses on the role of women in anti-doping research, it is important to consider the general context and the position of anti-doping-related research in sport science. To analyze the trends of the share of these publications

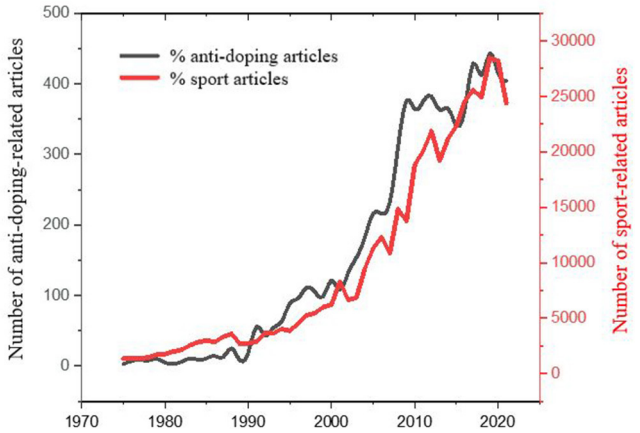

FIGURE 3 | Trends in research outputs between 1975 and 2021 in sport and anti-doping studies.

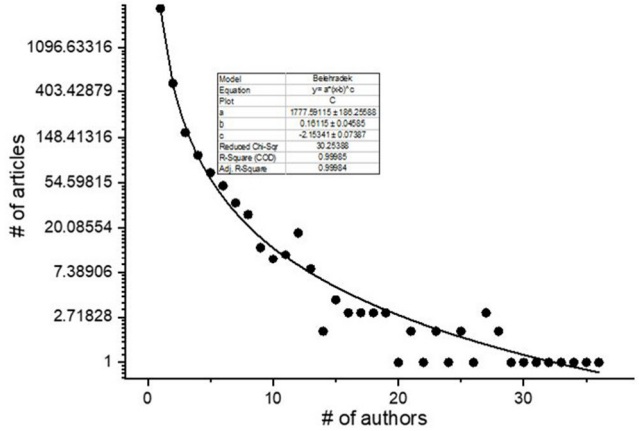

FIGURE 4 | Distribution of all authors, by number of articles.

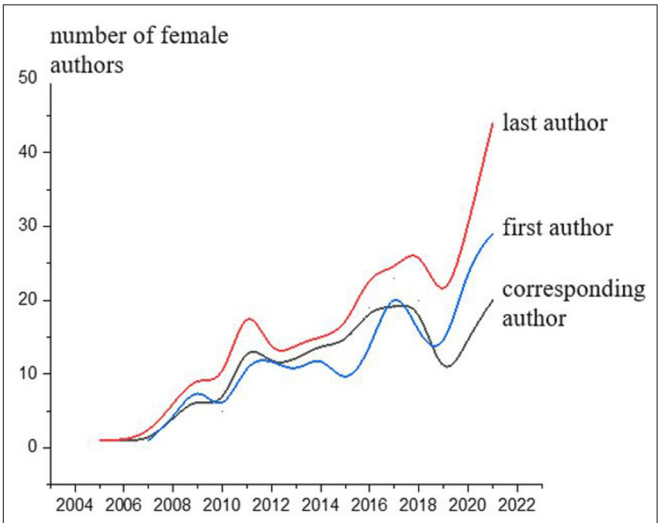

FIGURE 5 | Number of female authors in key positions by year of publication.

and the absolute number of them, we have downloaded the number of bibliographic units, registered in Web of Science (WoS) one of the worlds' most acknowledged academic databases (Martín-Martín et al., 2018; Liu, 2021) as units, attached to the field of science "Sport". The results are depicted in **Figure 3** and **Supplementary Figure 1**. There is an exponential trend in increasing sport related publications between 1975 and 2021. The number of anti-doping publications had also been increasing, however the share of anti-doping articles from all sport-related articles has been three times higher in the last decade.

Basis Statistical Features of the Database

The original dataset consisted of 1,802 documents. More than two-thirds of publications have been research articles (1,268), with 205 reviews. Due to the extremely rapid development of this sphere of sciences, we have taken into consideration the proceedings papers ($n = 66$). The inter-professional discussions are well-reflected in editorial materials, which is why we also included 76 of these. In total, 3,628 authors were included in the basic corpus. Their names appeared 7,445 times in the publications, with only 219 outputs (18% of the total number of documents) being single-authored. On average, there were 4.13 co-authors of one document. This relatively high number indicates the highly complex nature of the field.

With language limitations acknowledged, the scientific analysis of the anti-doping field appears to be highly concentrated in the so-called WEIRD (western, educated, industrialized, rich, and democratic; Henrich et al., 2010) countries in the Northern Hemisphere. Based on the corresponding author's countries more than four-fifths of the articles were prepared in Europe, the USA, Japan, and Canada. The share of documents with European co-authors was nearly two-thirds. Contrary to another field of science share of Chinese (2.4%), Brazilian (2.2%), Russian (1.3%) and Indian (0.6%) authors were exceptionally low. This fact can be explained by differences in anti-doping research and regulation in these states, mainly in Russia (Rutland and Kazantsev, 2016; Altukhov and Nauright, 2018; Ohl et al., 2021 and China (Hong, 2006; Yang and Leung, 2008; Lu, 2012; Tan et al., 2020).

The distribution of actors shows a high level of concentration. The overwhelming majority of authors (2,595) appeared just one time in the corpus, no more than 70 authors produced more than ten articles. Fitting the Lotka distribution model generally applied for analysis of authors' distribution, the r square value was 0.85, the c value was 1.77 (**Figure 4**). This result highlights the fact that the anti-doping research community is a rather closed one.

Contribution of Women to Anti-Doping Research

Altogether the number of male authors was twice as high as the number of female authors with 1,100 being identified as female and 2,160 being identified as male in the data. The most important characteristic features of time dynamics of the absolute and relative position of authors are summarized in **Figure 5**. Over

time, there is a noticeable increase in the share of female authors appearing in key positions (i.e., first or corresponding) among the authors. The number of female first authors increased from 1 in 2005 to 29 in 2021, while the number of female corresponding authors changed from 1 in 2005 to 19 in 2021 in the anti-doping literature. Parallel with the number of anti-doping papers, the number of female authors has changed significantly over time, from 2 female authors in 2005 to 182 female authors in 2021.

Analyzing the authorship position, large differences in the corresponding author position were observed. Publications with male corresponding authors were noted in 774 out of 991 papers. There was an overall greater share of male corresponding and other author positions in anti-doping-related studies. The share of women in key author positions was low. The average percentage of female first authors was 23.5%, and only 14.5% as last author, although the significance of the last author position (as senior project lead) is not universally used across different fields. The average author position was 3.45 in the case of female authors and 3.65 in the case of male authors (**Table 1**), which is partially influenced by the field (i.e., social science publications tend to have fewer number of authors than in sciences).

Regarding the research field, most of the anti-doping-related paper was written in the field of analytical chemistry, followed by biochemical research methods, pharmacology & pharmacy, hospitality, leisure, sport & tourism, and sport sciences. The proportion of male authors was higher in all research fields, the number of male authors was twice as high in the research field of hospitality, leisure, sport & tourism (168 vs. 64), significantly higher in analytical chemistry (301 vs. 222) and sport sciences (196 vs. 96), suggesting that these research fields are dominated by male authors. The share of female and male authors was approximately equal in research fields that were present in a smaller size in the sample (e.g., applied psychology, nutrition &

TABLE 1 | Authorship position in the anti-doping related studies by gender.

Gender	Other author (# papers)	Corresponding author (# papers)	Average position (rank in the series of authors of a paper)*	Average weight (weight is calculated as an index: paper/author)**	Corresponding authorship (share of papers)
Female	473	217	3.45	0.22	0.19
Male	767	774	3.65	0.27	0.27

**Average position: the mean value of author's placement in their papers' co-author list.*
***Average weight: the mean value of author's share in their papers' co-author list (average of the inverse of the number of authors per paper).*

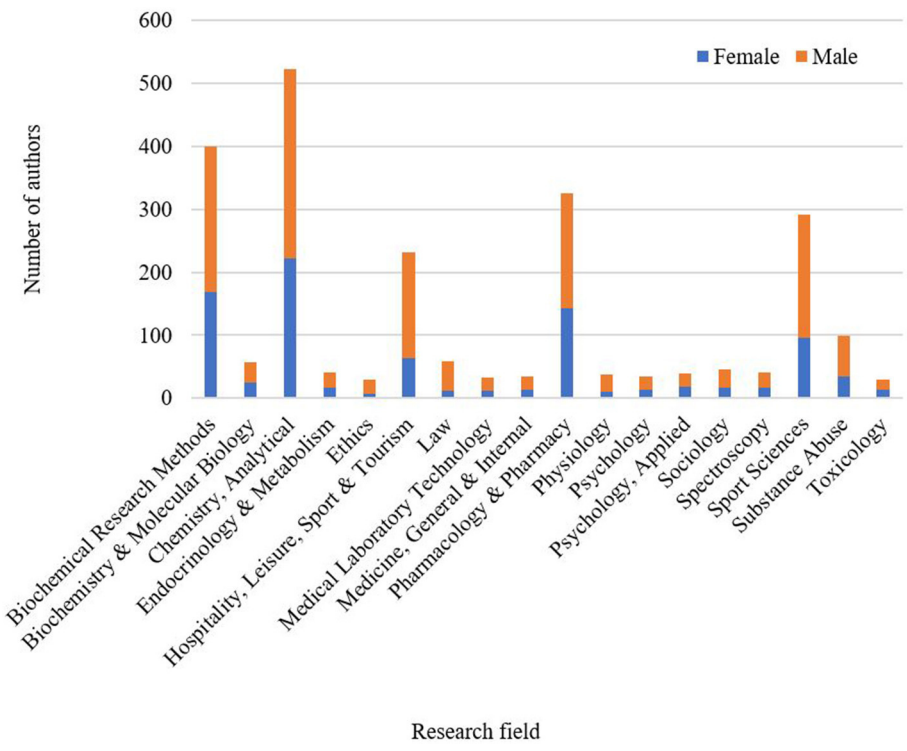

FIGURE 6 | The proportion of female and male authors by research field.

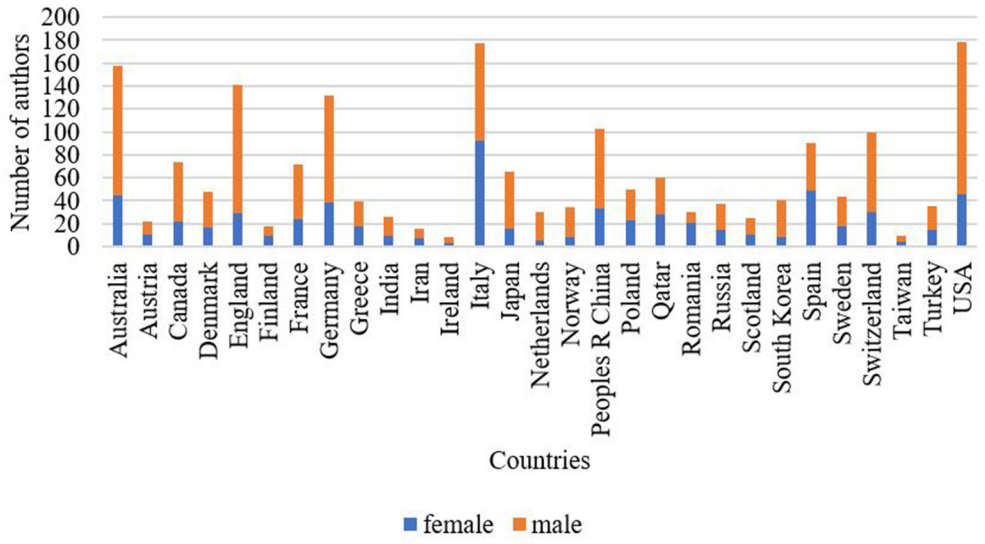

FIGURE 7 | The proportion of female and male authors by country.

dietetics, toxicology). **Figure 6** shows the share of women authors by research field.

With reference to geographical distribution, the highest contribution to anti-doping-related research was from the USA and Italy, followed by Australia, England, and Germany. Specific to gender distribution within, the share of female authors was approximately equal to male authors in Austria, Finland, and Greece. The proportion of male authors was more than twice as high in the USA, Australia, Canada, England, Germany, Japan, and Switzerland. Publications with female authors were dominated in anti-doping-related research in Italy, Romania, and Spain, as the proportion of female authors was higher in these countries (**Figure 7**).

Share and Performance of Women Among the Most Cited Actors

Analyzing the structure of the most cited productive authors in the field, the results show that most of these researchers have more than one and half-decade research history and their stream of academic outputs is relatively stable. Among the twenty most productive authors, there are five women, which is a robust standing, but also a good indication of gender imbalances in this field. Upon closer scrutiny, it appears that these five women show a long-time, stable performance in the anti-doping research field (**Figure 8**). Of them, three (Kuuranne, Ventura, Mazzarino) work in doping control and testing, whereas the remaining two (Backhouse, Petroczi) research aspects of doping prevention (primarily focusing on behavior, prevalence, integrity, and anti-doping education).

In terms of academic impact, there were 19,214 citation links between the included papers. However, the time span of cited documents embraced more than six decades with the first cited document being published in 1957. Indicating the degree of maturity of the field, the overwhelming majority of cited sources have been written in the last three decades. This fact highlights that the academic research of anti-doping is a relatively new field of science, basic pillars of which have been hammered down by the current and still active generation of researchers.

To delineate the research impact further, we augmented the results from the bibliometric analysis with publicly available information on successful grant funding to the World Anti-doping Agency (WADA). Due to the limitation in the data, at this point, we made no attempt to make a direct connection between the source of funding and academic output(s) but we recognize the need for specialized research funding. WADA is one of the most important funding bodies for doping-related research, thus the distribution of the grants according to gender can be an important indicator of equilibrium or disequilibrium between the genders in case of allocation of financial resources. Striking differences in the number of female and male authors and male and female principal investigators for WADA-funded projects were found (**Figure 9**). Specifically, twice as many male researchers obtained funding for their anti-doping research than their female counterparts.

Structure of Gender Aspects of Topical Features

Prominent research topics were determined via cluster analyses. Based on similarities of literature sources, six clusters were identified. The biggest cluster contains 771 publications and examines the social aspects of anti-doping research, followed by clusters focusing on the detection of prohibited substances and/or methods (doping), and the development of analytical methods. The most important characteristic features of the thematic structure are summarized in **Table 2**. Noteworthy is the nature of the largest cluster which essentially contains all social science outputs despite

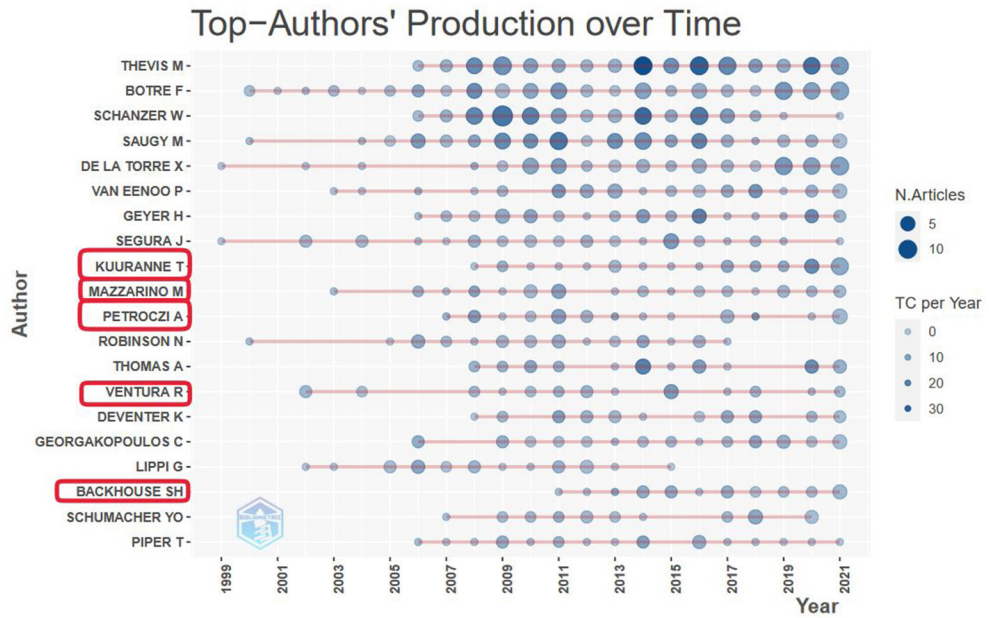

FIGURE 8 | Yearly academic production (number of articles) and citation (total citation per year, TC) of the twenty most productive authors in the fields of anti-doping sciences. Women are indicated by a red circle.

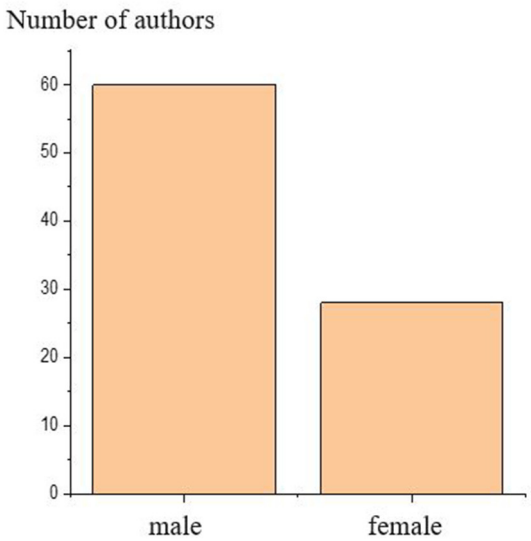

FIGURE 9 | Number of authors by gender, whose name appears at least once among authors of papers, and obtained research funding from WADA.

TABLE 2 | Characteristic features of clusters of publications, based on their sources.

Cluster number	Size of the cluster (number of publications)	Description
1	771	Social aspects of anti-doping and anti-doping policy formation
2	737	Development of chemical methods for detection and identification of doping
3	614	Detection of blood doping, the biochemical mechanism of doping
4	127	Pharmacology and pharmacokinetics in the detection of doping-agents
5	61	Anti-doping control practices, drug-testing methods
6	22	Role of pharmaceutics and pharmaceuticals in anti-doping; Application of cannabis, and cannabis-related products in sport

the fact that the cluster can be easily deconstructed by sub-fields such as sociology, psychology, ethnics, law, education, management, or governance. The formation of a single cluster of these fields suggests a high degree of permeability of the topic (doping and anti-doping) between the disciplines that concern about the behavioral aspect of doping.

The structure of different clusters shows highly important aspects regarding the genders of the most cited actors. If we analyze a relatively small cluster (e.g., Cluster no. 5) it shows, that this cluster can be sub-divided into two components. One cluster (the larger one) deals with different methods of detection of doping and the smaller one deals with the issue of the establishment of an adequate regulatory framework. This cluster is a good example of the practical application of results, achieved in the field of doping identification and detection. It is a common feature of both sub-clusters, that the share of women is rather low among the most cited actors. However, in recent years some

TABLE 3 | The thematic structure of the field of anti-doping science and women's contribution within it.

Cluster names	Total number of articles	Share of articles with at least one woman author	2012/2016 average of the share of articles with at least one woman author	2017/2021 average of the share of articles with at least one woman author	Change in percent point of the share of articles with at least one woman author
Critique of anti-doping rules and implementation	26	0.06	0.12	0.00	−0.12
Anti-doping and ethics	80	0.19	0.15	0.33	0.19
Detection: hair analysis for steroids	5	0.25	0.00	1.00	1.00
Threats against integrity	95	0.30	0.31	0.23	−0.08
Detection of blood doping|Athlete biological passport	120	0.36	0.12	0.39	0.27
Detection: endogenous hormones	13	0.38	0.67	1.00	0.33
Detection: EPO/Blood doping	37	0.41	0.25	0.49	0.24
Doping control and treatment of asthma	40	0.41	0.48	0.26	−0.21
Legal aspects of anti-doping	15	0.43	0.17	0.54	0.38
Doping control and global harmonization	10	0.44	0.75	0.33	−0.42
Implementation of the anti-doping regulations	15	0.45	0.17	0.50	0.33
Doping control: new and special methods	10	0.50	0.00	0.33	0.33
Performance-enhancing substances in the society	29	0.50	0.67	0.42	−0.25
Role of pharmacists in anti-doping	12	0.52	0.67	0.58	−0.08
Anti-doping education and doping prevention	172	0.55	0.38	0.49	0.11
Advances in doping control: detection of endogeneous hormones (growth hormone, insulin)	41	0.60	0.62	0.46	−0.16
Gene doping	27	0.63	0.28	0.47	0.19
Detection: dried blood spot and alternative matrices	33	0.63	0.50	0.18	−0.32
Detection: Steroids/stimulanst & narcotics	111	0.65	0.58	0.50	−0.08
Dietary supplements and doping	41	0.66	0.42	0.46	0.05
Detection: endogeneous steroids and precursors (prohormones)	93	0.67	0.27	0.59	0.32
Detection for cobalt and meldonium	25	0.75	0.50	0.45	−0.05
Cannabis use as anti-doping rule violation	9	0.96	1.00	0.88	−0.13

articles with women's participation have achieved considerably more attention in this cluster, than earlier publications by men (**Supplementary Figure 2**). Of course, this trend is likely to be driven by the focus of these research outputs and not the gender of the authors *per se*. What this perhaps suggests is the tendency of women researchers focusing more on emerging and/or "hot" issues; or the interdisciplinarity of the issues where women scientists generally do better than their male counterparts.

More analytical chemistry-oriented, large cluster (**Supplementary Figure 3**) features a considerable number

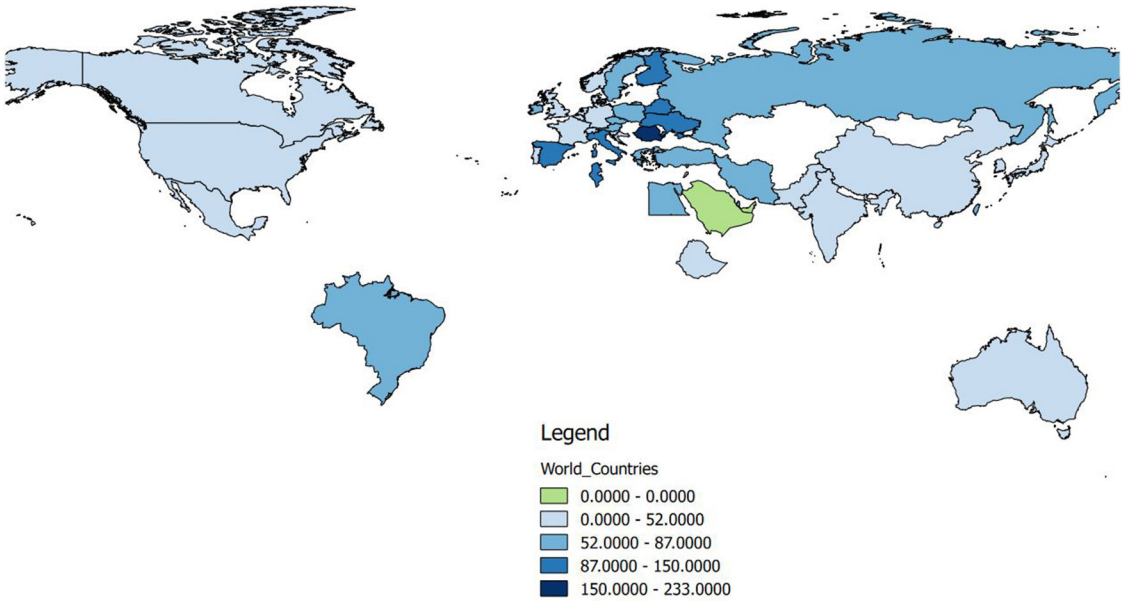

FIGURE 10 | The average share of women authors in articles, prepared in different countries (in percent of male authors).

of publications with women scientists. At the same time, no paper can be characterized by a preponderance of the women authors, and two papers achieved a 50-50 male-female ratio.

Theoretically, the position of the largest cluster, which deals with sociology and social psychology as well as the sport-policy aspect of anti-doping, is extremely important because this cluster comprises publications aiming to determine the key direction of anti-doping policy. In this case, a very high level of male-author dominance is noted with just a quarter of publications had been written with contributions from women. On a positive note, there is an upward trajectory showing that near the beginning of the second decade of the new century the relative frequency of the articles by or with female authors is increasing (**Supplementary Figure 4**).

Women's Contribution to the Key Areas in Anti-Doping Research

Results of bibliometric mapping—another methodological approach to determine the key areas in anti-doping science—led us to further divide the publications in this database into 23 clusters, thus these results provided a more detailed view of the cognitive structure of the field. The absolute and relative size of the topics, derived from the number of publications belonging to a cluster, offers valuable insights into the research trends in anti-doping sciences, and the contribution of women within this field. The three most dominant clusters are: "Anti-doping education and doping prevention" with 172 publications, followed by a topic with 120 publications "Detection of blood doping/Athlete Biological Passport" and topic "Detection: Steroids/stimulants & narcotics" with 111 publications. The share of articles with at least one woman author was the highest in the cluster "Cannabis use as anti-doping rule violation" (0.96), the second-highest was the "Detection for cobalt and meldonium" (0.75). Women's contribution was higher in smaller clusters. In terms of change in percent point of the share of articles with at least one woman author clusters "Legal aspects of anti-doping," "Implementation of the anti-doping regulations," and "Doping control: new and special methods" have the highest positive change over time. The thematic structure and its important features by gender distribution are summarized in **Table 3**.

Structure of Gender Aspects of Authorial and Country-Related Features

The share of women in articles from different countries and geographic areas shows considerable differences. **Figure 10** depicts the relative values regarding the presence of women authors, the highest proportion of female researchers was in the Central-European region, and the lowest proportion was in the Middle East region.

Authorship Network

To map research influence and academic impact via shared knowledge and expertise, we have analyzed and visualized the network of authors based on their co-authored publications. Based on the final dataset, we generated a network consisting of just 50 authors (**Figure 11**). This observation highlights the relatively low level of stability of cooperation networks between the key personalities of the research field.

Because there is no one indicator of the centrality of different nodes in a system (Tang et al., 2015), author networks are interrogated via a combination of different parameters. To determine various indicators of the centrality of authors as nodes, we obtained the following parameters: the betweenness centrality (Barthelemy, 2004), closeness centrality (Goldstein

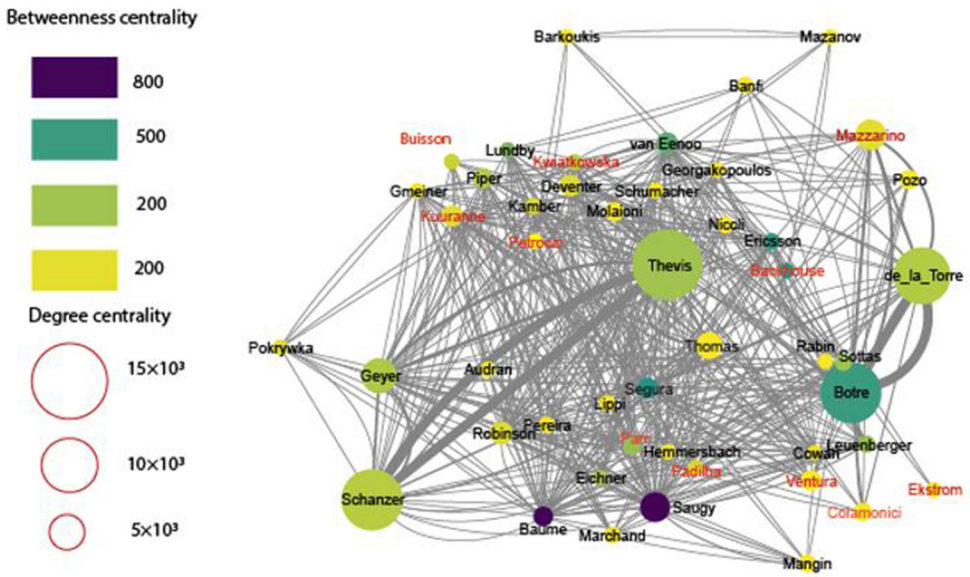

FIGURE 11 | Network of key authors in anti-doping research, based on joint publications. The nodes (circles) indicate the authors, and edges (lines) mark the joint publications. The color of nodes is proportional with the betweenness centrality, the size with degree centrality, and the thickness of lines with the number of joint publications. The women authors are denoted in red.

and Vitevitch, 2017), eigenvalue centrality, degree centrality (Pal et al., 2010), network centrality (Wang et al., 2011), information centrality (Rastogi, 2019) and local average connectivity based indicator. Each of these has shed new light on the centrality of the nodes, in our case of authors. The most important positions, determined by edge betweenness and degree centrality (indicators for characterization of the relative importance of nodes in the network, from point of view of the flow of connections among different parts of it), are occupied by men. Taken all together, only eleven women appeared as a node (individual) in the network, and only two of them (Backhouse and Petroczi) were from social sciences. Centrality measures for authors in anti-doping sciences are presented in **Table 4**.

Although the differences between male and female authors were visible in all indicators, due to the large standard deviations, statistically significant difference at $p < 0.05$ was not reached (**Table 4**), except for the information centrality indicator which shows a significantly higher value for women ($p = 0.008$). The significantly higher information centrality of women means that they have a higher level of control over information flow in the system.

DISCUSSION

The purpose of this study was to obtain an overview of the contribution of women to the scientific foundations of anti-doping, based on a rigorous, systematic analysis of international academic literature. To characterize the presence, role, and contribution of women to research outputs in anti-doping science over the last two and a half-decades, and to gain a comprehensive picture of gender trends in the field of anti-doping, we have applied a combination of different bibliometric approaches because they offer additional, complementary pieces of information, uncover hidden relations and perspectives to the gender footprint.

Usefulness of Bibliometric Analyses

To reveal the scientific landscape of anti-doping and the positions of women within that landscape, we applied two different methodological approaches: cluster analysis and bibliometric mapping. The results confirm the significance of bibliometric mapping because the outcome of this method provides a more comprehensive view of the thematic structure of the field. On the other hand, the bibliometric mapping approach offers prospective ways of further research, identifying key actors within the research field, and contributing to an optimal allocation of intellectual and material resources of research.

Specific to anti-doping, this study showed that scientific output has been continuously rising in the last decades. Expanding the scope of study beyond women researchers and employing a different focus for either comprehensive or targeted enquiry, bibliometric analyses can offer a systematic map of anti-doping research activity and its impact to facilitate these focused and targeted reviews by creating a comprehensive overview, and handy clustered collection of the body of anti-doping knowledge and research output. The methodology is suitable to uncover hidden relations of anti-doping research that emerge from the scientific output, thus besides the revealing of thematic organization of the field, bibliometric analysis can complement experts' interpretation of the anti-doping research field as featured in traditional critical or systematic literature reviews.

TABLE 4 | The indicators of the centrality of authors by gender (The scales are different, but the higher values indicate a more central role in the network).

Indicators	Sex	Mean	Standard deviation	Independent samples *t*-test statistics, *p*-value
Betweenness	Male	53.54	87.22	0.466, $p = 0.466$
	Female	44.07	24.35	
Closeness	Male	0.3761	0.09	0.141, $p = 0.483$
	Female	0.3925	0.042	
Eigenvalue	Male	0.04	0.05	0.899, $p = 0.373$
	Female	0.01	0.021	
Degree	Male	1810	3143	0.1006, $p = 0.316$
	Female	865	1221	
Network	Male	47.07	48.22	2.004, $p = 0.051$
	Female	16.76	13.44	
Information (homogeneity of variances hypothesis violated at $p < 0.05$ level of significance)*	Male	36.24	31.8	−2.767, $p = 0.008$
	Female	50.29	44.65	
Local average connectivity	Male	1656	155	0.302, $p = 0.408$
	Female	1462	1429	

**Information centrality is a centrality measure of nodes (in this context), a variant of closeness centrality. It measures the relative drop in network efficiency (defined in terms of communication potential through shortest paths) caused by deactivating the node in question. Homogeneity refers to the assumption of the homogeneity of variance in testing the significance of the (mean) differences between women's and men's centrality values.*

Presented in a form of knowledge and impact (science) maps, bibliometric knowledge maps demonstrate the key elements of each research direction, the intellectual basis of them, and the conceptual structure of the scientific discourse. Therefore, bibliometric studies have multiple potential uses in anti-doping. Such studies can help organizations and funding bodies to minimize duplication of research, provide context for funding allocations, offer insight into how to improve their research programs, and inform decision-makers on the success of funding allocation strategies. Bibliometric analyses can identify key researchers and research hubs to facilitate collaboration and the dissemination and implementation of knowledge, opportunities for new collaborations for multidisciplinary work, and cognate subject areas that can bring fresh approaches, new expertise, and new methodologies to anti-doping. It can also detect the so-called "invisible colleges" (Newman, 2004; Palacios-Núñez et al., 2018) that may help or hinder research development.

The Role of Women Authors in Advancing Anti-Doping

Like other gender studies in sport science, the presence and role of women in anti-doping science were under-represented. The number of female authors was half of the number of male authors in our analysis. As a whole, our results do not confirm the pattern observed elsewhere for health, life, and social sciences, which shows that multidisciplinary research areas have higher or the highest representation of women (Dehdarirad et al., 2015; Elsevier, 2021). However, in the social science subset alone, which appears to be highly interdisciplinary within social sciences, women researchers have been better represented. Generally, there were very few research outputs in anti-doping that crossed science and social sciences within a single study.

Furthermore, female authors were more likely to be in authorship positions other than first or corresponding. There were also differences in the citation patterns of male and female scholars, share and performance of women among the most cited actors were low. Our results are in line with the study of Larivière et al. (2013) who examined global gender disparities in science and showed that papers with female authors in key positions are cited less compared to publications with male authors in key positions. However, it is important to mention that citation differences are not directly because of the gender of authors but also the research field they are linked to. Females are involved more in "applied" and "practical" research which means that their impact is outside academia and could not be detected by citations. The number of citations is just one but not the only indicator of women's contribution to anti-doping research.

Regarding the authorship network, the most important network positions were occupied by men. This fact highlights that with some exceptions women have not been able to set up a considerable network in this men-dominated realm. Dehdarirad et al. (2015) showed that women had the highest contribution to the field of education and psychology among others. Education and psychology studies related to anti-doping research were important and dominant in more clusters such as in cluster "Anti-doping education and doping prevention" but in contrast to Dehdarirad et al. (2015), the share of articles with at least one woman author was relatively low at just 55%.

The presence of women in the authorship network showed great differences, especially in network indicators. Among the centrality indicators, the Information centrality indicator shows a significantly higher value in the case of women. This fact can be evaluated as a favorable one because according to Shan et al. (2018), actors in a network with higher information centrality have a higher level of control over information flow in the

system. In our opinion, this relatively favorable position of women authors in the network can be explained by the fact, that women could be key actors in knowledge integration in anti-doping sciences.

Although women are under-represented in anti-doping, their share in scientific communication is increasing, the number of female authors is doubled in key positions within the 24-year time frame. The increasing share of women in the anti-doping field is especially important for three reasons: (1) this should be a natural contribution to the enhancement of gender equality, which is a natural part of the development of the societies and sciences. (2) The enhancement of women in science means an increase of intellectual capacities. This is especially important in an era when there is a new, and ever-increasing development of different methods of doping, threatening its integrity. (3) The integration of the feminist approach into the anti-doping realm can further enhance the anti-doping knowledge, research, and discussion by critical evaluation and reconstruction of the subject. Following the logic and argumentation of Israel and Sachs (2013) on the role of feminist science studies on climate change, in the case of anti-doping science feminists' approach (a) can contribute to enhancing the anti-doping activism, which is not built just on control and regulation, but is based upon the voluntary activity and self-conscience of athletes; (b) increased integration of standpoints and opinion as well as specific problems of oppressed, marginalized group of athletes (e.g., children, athletes from the third world), (c) contribution to the better understanding of doping-problem by the deconstruction of it and stepping beyond the traditional approaches, based on "wet" and "hard" science and ever-increasing control.

Implications of the Observed "Gendered" Research Trends

The most prolific female authors appear to be successful in obtaining funding for anti-doping research. Having funding not only facilitates research activities but often provides support for research assistants and builds collaboration networks—both of which can have a positive impact on the number of publications. Specific to social sciences, international collaboration can generate more impactful research with larger and more comprehensive samples. Academic institutions that use bibliometric data to inform decisions about internal funding (e.g., for PhD studentships, seed grants, open access publication) and/or promotion should be aware of the gender disparity, which is exemplified in this paper but not limited to anti-doping science (Gender Equality in Research Innovation, 2021). Equally, countries, where governments are using some form of research evaluation to allocate research funding to academic institutions (e.g., the Research Excellence Framework (REF) in the UK, or similar central assessments in Australia or Italy), are also impacted. For example, in the UK's REF assessment, gender equality is monitored, but because the Unit of Assessments for REF submission is an institutional choice, gender equality indices are not comparable across institutions (Gender Inequality Is Still Baked in to the REF, 2020).

The under-representation of women in anti-doping research and their low share of research funding lock many women researchers into a vicious circle. Lundine et al. (2018) argue that "the gendered structure of academic publishing is both a reflection and a cause of women's under-representation and disadvantage in other areas of the scientific enterprise" (p. 1755). By receiving less research funding, women were not only handicapped in the race for high-impact research, but they became less visible in academic publishing, which then leads to being less likely to be invited as peer reviewers or editors for scientific journals, which then reduces their chances to obtain research funding. Results from the current study on anti-doping appear to confirm this pattern. Women researchers featuring among the top twenty authors have multiple research fundings from WADA and other sources, under their belts. Furthermore, most authors on this top-twenty list work or worked in WADA accredited anti-doping laboratories, which have a mandatory allocation of 7% or more of their operational annual budget on research (WADA International Standards for Laboratories, 2021, Articles 4.3.2 and 4.4.2.6), or linked to WADA in some other (academic) capacity such as serving on expert panels, working groups or filling *ad hoc* advisory roles for bespoke projects.

LIMITATIONS

The current study had been focusing on the role of women researchers in anti-doping. The set of publications, used for the analysis was just a relatively small, but carefully curated part of the total publications dealing with the doping problem. Based on a larger sample, more exact mathematical models could be constructed to determine the most important influencing factors of place and role of women in anti-doping-related articles. If and when the number of publications increases, the application of more sophisticated methods of identification of the sex of authors could enhance the explanatory power of the models. Of course, we have tacitly supposed that the participation of women in academic articles is proportional to their role in research. The reality of this statement should be validated by more sophisticated, qualitative methods.

Overlaying grant data to key authors was purposefully limited to WADA-funded research. Although it is a limitation on the available information, we felt that relatively new funding avenues with a preference for science vs. social science (e.g., Partnership for Clean Competition, EU ERASMUS+ Collaborative Partnership grants) and *ad hoc* opportunities (e.g., research funding provided by the International Olympic Committee for 3 years) would skew the results. It must also be acknowledged that national-level funding for anti-doping is also available, but both the access to these and the level of funding available vary widely between countries and regions. Future investigation with a more nuanced analysis of the relationship between grant funding and academic outputs will contribute to research impact assessment, and thus be recommended.

Last, but not least we must stress that we have identified the gender of the authors on the base of their names. It is another

question how accurately this reflects the authors' gender identity. Notwithstanding these shortcomings of the current study, we hope, that our research sheds light on an existing problem, and it will motivate other research activities for a better understanding of the participation and role of women in anti-doping sciences.

Recommendations

We have seen that there is a considerable gap in the participation of women and men in anti-doping sciences. This situation is similar to other fields of sciences, hence (re)citing the general guidelines (e.g., National Research Council, 1991), strategies, and best practices (Coe et al., 2019) to improve gender inequality offers a rather limited added value. Instead, the field should utilize and build on the fact that anti-doping is a relatively new subject field, with pioneering researchers still active and most likely available for mentoring the next generation of researchers. Instead of solely focusing on compliance by artificially "ensuring gender balance" in recruitment, boards and expert panels, the field should focus on a long-term solution via the next generation of researchers, and beyond.

To facilitate this progress, two specific aspects of the anti-doping field should be taken into consideration. Firstly, the public and implicitly the political level of interest shows a large and relatively cyclical fluctuation. The important sport events (e.g., the Olympic Games) and some notorious doping scandals, like the case of Armstrong (Zurloni et al., 2015) increase the level of interest in the anti-doping topic. Under these conditions, it is a real danger, that the political decision-makers will be reluctant to allocate additional monetary resources for research and development. On the other hand, there is a rapid increase of challenges that need academically well-founded, non-partisan answers in this field. The continuous finance of these activities is a necessary precondition of efficient anti-doping regulation. Another relatively specific aspect of anti-doping research, as an academic field is a relatively low degree of overlapping between the "wet" sciences (analytical chemistry, pharmaceutics) and the research of social aspects of the topic. Consequently, the organization of interdisciplinary teams should have been a priority, while taking gender disparity into account. In fact, the findings of this research indicated that women researchers—through their better connectivity—are well-positioned to lead this line of research.

Secondly, by applying the model of the triple helix (Leydesdorff and Etzkowitz, 1998) to anti-doping research outputs, one can determine the set of theoretical possibilities (indicated by ABC triangle) which as—due to the socio-ethical, legal, or scientific conditions—limited a relatively small part (indicated by X, Y, Z triangle) that can be put into the practice (**Supplementary Figure 5**). In the achievement of enlargement, this scope of action the mobilization of all intellectual forces is imperative. Because sport has served the emancipation of the "second sex" (Beauvoir, 1953), several studies have been focused on the importance of gender equality via gender quotas on sport boards (e.g., Knoppers and McLachlan, 2018; Piggott, 2021). Anti-doping sciences should and could demonstrate the possibility and importance of overcoming gender inequalities due to its high degree of inter- and multidisciplinarity, and show that gendered perspectives can have an impact on how the anti-doping research field is evolving (e.g., research priorities or interpretations of findings).

Future Research Directions

In the analyses presented in this study, we have investigated diverse structural characteristics of women's involvement in anti-doping research. This diversity, however, triggered several further questions and promising research lines that should be addressed in future work. As a direct extension of this research, future directions should include the following research directions:

(1) The scientific impact of women's contribution to anti-doping science. A topic of outstanding importance is the exploration of the impact of women-related anti-doping research on the scientific community. The impact of research in terms of citation indicators and measures, and also in bibliometric quality measures (such as journal metrics like the Journal Impact Factor, or the corresponding journal quartiles) reveals the extent of both the recognition and the scientific quality of women's contribution to anti-doping science. Recognizing that real research impact cannot be ascertained by journal metrics, future research is warranted to develop standardisable qualitative approaches for research impact assessment. These may include path analysis using bibliometric data and citations, exploring the mentions and uptake of the research findings outside academia, or a form of expert/peer-assessment or self-assessment of the research output based on its own merit (as opposed to the journal where it was published).

(2) The key actors of knowledge integration in anti-doping science. An equally important topic is the identification of actors (authors, groups) within the anti-doping research landscape who plays the role of connecting different research fields in their work. By doing so, these actors facilitate knowledge integration in the multidisciplinary domain of anti-doping science and strengthen the evidence that women have a higher share in highly interdisciplinary research (Elsevier, 2021). Exploring the involvement of women in this process (via bibliometric science mapping tools used in modeling interdisciplinarity) can greatly improve our understanding of their potential in the field, which then can lead to tailored support for women in anti-doping research.

(3) The analyses presented in this work applied the analytic framework of science mapping, the latter being a state-of-the-art toolbox of computational social science, but largely explorative in nature. A natural step is to complement these results with an explanatory approach in the sequel, with an investigation of how the structural features of women's involvement (such as authorship positions, research fields, institutional background, "invisible college" status, etc.) affect their success in the field (as measured, for example, via recognition measures such as citation measures). Finally, future investigations should use this study, and other bibliometric analyses, as a basis for follow-up studies, and explore the key results qualitatively, or via utilizing mixed-methodology.

CONCLUSION

Monitoring gender representation in science, research, and technology is vital for progressing from under-representation of women to awareness, equity, and transformation in all subject areas, including anti-doping research. Gender inequalities in sport science in general, and in anti-doping research in particular, have been poorly recognized. With rapid advances in computational social science, modern bibliometric analyses now afford quantification of the potential differences and uncover the cognitive and social structure of anti-doping research in both hard- and social sciences. The comprehensive analysis of the academic publications in this study indicates that anti-doping research is a closed community with only 70 authors producing more than one output, and women have been under-represented in the field of anti-doping research for a long time, but their presence in and contribution to the field is evolving and steadily increasing. WADA's direct and indirect impact on research through funding and governance structure through the most influential men and women authors is noted and warrants further exploration. Anti-doping is in need to mobilize all intellectual capacities to tackle new challenges that threaten the integrity of elite sport, and women can play a unique role in this. The significantly higher information centrality of women means that they are better positioned to control and facilitate the information flow in the system, which can be highly beneficial in problem-focused multidisciplinary research as well as in fostering new collaborations both within the anti-doping community and with researchers in cognate fields. Bibliometric approach has the potential to play a significant role in anti-doping research. Alongside traditional systematic literature reviews and meta-analyses, bibliometric analyses can make a unique contribution to delineating the research field, map the knowledge base, and portray hidden relations in the field of anti-doping science.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

AK, SS, and AP contributed to the conception and design of the study. SS organized the database. ZL performed the statistical analysis. AK and ZL wrote the first draft of the manuscript. SS, AP, and ZL wrote sections of the manuscript. AK, AP, and ZL contributed to writing, review, and editing of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fspor.2022.866648/full#supplementary-material

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frontiers | Frontiers in Sports and Active Living

TYPE Original Research
PUBLISHED 23 September 2022
DOI 10.3389/fspor.2022.859153

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Anti-doping Sciences, a section of the journal Frontiers in Sports and Active Living

RECEIVED 21 January 2022
ACCEPTED 01 September 2022
PUBLISHED 23 September 2022

CITATION
Manges T, Seidel K, Walter N, Schüler T and Elbe AM (2022) Answering the call for values-based anti-doping education—An evidence-informed intervention for elite adolescent athletes in Germany and Austria. *Front. Sports Act. Living* 4:859153. doi: 10.3389/fspor.2022.859153

Answering the call for values-based anti-doping education—An evidence-informed intervention for elite adolescent athletes in Germany and Austria

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Doping has serious negative consequences for athletes and the integrity of sports, implying the need for effective prevention programs. Since educating young athletes about doping-related knowledge is deemed to be not sufficiently effective to minimize doping, a focus on values, emotions and morality is seen as a promising approach and previous research indicates which variables exactly could be addressed in anti-doping efforts. These variables are anticipated guilt, empathy, moral disengagement, and collective moral norms, since these constructs have been strongly and consistently linked to doping intention, likelihood, or behavior. Therefore, the purpose of this study was to develop a values-based anti-doping intervention, which targets the aforementioned variables, and to evaluate its effectiveness in producing changes in outcomes in comparison to an information-based intervention and a waiting control group. To evaluate their effectiveness, both interventions, which each consist of six 45-min sessions (one session per week) were implemented in a sample of 321 young elite athletes, aged 13–19 years, from a broad range of team and individual sports. Thirty different teams, training groups or classes were randomly assigned to either the values-based intervention, the information-based intervention, or to a waiting control group. Doping intention, doping susceptibility as well as the above mentioned variables were assessed at pre- and posttest and, for participants of the values- and information-based conditions also at a 3 to 4-month follow up. Within a multilevel modeling framework general linear mixed regression analyses revealed that the values-based intervention, compared to the control group, was able to decrease athletes' moral disengagement and increase their anticipated guilt immediately after the intervention (at posttest), whereas no effects for the information-based intervention emerged. Looking at how the outcomes developed over time (i.e., at the follow up measurement), it could be demonstrated that the reduction in moral disengagement sustained. The increase in anticipated guilt, however, was not sustainable and, surprisingly, decreased from post to follow up. Furthermore, athletes in the values-based intervention reported higher empathy from post to follow up, which could

10.3389/fspor.2022.859153

possibly indicate a "delayed" effect. This study provides support that a values-based approach can produce changes in some, yet, not all addressed variables and specific elements from this intervention could potentially be a useful addition to traditional anti-doping education (i.e., information provision).

KEYWORDS

anti-doping intervention, doping prevention, morality, values-based, empathy, moral disengagement, moral norms, anticipated guilt

Introduction

Even though sport is an ideal setting to foster moral competencies, these competencies are at the same time challenged by one of sport's major threats, namely doping. As defined by the World Anti-Doping Agency (WADA), doping comprises the occurrence of one or more out of 11 anti-doping rule violations set out in the World Anti-Doping Code (1). To name a few, evading or refusing sample collection, possessing and (attempted) trafficking prohibited substances or methods, or (attempted) tampering of a doping control all belong to anti-doping rule violations. However, the most common violation is the use or attempted use of banned substances or methods to enhance performance. With estimated prevalence rates ranging from 14 to 39% (2) up to 44–57% (3), it is obvious that doping is a widespread problem, especially in elite sport. Due to the potential health damages of doping, its threat to fair play and its negative influence on the integrity of sports, there are considerable efforts to minimize doping. The most commonly used strategy so far has been the detection and deterrence approach (4), which assumes that detecting and sanctioning doping will deter other athletes from resorting to it. However, since this approach is costly and at the same time not sufficiently effective in reducing the prevalence of doping, an educational anti-doping approach is viewed as promising and has been gaining importance [see (5)]. WADA [(6), p. 56] recognizes education "no longer [as] [. . .] a worthy but optional extra", but as "an essential and central pillar of the global anti-doping program". This statement is further supported by the publication of the International Standard for Education [ISE, (7)] in which WADA also emphasizes the need for developing and delivering doping prevention programs that go beyond raising awareness and providing information about doping and that focus on a values-based educational approach. The purpose of the present study is to address that need and to develop, deliver and evaluate a values-based doping prevention program.

Current state of anti-doping programs

Having a closer look into the overall "prevention through education" approach, one can typically differentiate between "information programs" and "education programs" (5, 8). In addition, the ISE (7) distinguishes between a cognitive and an affective domain. Information programs align with the cognitive domain and aim at creating awareness and increasing knowledge about doping (e.g., forbidden substances, side effects, consequences) in athletes, coaches and other support personnel in order to prevent -especially unintentional- doping (8). Education programs that align with the affective domain are meant to go beyond a knowledge transfer and often focus on "values-based" education (9). According to the ISE, values-based education means "delivering activities that emphasize the development of an individual's personal values and principles. It builds the learner's capacity to make decisions to behave ethically" [(7), p. 10]. As such, values-based anti-doping education can address emotions, motives, attitudes and values and often incorporates the fostering of moral competencies. This seems plausible since a person's morality, defined as his or her beliefs and practices about what is right or wrong, which is developed over time, influenced by social contexts (i.e., group, culture, society) and guided by personal values, is presumed to be shapeable/trainable [e.g., (10, 11)]. The following paragraph provides an overview of the current state of interventions/programs.

Prominent examples of information-based interventions are the ATLAS [Adolescents Training and Learning to Avoid Steroids (12)] and ATHENA [Athletes Targeting Healthy Exercise and Nutrition Alternatives (13)] programs, which both impart knowledge about a variety of unhealthy behaviors including doping. Research evaluating these programs in large samples of athletes did not demonstrate a significant decrease in the number of reported doping cases over a season or school year compared to a control group (14, 15) and showed only slightly decreased doping intentions compared to a control group (14, 16). Nevertheless, these two programs formed the starting point for a prevention initiative during the last two decades, marked by the development and evaluation of several anti-doping interventions. A recent example for interventions that focus on knowledge about doping and particularly about the associated health consequences is WADA's Athlete Learning Program about Health and Anti-Doping (ALPHA); however, while Murofushi et al. (17) found the ALPHA program to be effective in increasing knowledge about doping, they did

not measure or report any outcomes on doping intentions or behavior.

Three recent reviews examining (a) 30 doping prevention studies (9), (b) 53 national anti-doping organizations' prevention campaigns (18), and (c) 14 anti-doping interventions (19) demonstrate that information-based (i.e., conveying anti-doping knowledge inclusive health consequences) approaches dominate other approaches (e.g., values-based approach). This is surprising, since the information-based approach has been criticized and deemed to have no or only a modest effect on reducing doping intentions and behavior (20, 21). Moreover, as the review results further indicate, information-only programs are rated significantly lower in usefulness and trust by athletes, compared to other, more comprehensive educational programs [e.g., (18)]. This emphasizes the need for multifaceted education in which at least one additional approach is implemented together with the information-based approach.

As a response to the latter, there is a trend towards including additional elements beyond mere information provision, and these additional elements often focus on targeting psychological variables that are empirically related to doping proxies (e.g., doping intentions, doping likelihood). An example is the Hercules program (22) which conveys knowledge to athletes in combination with providing information on the ethics of doping and on resisting peer pressure to dope. Other programs also include psychological, moral and ethical aspects of doping such as fair play and the values of sport (23–25), alongside knowledge transfer. The iPlayClean program (26) addresses a variety of topics such as doping myths, health, nutritional supplements but also motivation, playing fair and resisting temptations and was successful in reducing favorable attitudes toward doping in adolescent athletes. A somewhat different approach is a media literacy intervention, which deals with the moral aspects of doping and how the media may disregard them (27, 28). Noteworthy is also a program that focusses on coach education and which showed that athletes were less willing to take banned substances when their coaches adopted a motivationally supportive communication style in regard to doping-related discussions [CoachMADE (29)].

Looking at the interventions that exclusively focus on psychological, moral and ethical aspects {which, for the sake of this study and in line with the distinction pointed out above [see (8) and ISE; (7)], will be labeled as "values-based" programs}, three programs stand out. Based on the Konstanz dilemma-discussion method (10, 11) Elbe and Brand (30) developed an ethical decision making training for young athletes. An online intervention with doping-specific moral dilemmas aimed at promoting moral reasoning in athletes. Although, contrary to the authors' expectations, this intervention slightly increased athletes' doping attitudes, the authors argue that the training challenged stereotypes in reasoning about doping. Most recently, the research of Kavussanu et al. (31, 32) showed that intervening specifically on moral and psychological variables, which are associated with doping behavior proxies in empirical research, seems to be a promising way to prevent athletes from doping. For both studies, adolescent athletes from the UK and Greece were recruited and randomly assigned to an intervention or control group. In study one (31) the researchers developed a moral intervention that addressed moral identity, moral disengagement, and moral atmosphere and compared it to a so called "standard", i.e., information-based intervention that conveyed knowledge about the health consequences of banned substances, the risks of nutritional supplements, the doping control process, etc. In study two (32) a psychological intervention which targeted anticipated guilt, moral disengagement, and self-regulatory efficacy was developed and, likewise, compared to the information-based intervention. Results showed that, in study one, both the moral and information-based intervention were able to reduce doping likelihood at a post measure as well as at a 6-month follow-up. Study two revealed that the psychological intervention was superior to the information-based intervention in reducing doping likelihood from pre to post, but the sustaining effects at the follow-up were similar in both intervention groups. However, as both studies lacked a no-intervention waiting control group, it is not entirely clear if the changes in outcomes were caused solely by the contents of the interventions. Incorporating a no-intervention waiting control group into these designs would help provide an untreated comparison for both active intervention groups.

The current state of anti-doping interventions suggests that intervention programs targeting psychological and moral doping-related variables can have a meaningful impact on athletes' decision to dope. Over the next paragraphs we address the question which specific variables should be targeted in an intervention.

Theoretical and empirical background

In general, research indicates that both personal moral variables such as moral disengagement and social context variables such as perceived norms should be taken into account (33, 34). This is in line with Bandura's (35) social cognitive theory of moral thought and action which has served as a foundation for recent anti-doping research [e.g., (32, 36)] and also informs the study at hand. According to Bandura (35), a person's behavior is governed by the moral standards that this person has developed and internalized through socialization processes. When engaging in a behavior that contradicts one's own moral standards people usually experience negative emotions such as guilt or shame. In order to avoid such affective self-sanctions people tend to behave according to what is expected based on their moral standards. Those emotional reactions, positive or negative, play a central role in regulating moral conduct since they operate anticipatorily.

The role of anticipated guilt, a regulatory moral emotion, has been investigated increasingly in relation to transgressive behavior and especially doping over the past years. Studies outside the sport context show that the proneness or anticipation to feel guilt has been inversely associated with bullying behavior and aggression (37, 38). Doping specific research from a wide range of sports evidences a strong inverse relationship between athletes' anticipated guilt and doping likelihood/doping intentions [e.g., (36, 39–41)]. Athletes know that by doping they would transgress the rules of sport and therefore engage in cheating behavior which is seen as morally wrong (42). Hence, they may anticipate feeling unpleasant emotions like guilt or regret when making the decision to dope. Since people try to avoid such feelings, anticipating those unpleasant affective reactions can therefore deter athletes from doping.

However, people are able to situationally disengage from their moral standards in order to minimize the expected negative emotions that would typically arise from transgressive conduct like doping. As explained by Bandura (35), people do so by making use of one or more cognitive mechanisms, collectively termed moral disengagement (MD). Past research identified six mechanisms relevant to doping in sport (43). In a doping-specific situation athletes may, for instance, try to justify their behavior by arguing that "everyone on the team is doping, too" (i.e., diffusion of responsibility) or that the coach, teammates or support personnel pressured them to dope (i.e., displacement of responsibility). Also, athletes may use favorable names for doping substances or methods, such as "vitamins" or "medical treatment", making doping sound less severe (i.e., euphemistic labeling). Further mechanisms are downplaying or ignoring the harmful consequences by saying that it "does not really hurt anyone" (i.e., distortion of consequences) or by comparing doping to transgressive behaviors from other contexts that seem worse, such as criminal conduct (i.e., advantageous comparison). Finally, athletes may cognitively restructure their transgressive behavior into a "good" behavior by justifying, for example, that doping "helps the team", thereby making it appear acceptable (i.e., moral justification). The use of the described mechanisms facilitates athletes' doping behavior through minimizing the negative feelings typically associated with it. Qualitative research highlights the importance of MD in regard to doping [e.g., (44)] and quantitative designs support the strong and positive relationship between MD and doping intentions, doping likelihood and reported doping behavior [e.g., (33, 36, 39, 43, 45, 46)].

Another key aspect of the social cognitive theory of moral thought and action, which is important in relation to doping is empathy (36). Empathy reflects the capacity of vicariously producing emotional and cognitive responses to another person's emotional state (47). That means, an empathic person possesses the ability to change the perspective and see the world from another person's view. It is supposed that, the better an athlete can understand the consequences of his or her unethical behavior for others, the more difficult it is to engage in such behavior (35). Although empathy has received less research interest, there is empirical evidence that empathy is negatively linked to antisocial behavior in sport (48, 49). Furthermore, Boardley et al. (36) demonstrated a negative predictive effect of empathy on MD and a positive predictive effect of empathy on anticipated guilt, thereby suggesting that increased empathy is associated with lower MD, higher anticipated guilt and hence, with reduced doping behavior or its proxies. These findings concerning the interplay between guilt, empathy and MD are consistent with theory (35) and with empirical evidence from other contexts, such as the business context (50), making all three variables promising targets in our intervention.

Nevertheless, not only personal moral variables play a role in explaining doping behavior but also social context variables should be considered, as suggested in various doping research models [e.g., the Sport Drug Control Model (51); or the Life Cycle Model (52)] and underpinned by the social cognitive theory (35). Since an athlete's social context is determined primarily by his or her team or training group, collective group norms and values, that develop over time through the interaction of group members and define what kinds of behaviors are considered acceptable within a group, are of interest. Sport research shows that collective group norms, sometimes referred to as moral atmosphere [e.g., (39)] moral climate [e.g., (53)] or collective moral attitude [e.g., (54)] strongly influence the moral behavior of group members. Doping research, specifically, provides evidence for a strong relationship between collective moral norms and doping intentions (33, 34, 54). In light of these findings, integrating and targeting collective moral norms/attitudes may be beneficial in our doping prevention program.

After having examined the theoretical and empirical background on which target components should be incorporated in our intervention, the question of the timing of doping prevention efforts is a crucial point as well (7), that is, which target group the intervention should be designed for. WADA (7) points out that anti-doping efforts should occur at an early phase of athletes' careers, so that their first contact with anti-doping happens through education rather than doping control procedures. Researchers agree on that by stating that primary prevention before potential onset of doping behavior is beneficial (20, 55). Asking the athletes themselves, qualitative studies provided additional support for an early implementation of anti-doping programs (56, 57). Adolescence is seen as a critical doping entry phase (9) but at the same time as a phase paramount for developing and changing values, attitudes and moral behavior (58, 59).

Therefore the intervention program was designed for adolescent elite athletes.

Aims of the present study

As WADA (6, 7) declares education a central pillar in the global fight against doping, the need for effective education programs is obvious. A focus on a values-based educational approach is emphasized in the ISE (7) and has become increasingly present in anti-doping efforts. Some intervention studies have gone beyond the knowledge transfer and have included elements that target psychological and/or moral variables that are empirically associated with doping [e.g., (23, 24, 28)], yet only a few were able to show long-term effects in reducing doping proxies, such as doping likelihood (31, 32), doping susceptibility and attitudes (26), highlighting the importance of study designs that evaluate long-term effectiveness.

Concerning the theoretical and empirical background on doping-related psychological and moral factors, several key variables from Bandura's social cognitive theory of moral thought and action (35) have been found to strongly relate to doping likelihood, intention or susceptibility [e.g., (36, 39)] and therefore should be considered in our intervention program (i.e., anticipated guilt, moral disengagement, empathy and collective moral norms). When designing this intervention we could also draw upon previous studies by Elbe and Brand (30) as well as Kavussanu et al. (34) which served as inspiration.

In conclusion one can state that there is knowledge about the effectiveness of doping prevention programs, about the variables that should be addressed and about the most promising target group, namely adolescent (elite) athletes. However, most of this research was conducted in countries outside the German speaking countries [with exception of the study by Elbe and Brand (30)].

Consequently, the present study aimed at, first, developing a values-based intervention program, designed for adolescent athletes and based on theory and empirical evidence; second, implementing the intervention program in young elite athletes in Germany and Austria along with an information-based program; and, third, evaluating its effectiveness. For the sake of the latter we formulated two research questions, namely: (1) Are the values-based intervention and the information-based intervention effective in producing changes in outcomes after the intervention, compared to a waiting control group? and (2) Can changes in outcomes within each intervention group be maintained over time, i.e., at a 3 to 4-month follow up? The primary outcomes are doping intention and doping susceptibility and the secondary outcomes are anticipated guilt, moral disengagement, empathy as well as collective moral attitude/norms.

Materials and methods

Development of the intervention programs

The main purpose of the study's first stage was the development of the values-based intervention program, along with the development of an information-based program for reference purposes during the evaluation process. Both interventions were designed to be implemented by a facilitator/instructor in small groups of athletes (5–15 participants). They consist of six sessions, respectively, with each session lasting 45 minutes in order to enable potential realization within the timeframe of a school lesson. By having one session with one topic per week over a 6-week period, time for reflection and retention in between the sessions was warranted. This also followed previous findings that effective interventions should run over longer periods [2–10 weeks; (60)]. During the development it was key for us to base it on a high-quality pedagogical foundation and to ensure an appealing content delivery. Therefore, two experienced high school PE and ethics[1] teachers, whose competencies and credentials were known to the research team members, were recruited to work for the project through a professional fee agreement and substantially contributed to the intervention development. Both interventions were grounded on a problem-based learning approach, which allows the learner to become actively engaged with the subject matter (61). For this purpose, fictional and real athletes' cases were included in the learning materials as the story-like character is seen to enhance immersiveness and makes the topic more approachable than talking about doping and related emotions, attitudes, etc. at an abstract level. Furthermore, to promote athletes' engagement, role-playing games and quizzes were applied; interaction and group discussions were encouraged; arguments were generated and contents, like posters or letters, were created. This approach aims at ensuring that participants effectively acquire skills and knowledge, reflect on the content and apply it to problem-solving in potential real-life situations (62). The first version of the two programs were presented to a number of coaches, teachers and stakeholders in sports within a project meeting. Minor content adjustments were made following the feedback received during the meeting (e.g., since students may need more time than originally allotted to comprehend and conduct the tasks/activities, two sessions were deemed as too full and activities were reduced to better fit the 45 min session length).

The delivery mode of the interventions was initially planned as face-to-face teaching and both interventions were pilot tested with soccer and judo athletes (in total 40 athletes, aged 15–18) in order to improve the interventions following the participants'

1 Ethics is a subject that is taught in most German high schools just like PE and for which teachers need a university degree in ethics.

extensive qualitative feedback. However, due to the pandemic situation, face-to-face teaching was no longer feasible and the teaching materials were adapted to an online format. During this adaptation process the content remained unchanged but the didactical methods had to be modified to digital synchronous teaching. For each session, the group of athletes comes together with the facilitator at a set time *via* the video communication platform Zoom and synchronously participates in the session. Special features of Zoom, such as breakout rooms and surveys but also further online tools, such as quiz-apps and a digital whiteboard software provided options for working together in small subgroups, creating mind maps, conducting opinion polls or visualizing information. The newly designed online materials were then tested in a further pilot study within the framework of the final theses of two trainee PE teachers in a sample of 10 handball athletes, aged 13–15. Participants in the pilot study provided comprehensive feedback as they were asked to fill in a feedback questionnaire after each session and to engage in a general feedback discussion after completion of the program. Both elements (i.e., each session's questionnaire and general discussion) addressed a wide range of issues, such as the sessions' content, comprehensibility, didactical methods, (technical) feasibility and timing as well as participants' engagement and commitment. Based on the athletes' feedback and the facilitators' impression, final, minor adjustments, especially regarding the timing, were made. An overview of both online intervention programs are presented hereafter[2].

Values-based intervention

The values-based intervention was designed to encourage cognitive, emotional and group dynamic processes and to create awareness and reflection of personal values and attitudes. Grounded on theory (35) and empirical evidence [e.g., (33, 39)] and underpinned by previous intervention studies in and outside the German language area (30–32) the intervention aimed at affecting anticipated guilt, empathy, moral disengagement and collective moral norms. Each variable is addressed in one specific session (session 2–5), whereas session 1 and 6 form the intervention's framework.

Session one serves as an introduction to the topic "Doping—yes or no?" After words of welcome and a warm-up participants are asked to mark a spot in a coordinate system in a web-based interactive whiteboard, indicating if they generally approve or disapprove doping and if this was an easy or tough decision for them to make. Then, a doping-specific hypothetical scenario is presented *via* an animated video, depicting the moral dilemma situation of a young female athlete ("Lisa") who wants to perform clean but now thinks about taking banned performance-enhancing substances as she witnesses her better-performing teammates talking about their substance-use. Working with such dilemma situations, based on the Konstanz dilemma-discussion method (10, 11), is seen as a beneficial method to confront athletes with, and train potential future decisions in their athletic career (63). The employed moral dilemma story originates from Elbe and Brand's (30) ethical decision making training and serves as a common thread through subsequent sessions. Once participants have seen the video, they are asked to imagine that they were in Lisa's situation and, again, enter their position in the coordinate system from Lisa's perspective. By comparing the before-and-after marks in the coordinate system and discussing related arguments for and against doping, the athletes should recognize the conflicts young athletes may face, when they encounter contradicting interests and values. The overall aim of this session is to encourage participants' reflection and to make them aware that decision making might be more difficult as soon as the situation becomes less hypothetical and more specific by describing an athlete's real dilemma.

Session two addresses anticipated guilt and refers back to Lisa's dilemma story. An animated video is presented, illustrating how the athlete now has decided to try the forbidden substances in order to keep up with her teammates. Participants are requested to create a fictional ending for Lisa's story. They have the option to end the story in two ways, either Lisa is caught doping or not. Regardless of the ending they choose, they are instructed to consider a variety of potential consequences and to pay special attention to feelings, the person in question might experience, thereby getting a glimpse of emotions such as guilt or regret. In the discussion that follows, some of the created stories are presented and the possible endings are visualized through an interactive whiteboard. The consequences the participants mention are clustered into categories like health, legal, financial, psychological, and social, with a focus on the latter two. Based on evidence from previous interventions (31, 32) the purpose of this session is to sensitize athletes about potential feelings of guilt and remorse that might occur when deciding to dope.

Session three targets empathy and tries to foster participants' ability to take the perspective of other persons that are potentially affected by one's doping behavior. The last part of the Lisa-dilemma-video is shown, which illustrates how Lisa has been tested positive in a doping control. Various characters, such as a former competitor, who has been awarded her medal 5 years later due to Lisa's doping, Lisa's parents, or a long-standing fan of hers, are introduced by the facilitator. The participants receive the task to write a diary entry from the respective person's point of view, addressing their feelings and thoughts. In Zoom breakout rooms, athletes who have been assigned the same characters come together to discuss their diary entries before presenting some of them to the entire group and reflecting on the feelings of those third persons that were involuntary affected by Lisa's decision to dope. In addition to training participants' perspective taking this session

2 Comprehensive materials for all sessions in both interventions can be obtained from the first author upon request.

also highlights the tremendous consequences the decision to dope has for others. Thus, session three at the same time opens the way for session four, as it challenges the moral disengagement mechanism of distorting the consequences one's decisions have.

Session four deals with the construct of moral disengagement. After a brief definition athletes are encouraged to think about possible "justifications" a person who decides to dope could use. In order to learn about the different types of MD, participants take part in a memory game that has been prepared in the interactive whiteboard and are asked to connect real athletes' statements concerning their doping to the associated MD mechanisms. Then, an interview-video of a well-known athlete who doped is shown. Participants are asked to pay attention to the justification strategies this athlete used. They receive the task to prepare a role-play in groups, in which a journalist interviews a sportsperson who has been caught doping and several role-plays are presented and discussed at the end of this unit. Through this session's activities, participating athletes are expected to not only detect typical justifications for doping but also to challenge these by finding counterarguments. This process is especially fostered through the role-play (i.e., the journalist's role).

Session five targets the participating group's collective moral norms. The athletes get to know the values of sport by, initially, watching a video of an athlete who talks about the values of his clean-competing team. After discussing the video, the athletes, as a group, are invited to pick values from a catalog of values in the interactive whiteboard and sort them according to their perceived significance. This task is followed by finding arguments whether their top three values are reconcilable with doping behavior. This session's purpose is to provoke thinking about and reflecting on collective values and norms and to guide the group toward a shared understanding that doping is incompatible with the majority of sport values. Additionally, due to the fact that the athletes take part in the intervention as a group, it is assumed that all the sessions will impact not only their individual but also their collective moral norms.

Session six serves as a summary unit of all topics discussed in session one to five. Participants are assigned to two groups (in two breakout rooms) and instructed to apply their knowledge/skills to a new dilemma situation. Through analyzing the pros and cons, considering possible consequences for the athlete in question as well as for third parties that may be affected by this athlete's decision to dope, participants are expected to arrive at a sound decision. The two groups then present their respective dilemma stories, along with their analyses and final decision. This is followed by the instructor's summary, conclusion and fare-well.

Information-based intervention

The information-based intervention which served as a comparison was designed based on the German National Anti-Doping Agency's (NADA) current prevention program "Gemeinsam gegen Doping" ("Together against Doping") and strictly followed its content but employed various didactical methods to create an intervention that is comparable to the values-based intervention regarding its engagement enhancing delivery and interactive character. In collaboration with the NADA and the two ethics and PE teachers, six sessions with the following topics were developed:

Session one Introduction. Doping—what is it?: Through providing a worksheet about doping and conducting breakout rooms for exchanging ideas before coming back together in the plenum, students elaborate a definition of doping, discuss the role of NADA and WADA and are introduced to famous doping cases and frequently asked questions about doping;

Session two The prohibited list: Through examples of famous doping cases prohibited substances and methods as well as their side effects are discussed. Acquired knowledge is deepened by connecting substances and methods with their respective effects and side effects within a digital whiteboard based memory game and by editing a "truth or lie"-text on that topic.

Session three Consequences of doping: Again, stories of real athletes are utilized in order to make participants understand the consequences doping can have on different levels. Participants are asked to read stories about persons who doped, complete a worksheet listing the consequences, and, finally categorize these into legal, social, health related and financial consequences.

Session four Doping control procedure: After an introduction exercise "Position yourself regarding the statement that doping controls are manipulated anyways" athletes watch a NADA video, illustrating the procedure of an urine doping control. Thereafter athletes have to sort terms/words in the correct order of the procedure's steps on a digital worksheet (e.g., "A and B sample" goes to step 4 "Packaging of the sample"). The aim of this session is to convey information about doping control procedures thereby emphasizing that the statement in the beginning of the session is not correct.

Session five Supplements and related risks: Athletes are provided with a digital mind map in which comprehensive information about nutritional supplements, promised effects and related risks are presented before they engage in a quiz, prepared with the online tool *Kahoot*, whereby they can test their knowledge and compete against each other.

Session six Summary and internet resources: In small groups *via* breakout rooms students prepare a creative poster (in Microsoft Word or Power Point or other tools) which should contain all information and facts that they remember from the preceding sessions. After working on these together for a few minutes they are allowed to use anti-doping internet resources, e.g., NADA and WADA website and other important websites

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TABLE 1 Participant demographics.

		Values $k = 14, n = 134$	Information $k = 9, n = 114$	Control $k = 7, n = 73$
Age	Mean (SD)	15.59 (1.54)	15.38 (1.67)	15.15 (1.60)
Gender *n* (%)	Female	56 (41.8%)	38 (33.3%)	47 (64.4%)
	Male	77 (57.5%)	75 (65.8%)	26 (35.6%)
	Other	1 (0.7%)	1 (0.9%)	
Sport type *n* (%)	Team	30 (22.4%)	45 (39.5%)	38 (52.1%)
	Individual	104 (77.6%)	69 (60.5%)	35 (47.9%)
Competition level *n* (%)	Regional	32 (23.9%)	26 (22.8%)	39 (53.4%)
	National	68 (50.7%)	75 (65.8%)	31 (42.5%)
	International	32 (23.9%)	12 (10.5%)	2 (2.7%)
	Other	2 (1.5%)	1 (0.9%)	1 (1.4%)
Years main sports	Mean (SD)	7.06 (2.94)	8.95 (2.88)	7.55 (2.75)
Hours/week training	Mean (SD)	13.72 (4.85)	12.11 (5.58)	13.69 (4.20)
Doping prevention measure before *n* (%)	Yes	52 (38.8%)	28 (24.8%)	29 (39.7%)
	No	82 (61.2%)	85 (75.2%)	44 (60.3%)

$k = 30$ teams/classes/training groups, $N = 321$ athletes.

[e.g., Anti-Doping Administration and Management System (ADAMS), Cologne list] in order to complete and improve their posters, which are finally presented in the plenum and commented (and corrected if needed) by the instructor.

Implementation and evaluation

Design

The study was carried out as a cluster randomized controlled trial (RCT), in which clusters of athletes (i.e., teams/training groups/school classes) were randomly assigned to the different conditions. The RCT was delivered in the sport school- and sport club setting in Germany and Austria.

The first research question was addressed by implementing a three-arm parallel-group trial with two measurement points, with group/condition (values-based, info-based, control) as between-subjects factor and time (pre, post) as within-subjects factor.

Research question two was investigated by collecting participants' data (values-based and info-based condition) at a third measurement point, thereby employing a two-arm parallel-group trial with three measurement points, whereby group/condition (values-based, info-based) was the between-subjects factor and time (pre, post, follow up) was the within-subjects factor.

Participants

A total sample of 321 athletes from 30 teams, classes, or training groups were recruited. Their demographic characteristics are presented in detail in Table 1. Inclusion criteria were performing a team- or individual sport on competitive level and being aged between 13 and 19 years old. Based on comparable intervention studies [e.g., (26, 32)] we specified an effect size of 0.45, set alpha at 5% and aimed for a power of 0.80. Using Optimal Design Software (64) for cluster RCT with outcomes on the person-level, it was shown that for the primary outcome of doping intention a sample of 30 clusters with on average 11 athletes per cluster provided the envisaged power of 80% to detect a moderate effect size of 0.45, accounting for an intraclass correlation coefficient (ICC) of 0.10.

Measures

Doping susceptibility

Doping susceptibility which reflects the "absence of a firm resolve not to engage in doping activities or to give any consideration at all to an offer to do so" [(65), p. 481] was measured with the item "If you were offered a banned performance-enhancing substance under medical supervision at low or no financial cost and the banned performance-enhancing substance could make a significant difference to your performance and was currently not detectable. How much consideration would you give to the offer?" utilizing a 7-point Likert-type scale (1 = none at all; 7 = a lot of consideration). Participants responding with "none at all" are seen as non-susceptible, whereas all other answers would express that the respondent can be classified as susceptible (65). This one-item measure has been used in previous studies and has been found to be a suitable instrument for indicating doping susceptibility (65, 66).

Doping intention

Our primary outcome doping intention was ascertained *via* two scenarios, developed and used by Kavussanu et al. [e.g., (31, 39, 43, 67)] and translated within a previous study (54). These scenarios describe hypothetical situations in which athletes are tempted to dope in order to enhance their performance (scenario 1) or to recover faster from an injury (scenario 2). As described in Kavussanu et al. (67), after each scenario, athletes have to rate the following three questions "How likely…/How tempted…/How willing would you be to use the banned substance?" on a 7-point Likert-type scale (1 = not at all likely/…tempted/…willing; 7 = very likely/…tempted/…willing). The mean of the six items was computed for a total score of doping intention, whereby higher scores represent a higher doping intention. With the help of these scenarios a vicarious behavioral intent and thereby answers that are more truthful can be obtained, as compared to a direct question if one intends to dope (68). Manges et al. (54) proves very good internal consistency ($\alpha = 0.88$) for the German version of doping intention.

Moral disengagement

A German version of the Moral Disengagement in Doping Scale (43) was employed to measure doping moral disengagement. Participants rate their degree of consent with six statements on a 7-point Likert-type scale (1 = strongly disagree; 7 = strongly agree). Items are, for instance, "Doping does not really hurt anyone" or "Doping is just a way to maximize your potential". The mean of the six items was computed as a total moral disengagement score with higher scores implying greater moral disengagement. With values of $\alpha = 0.69$ for internal consistency and *corr* $r_{tt} = 0.80$ for split-half reliability as well as demonstrated construct validity the German version represents an appropriate measure of doping moral disengagement (69).

Anticipated guilt

To assess anticipated guilt, we used the guilt subscale of the State Shame and Guilt Scale (70). Participants are requested to answer five items with the preceding stem "If I had used a banned substance…". Example items are "I would feel bad about what I had done" or "I would feel remorse, regret". Answers were given on a 7-point Likert-type scale (1 = not at all; 7 = very strongly). For a total score of anticipated guilt the mean over the 5 items was computed; the higher this score is, the higher is the degree of anticipated guilt. Evidence of this measure's internal consistency ($\alpha = 0.82$) is reported by Marshall et al. (70) and preliminary analyses preceding this study also reveal very good internal consistency ($\alpha = 0.92$) for the translated German version.

Empathy

For the assessment of empathy, two subscales of the German version, i.e., "Saarbrücker Persönlichkeitsfragebogen" [IRI-S-D; (71)] of the Interpersonal Reactivity Index (72) were utilized. The respective four items of the subscales empathic concern (example item "I am often quite touched by the things that I see happen") and perspective taking (example item "Before criticizing somebody, I try to imagine how I would feel if I were in their place") were answered on a 5-point Likert-type scale (1 = never; 5 = always). A total score for empathy was computed through the mean over all items, with higher scores indicating higher degrees of empathy (consisting of empathic concern and perspective taking). Paulus (71) reported acceptable internal consistency for the German version ($\alpha = 0.71$).

Collective moral norms

This construct reflects the dominating moral group norms and values, perceived by the group's members and was measured with the Collective Moral Attitude in Sport Groups scale ["Kollektiv-moralische Einstellung in Sportgruppen" (54)]. The scale consists of eight items that are answered on a 5-point Likert-type scale (1 = extremely; 5 = not at all). Example items are "In our training group, success is more important than dedication and loyalty" and "In our training group, assertiveness is more important than fairness". The scale's score was computed by the mean, with higher scores representing high perceived moral group norms. The scale's internal consistency has shown to be very good ($\alpha = 0.91$) and evidence for its construct validity is provided (54).

Pre- and post-intervention manipulation checks

In order to better understand and critically discuss the study results, athletes were asked to answer several questions, that differed from pre to post to follow up test. In the pretest the questions were "Have you participated in a doping prevention program/workshop before?" (yes/no) and "If yes, which one/what kind/what program (e.g., NADA workshop) was it?". In the posttest the questions for the two intervention groups were "In how many of the six intervention sessions did you participate?" and "Which technical device did you use to participate in the Zoom sessions?" (laptop computer, tablet, smartphone, or other) whereas the questions for the control group were "Did you participate in any doping prevention program during the last 6–8 weeks?" (Yes/no) and "If yes, which one/what kind/what program (e.g., NADA workshop) was it?". The same questions were used for the follow up measurement, with the modification of asking for "the last 3 months" instead of "the last 6–8 weeks".

Procedure

This study was approved by the Ethics Committee of the authors' university. Study participants were recruited by contacting coaches or stakeholders of sport clubs and associations as well as teachers or youth officers of elite sport schools *via* telephone and email. They were provided with a brief study outline and asked for their interest in letting their athletes

participate in the study. Teams, training groups, or classes that volunteered to participate were randomly assigned to one of the three conditions/groups by a research associate who was part of the research team. Randomization was performed by allocating teams/classes/training groups instead of individuals to avoid potential transfer effects of the differing contents of the interventions, that is, when individual athletes of one and the same team/class talk to each other about the contents of their respective intervention program. In order to ensure balance of athletes' gender and sport type across the three groups during the randomization process we applied minimization. This technique, which is seen methodologically equivalent to randomization (73), helped to minimize imbalances regarding important participant characteristics, i.e., gender and sport type, between the three groups.

Ahead of the first measurement point, participants and their parents/legal guardians received information about the study's aims and its voluntary nature, the warranty of treating all obtained information anonymously, and an outline of the investigation phase. After obtaining informed consent of the athletes (and their parents/legal guardians if athletes were under the age of 18), a Zoom link for the upcoming online sessions was sent *via* Email to the responsible person of the respective team or class who forwarded it to the participating athletes. The first online session in all three conditions in which the group comes together with the facilitator was the pretest. The athletes attended the sessions from a location they chose and, in general, used one device (e.g., laptop or tablet) per person. For the teams/classes that were assigned to either the values-based or the information-based intervention, their respective program started 1 week after the pretest and had a duration of 6 weeks with one 45-min synchronous online session per week. The teams/classes that were assigned to the control condition did not receive any intervention during that period of time. Six to eight weeks after the pretest athletes of all conditions came together with their respective group in their respective Zoom session for the posttest. For athletes of the values-based as well as the information-based intervention condition this was followed by a 3–4-month no-treatment phase and the follow up measurement in a final Zoom session. During these months, i.e., after completion of the interventions' implementation phase, the waiting control groups/teams were provided with the material of the values-based intervention program for ethical/equal treatment reasons.

For all measurement points participants joined a Zoom session, in which the instructor provided the link to an online questionnaire. This questionnaire consisted of sociodemographic questions (e.g., age, gender, sports, years competing, etc.), the measures described above, pre- and post-manipulation checks as well as an individual password, that the athletes created themselves. This password was used to connect the data, obtained at the two, respectively, three measurement points, while at the same time ensuring anonymity and, hence, reducing social desirability in athletes' responses.

All intervention sessions as well as data collection sessions were conducted by one of two trained facilitators who both were members of the research team. They were one female and one male facilitator both with extensive experience in instructing adolescent athletes, sport school students as well as university sport students. Since they substantially took part in the intervention development they were well acquainted with the material and intended delivery. Additional training for the instructors was ensured by having them conduct the sessions in the two pilot studies (one in person and one online), in which they were observed by colleagues from the research team and received feedback regarding their intervention implementation. By the time the interventions were adapted to an online format both instructors had undertaken various Zoom meetings both from a teacher's and participant's perspective and therefore were able to competently lead the sessions *via* Zoom. The instructors communicated with coaches and/or athletes in between the sessions and measurement points for scheduling/rescheduling Zoom sessions according to the teams'/classes' convenience and sent out reminders for each session and each measurement point in order to retain groups and athletes in the study. Additionally, before and in each measurement session, athletes were encouraged to fill in and complete the online questionnaire by outlining the importance of its completion in relation to the short amount of time needed to do so. Also they were reminded that, upon completion of the last measurement point, small thank-you gifts (e.g., colored pens) would be sent out to the participating clubs/schools. Study implementation occurred over a period of several months with individual starting points for each team/class depending on their annual training and competition schedule.

Data analysis

Data were analyzed with IBM SPSS Statistics 27.0. and R language 4.1, employing multilevel modeling. Specifically, general linear mixed models with adjustment for team/class level clustering as a random effect were performed to assess intervention effects for our outcomes (doping intention, doping susceptibility, moral disengagement, anticipated guilt, empathy, and collective moral norms). Data were collected and analyzed on the individual level (athletes, level 1) and athletes were nested in teams/classes (level 2). Research question 1 was analyzed by conducting two-level regressions with each of our outcomes at posttest as the dependent variable, adjusted for the respective pretest score and intervention group (i.e., condition). We also adjusted for gender, age, and exposure to external doping prevention measures. The intervention effect for each outcome represents the effect the condition had on the respective regression slope, compared to the control group. For research question 2, three-level regressions were

conducted, with repeated measures outcomes (pre, post, follow up; level 1) nested in athletes (level 2) and athletes nested in teams/classes (level 3). Again, the models were adjusted for condition, gender, age, and exposure to external doping prevention measures.

For all analyses, confidence intervals (CI) were used for interpretation of the meaningfulness of changes in outcomes. This entails that when CIs do not include zero, an effect is classified as significant. If effects were found to be significant, effect size Hedge's g (for comparing to the control group) or Cohen's d (for comparing different time points within one condition) was computed and interpreted according to the following rules of thumb: 0.2 = small effect, 0.5 = medium effect, and 0.8 = large effect. All analyses were carried out per protocol which means that athletes who did not complete all measurement points for the selected analysis were listwise deleted. As suggested in the CONSORT Guidelines (73), we did not examine if there were significant group differences at baseline.

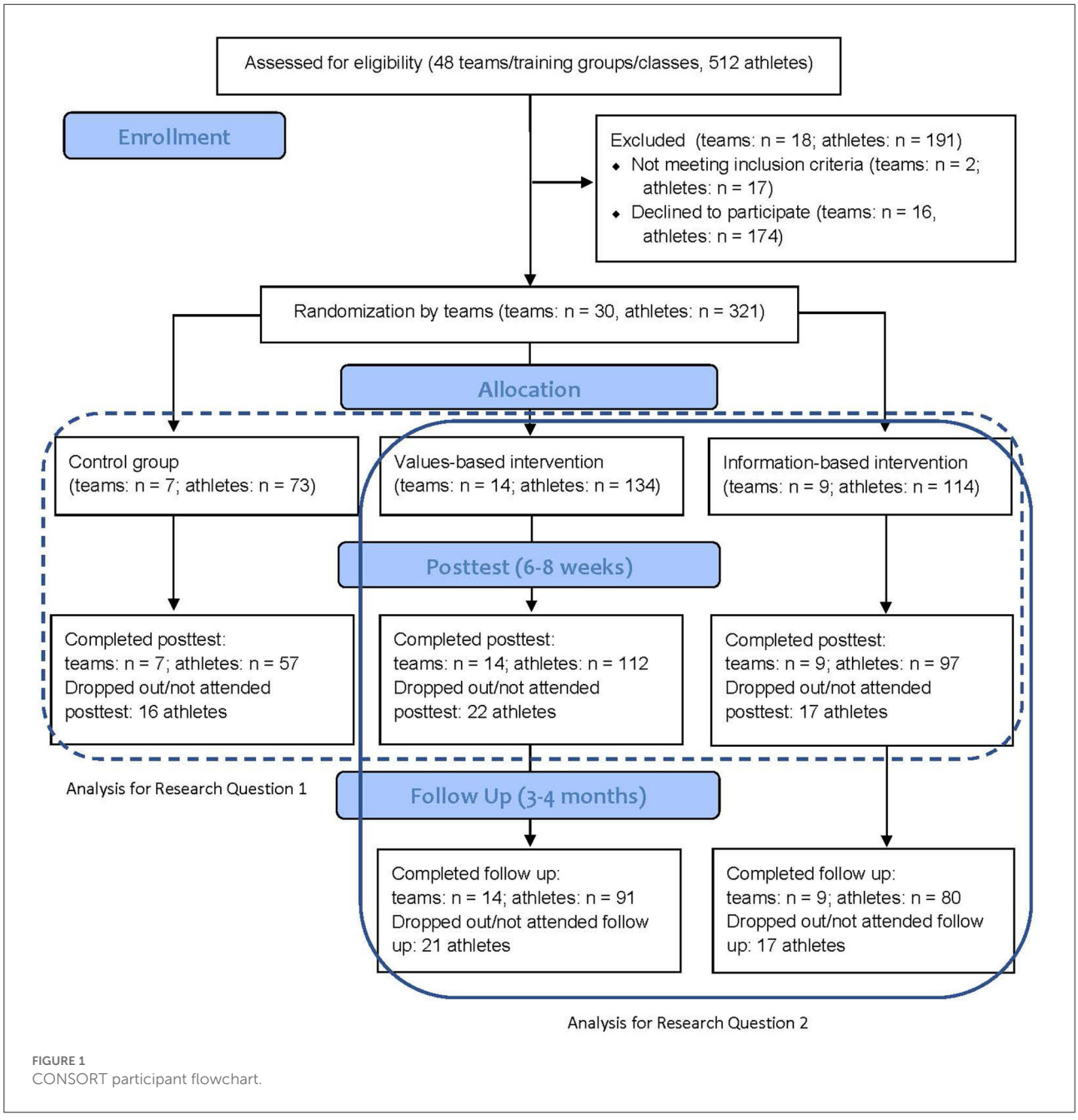

FIGURE 1
CONSORT participant flowchart.

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TABLE 2 Unadjusted means (SD) for all outcomes by experimental group.

		Values			Information			Control		
		N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
Doping susceptibility	Pre	134	3.46	2.06	114	3.39	2.08	73	2.91	1.84
	Post	112	3.36	1.95	95	3.33	2.17	57	3.56	1.67
	Follow up	91	3.48	2.08	78	3.42	2.21	–	–	–
Doping intention	Pre	134	2.17	1.51	114	1.72	1.11	73	2.11	1.34
	Post	112	2.05	1.41	95	1.72	0.98	57	2.45	1.55
	Follow up	91	2.05	1.29	77	1.56	0.90	–	–	–
Moral disengagement	Pre	134	2.05	0.90	114	1.91	0.78	73	1.91	0.92
	Post	112	1.71	0.69	95	1.66	0.68	57	1.95	0.86
	Follow up	91	1.76	0.77	77	1.71	0.68	–	–	–
Anticipated guilt	Pre	134	5.79	1.40	114	6.06	1.23	73	6.05	1.20
	Post	112	6.16	0.99	95	6.13	1.33	57	5.93	1.46
	Follow up	91	5.34	0.87	77	6.02	1.32	–	–	–
Empathy	Pre	134	3.49	0.58	114	3.42	0.61	73	3.48	0.53
	Post	112	3.45	0.57	94	3.47	0.56	57	3.65	0.55
	Follow up	91	3.82	0.54	77	3.43	0.73	–	–	–
Collective moral norms	Pre	134	4.10	0.70	114	4.20	0.73	73	3.98	0.86
	Post	112	4.10	0.88	95	4.28	0.69	57	4.05	0.74
	Follow up	91	4.19	0.79	77	4.24	0.67	–	–	–

Results

A CONSORT flow diagram is depicted in Figure 1 and describes the flow of participants and teams/classes through the study's phases. Retention was satisfactory with a rate of 80% at posttest and 69% at follow up (for addressing research question 2, hence, without control group). The majority of athletes in the intervention conditions attended at least five intervention sessions (76.4%). Table 2 provides the descriptive statistics in the form of unadjusted means and standard deviations and corresponding sample sizes for all outcomes at pre, post and follow up assessments. The intervention effects for the comparison of the values-based and info-based condition with the control condition at posttest can be seen in Table 3. In contrast, Table 4 shows adjusted pre-post and post-follow up changes in outcomes for each of the two intervention groups.

TABLE 3 Intervention effect for both interventions at posttest compared to control group.

	Values Estimate (95% CI)	Information Estimate (95% CI)	ICC
Doping susceptibility	−0.33 (−0.74, 0.08)	−0.35 (−0.77, 0.08)	0.01
Doping intention	−0.36 (−0.81, 0.09)	−0.42 (−0.91, 0.06)	0.12
Moral disengagement	−0.52 (−1.02, −0.03)	−0.51 (−1.04, 0.03)	0.10
Anticipated guilt	0.59 (0.13, 1.06)	0.48 (−0.01, 0.97)	0.08
Empathy	−0.10 (−0.37, 0.18)	−0.03 (−0,32, 0.26)	0.001
Collective moral norms	−0.03 (−0.34, 0.26)	0.002 (−0.31, 0.31)	0.005

Estimate = effect of experimental condition on outcomes; gray shade = CI excludes zero.

Results for research question 1

As shown in Table 3, athletes in the values-based intervention reported a stronger decrease in moral disengagement directly after the intervention (i.e., at posttest), compared to the control group [−0.52, 95% CI = −1.02, −0.03, effect size (ES) Hedge's g = −0.43]. Furthermore, a significant effect was found for anticipated guilt. Athletes in the values-based intervention showed a greater increase in anticipated guilt at posttest (0.59, 95% CI = 0.13, 1.06, ES Hedge's g = 0.57) compared to the control group. No immediate intervention effects for other outcomes were found for the values-based intervention, nor for the info-based intervention.

Results for research question 2

There was a significant reduction in moral disengagement from pre to post intervention for athletes in the values-based condition (−0.38, 95% CI = −0.14, −0.61, ES Cohen's d = −0.42) and for athletes in the information-based condition (−0.31, 95% CI = −0.05, −0.57, ES Cohen's d = −0.34) (please

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TABLE 4 Adjusted pre-post and post-follow up changes by intervention groups.

	Values Estimate (95% CI)	Information Estimate (95% CI)
Doping susceptibility		
Pre-post	−0.04 (0.22, −0.29)	−0.06 (0.20, −0.33)
Post-follow up	0.10 (−0.17, 0.38)	0.04 (−0.26, 0.35)
Doping intention		
Pre-post	−1.2 (0.12, −0.35)	−0.06 (0.20, −0.31)
Post-follow up	0.04 (−0.22, 0.30)	−0.18 (−0.47, 0.11)
Moral disengagement		
Pre-post	−0.38 (−0.14, −0.61)	−0.31 (−0.05, −0.57)
Post-follow up	0.08 (−0.18, 0.34)	0.10 (−0.20, 0.40)
Anticipated guilt		
Pre-post	0.26 (0.48, 0.03)	0.001 (0.27, −0.26)
Post-follow up	−0.74 (−0.99, −0.49)	−0.07 (−0.38, 0.24)
Empathy		
Pre-post	−0.05 (0.17, −0.27)	0.15 (0.45, −0.15)
Post-follow up	0.93 (0.69, 1.18)	−0.04 (−0.37, 0.28)
Collective moral norms		
Pre-post	0.02 (0.25, −0.21)	0.18 (0.43, −0.07)
Post-follow up	0.11 (−0.15, 0.36)	−0.10 (−0.40, 0.19)

Estimate = changes in outcomes; gray shade = CI excludes zero.

see Table 4). For both groups there were no further changes in moral disengagement from post to follow up, indicating that the reduced moral disengagement was sustained also 3–4 months after the intervention had ended.

A significant increase in anticipated guilt occurred from pre- to posttest but only for the values-based group (0.26, 95% CI = 0.48, 0.03, ES Cohen's d = 0.31). From posttest to follow up test, however, athletes in the values-based intervention could not maintain this increase in anticipated guilt, but, instead, reported a significant reduction in anticipating guilt, compared to the posttest (−0.74, 95% CI = −0.99, −0.49, ES Cohen's d = −0.66).

For empathy, no effects emerged from pre to post in both groups, though, athletes in the values-based group reported increased empathy from post to follow up (0.93, 95% CI = 0.69, 1.18, ES Cohen's d = 0.56) indicating that there was no immediate effect (posttest), but a potential "delayed" effect of the values-based intervention on empathy.

Discussion

As doping has detrimental consequences for athletes and the integrity of sports, the need for effective prevention programs is obvious. Primary prevention through education with a focus on values, emotions and morality is seen as a promising approach to minimize doping (7) and research indicates which variables exactly could be addressed in anti-doping efforts. This study presents the development, implementation, and evaluation of a values-based anti-doping intervention that focuses on variables that have been empirically associated to doping intention, likelihood, or behavior [e.g., (33, 39)].

Effects on outcomes

Our first research question addressed the immediate (post intervention) effects of our values-based intervention and the information-based intervention in comparison with a no-intervention waiting control group. In line with our expectations, the values-based intervention, compared to a control group, successfully decreased moral disengagement and increased anticipated guilt at posttest, whereas no changes in those variables emerged in the information-based intervention, when compared with a control group. This supports existing literature [e.g., (31)] and highlights the importance of going beyond mere knowledge provision in prevention efforts. Contrary to our expectations we did not find a significant immediate effect for doping intentions, doping susceptibility, empathy, and collective moral norms. Concerning the latter, we can conclude that collective moral norms that usually develop over time could not be increased in only one session dedicated to this topic and in a relative short amount of time. However, since social context variables are essential in forming a person's (anti-) doping attitudes and intentions (33, 34, 54), it seems worthwhile to target this variable more intensively and examine the dosage and time scope needed to produce changes. Most likely, programs aiming at entire teams/clubs and which also involve the coach might have a greater impact on this variable than our intervention which mainly addressed the individual athlete.

Even though the effects of the values-based intervention on doping intentions and susceptibility were not significant at the 5% level (95% CI), the estimates and CIs in Table 3 show the trend that both variables slightly decreased. It can be assumed that if the intervention had been more intense and had lasted longer, significant changes might have occurred.

Unfortunately, we were not able to make comparisons with a control group at follow up since for ethical reasons the control group received the values-based material shortly after the implementation had ended (it was not feasible for them to wait 3–4 months). Therefore, for the direct comparison with an untreated control group as reference group no conclusions about the effects' sustainability can be drawn. This is a methodological limitation that needs to be considered when planning and designing future studies.

Nevertheless, we were able to gain insight into how the slopes of each intervention group developed over time from pre to post, and post to follow up, as we collected data of both intervention groups at a third measurement point

(research question 2). Results show that moral disengagement decreased from pre to post in both intervention groups, but not from post to follow up, demonstrating that the effects are maintained over time (i.e., 3–4 months after completion of the interventions). For anticipated guilt, an effect was found only for the values-based intervention at posttest, indicating that, for direct effects, this way of intervening might be more effective on outcomes that involve emotions, as compared to information provision. Surprisingly though, this effect was not maintained from post to follow up, but instead, anticipated guilt decreased, implying that the intervention effects on anticipated guilt could not be maintained over time. This could indicate a need for regular exposure to prevention efforts in order to ensure that effects are sustainable, but of course, the question of feasibility also has to be considered. Interestingly, for empathy, the effect was the other way around, namely there was no immediate effect at posttest, compared to pretest in both conditions; but at follow up athletes in the values-based intervention showed an increase in empathy. This finding suggests, that some effects might occur with a delay.

Limitations, benefits, and future research directions

In our effort to compare three conditions, we must consider that the facilitators who conducted the two intervention programs and collected the data of all three groups were aware of the expected results, that is, in which condition/group changes in outcomes were expected. Therefore, experimenter bias could have occurred in the way that the researcher might have been more motivated when conducting the intervention program which is supposed to lead to changes in outcomes. We tried to minimize this bias by preparing educational materials that are not only appealing to participants but also to the instructors, thereby ensuring high levels of joy and motivation in teaching both intervention programs.

In analyzing the data we used a per protocol approach which means that athletes who did not complete all measurement points for the selected analysis were listwise deleted. This provides us with full records in our models, however the possibility of a "completers-only" bias (74) persists. Another factor to consider is that participants may have had different preconditions regarding their anti-doping education. For the majority of athletes, especially for national athletes, doping prevention education (e.g., NADA workshops) are compulsory at least once a year. However, for some athletes this might have been their first experience with doping prevention. Additionally, participants especially from the control group may have received other doping prevention measures during the study's investigation phase which could have resulted in performance bias. By including pre- and post-intervention manipulation checks in our model (e.g., "Have you participated in a doping prevention program/workshop before?" at pretest; Have you participated in any further doping prevention program/workshop since the beginning of this program?" at post and follow-up) we controlled for these factors. Results of our analyses showed that there was no significant impact of exposure to other doping prevention measures before or during the intervention on the outcomes. In future studies, an additional manipulation check of whether participants received general drug prevention programs outside of sport could be incorporated in order to control for its impact on the findings, too.

For the delivery mode of both interventions online teaching was chosen in order to conduct the programs independently of pandemic-related restrictions in face-to-face teaching. Although online learning/teaching entails several drawbacks, such as technical problems or insufficient technical skills, altered group dynamics, and information loss due to transmissions delays, there are multiple advantages that have to be highlighted. The synchronous online sessions enable participants and facilitators to independently choose their workplace, thereby saving time and reducing costs for getting to a specific location. We can conclude from the pilot studies that the online delivery mode even seemed to enhance the attractiveness of participation. In addition to the autonomy of choosing a location, athletes praised the versatile methods that were applied online, e.g., working with the interactive whiteboard, watching the animated dilemma video, or working together in breakout rooms, stating that this variety contributed to interesting and even entertaining sessions. Further support for online learning/teaching is provided by research in [e.g., (26)] and outside of sport science (75), demonstrating efficacy of online delivered interventions. Finally, as we targeted young individuals belonging to a generation that, in general, is used to a safe handling of contemporary media, online teaching seemed to be a useful and suitable approach.

In the current study the developed intervention programs are either values-based or information-based. The values-based program is devoid of any content of the information-based program and the other way around. This strict separation allows us to draw conclusions about each intervention's effectiveness in influencing doping-related variables and doping intention in comparison to each other and a no-intervention waiting control group. However, it is argued that doping prevention programs, in order to be effective in minimizing actual doping behavior, should be multifaceted and incorporate both values-based education and knowledge-transfer about doping (18, 58). This is in line with Woolf's [(8), p. 2] notion that "information does have to play a role promoting doping-free sport", particularly to prevent unintentional doping. Thus, when delivering prevention programs in practice, it is recommendable to combine both approaches, for example, by adding an

introduction session to the values-based program, in which comprehensive information about doping is conveyed (e.g., definition of doping, banned substances, health consequences, control system, etc.). Future research could evaluate if this combination of elements may be more effective in changing outcomes.

Concerning the process evaluation and evaluation of the specific contents of our values-based intervention, this study does not include any qualitative data. However, for both programs it would be valuable to gain insight into athletes' perception of a variety of issues (e.g., which activities the participants liked the most, which sessions or activities particularly provoked their critical thinking, how did they perceive participants' engagement). Therefore, in a subsequent study we plan to incorporate a mixed design that contains a qualitative approach. Nevertheless, at the present time, we can draw upon qualitative feedback from the pilot studies. According to athletes' responses in a feedback questionnaire after each session as well as within the general discussion after completion of the intervention, they seemed to view their participation as very beneficial. For instance, they stated to better be able to argue about the decision for or against doping, to have learned more about their and their groups' value priorities, to have reflected on their attitudes and feelings, or to have thought about the consequences someone's decision to dope has for others. These responses suggest that the values-based intervention, seen from a preliminary qualitative perspective, might indeed be a promising approach to encourage cognitive, emotional and group dynamic processes and to create awareness and reflection of personal values and attitudes in regard to doping.

Practical implications

Since the German NADA is highly interested in incorporating values-based approaches into their educational material, workshops and website (and is already doing this) they are the main multiplier for the developed material as they will integrate elements of the values-based program into their material (e.g., activities to reduce moral disengagement). Since the intervention sessions were designed for 45 min in order to match the timeframe of a school lesson, an integration of topics (again, for example, the moral disengagement session) into the curriculum in elite sport schools, e.g., within PE or ethics lessons, is of particular interest. However, not only elite athletes should profit from doping prevention, but also athletes participating in grassroots sports could benefit from values-based anti-doping education [see (23)], which could also be incorporated in the general school setting [in line with (76)].

Conclusion

Our study has shown, from a quantitative perspective, that the values-based intervention can produce desired changes in some, yet not all of the targeted outcomes. It represents a starting point for values-based anti-doping education within the German speaking countries, since it is the first large sample study to comprehensively develop, implement, and evaluate an intervention that targets moral variables empirically related to doping in a longitudinal experimental design. The values-based intervention program is grounded on theory, empirical evidence and preceding intervention projects from in and outside the German language area and is designed for young athletes, guided by pedagogical expertise. This study, therefore, responds to the call for values-based anti-doping education, emphasized by WADA's new International Standard for Education, and lays a foundation for subsequent research.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Ethics Advisory Board of Leipzig University. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

TM and AME conceptualized the study. NW and AME supervised the study and further conceptualized methodology with TM. KS and TM contributed to recruitment of participants, implementation of the study, and data collection. TM and TS analyzed the data. TM wrote the draft of the manuscript. NW and AME commented, edited, and reviewed it for its final version. All authors contributed to the article and approved the submitted version.

Funding

The No2Doping project was funded by the Federal Institute for Sports Science (ZMVI4-070301/19-21). We acknowledge support from Leipzig University for Open Access Publishing.

Acknowledgments

The authors would like to say thank you to the participating sport clubs and schools, to Sven Schurzmann and Hendrik

Richter for their valuable contribution and to Marie-Christin Apel and Patricia Gutmann for their commitment.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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frontiers | Frontiers in Sports and Active Living

TYPE Brief Research Report
PUBLISHED 18 October 2022
DOI 10.3389/fspor.2022.849117

OPEN ACCESS

EDITED BY
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SPECIALTY SECTION
This article was submitted to Anti-doping Sciences, a section of the journal Frontiers in Sports and Active Living

RECEIVED 05 January 2022
ACCEPTED 30 September 2022
PUBLISHED 18 October 2022

CITATION
Melzer M, Elbe A-M and Strahler K (2022) Athletes' use of analgesics is related to doping attitudes, competitive anxiety, and situational opportunity.
Front. Sports Act. Living 4:849117.
doi: 10.3389/fspor.2022.849117

Athletes' use of analgesics is related to doping attitudes, competitive anxiety, and situational opportunity

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This study aimed to investigate athletes' hypothetical use of non-steroidal anti-inflammatory drugs (NSAIDs), a behavior similar to doping, and its association with doping attitudes, competitive anxiety and situational opportunity. One hundred twenty-two sport science students completed an online survey assessing biographical information, doping attitudes, and competitive anxiety. Students' intention to use analgesics was measured *via* two different hypothetical situations using the vignette technique. The favorable situation included an absence of potential witnesses and presence of an attractive good whereas witnesses were present in the unfavorable situation and an attractive goal was absent. The results of two hierarchical multiple regression models showed that doping attitudes and competitive anxiety, especially worry, predicted the use of analgesics. In the situation featuring a favorable opportunity, worry was the strongest predictor, whereas in the situation of an unfavorable opportunity, doping attitudes was the strongest predictor for using NSAIDs. Results indicate that NSAID use is associated with positive attitudes toward doping and competitive anxiety, and that it is situationally dependent. Future research perspectives and practical implications are discussed.

KEYWORDS

competitive anxiety, doping attitudes, NSAIDs, situational opportunity, deviance

Introduction

"No pain, no gain" is an adage that most athletes would agree with. Elite athletes in particular commonly exceed their physical and psychological limits during training and competition, despite experiencing pain (1, 2). Nixon (3) reported that about 94% of college athletes participated in sports competitions despite being injured. Thus, it appears likely that injured athletes' participation is facilitated by the use of non-steroidal anti-inflammatory drugs (NSAIDs), which are widely used among athletes. Thus, it seems to be obvious that athletes are familiar with the use of painkillers. Studies show that the prevalence of NSAID use in competitive sports ranges from 40 (4) to 86% (5). High rates of NSAID use were identified among Olympic athletes at the Sydney Games (1), in FIFA tournaments (2, 6), as well as in Finnish (7) and Belgian (8) elite athletes. However, the use of NSAIDs is not only a phenomenon related to elite sports. High consumption of

NSAIDs has also been identified in non-elite participants of the Bonn (9) and Boston (10) marathons. Athletes consume NSAIDs for the treatment of injury-related pain, pain prevention (prophylactic use), reduction in recovery time and for performance improvement (11–15).

NSAID use is not a violation of Anti-Doping Rules *per se*. Consequently, numerous drugs used to treat pain do not appear on WADA's (16) list of prohibited substances. While NSAID use does not represent an Anti-Doping Rule violation, athletes do mention using them for performance enhancement (13). As a corollary, NSAID use can be seen as a risk factor for the misuse of other substances [see (17, 18)]. In addition, several studies have shown similarities between NSAID use and doping behavior. Research has confirmed that athletes with a strong intention for doping or a history of doping abuse are more likely to misuse other illicit substances [e.g., (19, 20)]. Lippi et al. (21) highlight that there is a "strict parallelism" (p. 105) between doping and medication, nutritional supplements, alcohol or social drug use. The use of NSAIDs has also been related to increased use of doping substances (22). Research shows that medication use is correlated with doping [e.g., (18, 20, 22)]. A question that arises from the many parallels between NSAID use and doping is whether NSAID use, like doping, is also related to positive attitudes toward doping.

Doping behavior is explained as a dynamic interplay between personal attributes (e.g., doping attitudes and/or personality factors) and situational factors (23). Most of the relevant integrative models on doping behavior [e.g., extended Theory of Planned Behavior (TPB), (24), Trans-contextual Model, (25), Life Cycle Model, (26), Sports Drug Control Model (SDCM), (27) describe doping as a goal-directed, intentional and self-regulated behavior that is based on individual decision-making processes both in a broader context and in specific situations. It is, however, unclear whether the use of NSAIDs is determined by a similar interplay between personal and situational factors, and if so, whether certain factors explain NSAID use.

The personality factor competitive anxiety, which has not been widely investigated in relation to NSAID use, deserves special consideration. In fact, few studies focus on the role of anxiety in the use of legal and illegal substances in sports. Studies that have investigated the relationship between anxiety and doping or substance abuse in sport have found a positive correlation [e.g., (28–32)]. Results of these sport-specific studies confirm that one important reason for substance abuse is anxiety reduction (33).

Another aspect relevant to NSAID use is the situation itself. In their doping model, Lazuras et al. (24) include the variable *situational temptation,* which is the perceived temptation to engage in doping under certain conditions. The SDCM (27) also includes situational variables to explain doping, such as drug affordability and availability. Moreover, the SDCM's appraisal of threat and benefit are perceived evaluations of the situational conditions (e.g., perceived likelihood of being tested or sanctioned). According to the SDCM, consumption of doping substances will be high if threat appraisal is low and benefit appraisal is high [see (27)].

Although situation is clearly an explanatory factor in doping behavior models, few studies have investigated effects of the immediate situation on doping use [e.g., (26, 34, 35)]. The Rational Choice Theory [RCT, (36)] postulates that a person is likely to engage in deviant behavior if their assessment of the circumstances leads them to believe they could obtain a desired outcome in which expected gains would outweigh potential costs. According to RCT, a person's chosen methods are then guided and constrained by rational considerations. Following this theoretical viewpoint, individuals seek to maximize personal benefit and minimize costs or risks. Rational decision-making in situations which involve deviant behavior is characterized by a brief cost-and-benefit appraisal. Decisions are predominantly motivated by reward, perceived as temptation, and less by fear of being convicted (37).

Our assumption is that NSAID consumption will be more frequent in low-cost situations in which the benefit is high and risk is low, as opposed to high-cost situations in which the risk of being caught is high and chances for personal benefit are low. Furthermore, we assume that the personality factor anxiety will play a different role in favorable (low-cost) as opposed to unfavorable (high-cost) situations. That is, we assume that anxiety will show a stronger influence on NSAID use in favorable situations characterized by low costs (38).

On the other hand, a positive attitude toward doping is assumed to have a strong impact on doping behavior in both favorable and unfavorable situations. This is based on results showing that perceived opportunity does not substantially influence behavior when strong attitudes prevail [see (39)]. In a way similar to a distorting lens, strong attitudes affect perception of a situation and lead to less deliberation and an automatic behavior pattern regardless of situational context factors. Once in a situation, perceptive biases lead to a strong and easily assessable doping attitude, which may in result in positive doping behavior, and/or the decision to use NSAIDs.

Research questions

This study investigates three research questions. The first question interrogates whether the use of NSAIDs, a behavior presumably analogous to doping, is related to doping attitudes. We assume positive correlations between the hypothetical consumption of NSAIDs and doping attitudes.

The second research question investigates if competitive anxiety is related to situations characterizing NSAID use. We assume that competitive anxiety is related to the hypothetical use of NSAIDs.

The third question investigates if the likelihood of NSAID use is dependent on situational condition. We assume that NSAID use is indicated if the situation is favorable rather than unfavorable. A favorable situation is characterized by the absence of potential witnesses and the presence of an attractive good (40). We also assume that anxiety is more strongly related to NSAID consumption if the situation is favorable rather than unfavorable.

Materials and methods

Participants and procedure

Study participants were recruited by means of different sport-related online social media groups as well as through the university mailing list. Participants completed an online version of the questionnaire that was programmed using EFS Survey 6.0 from Globalpark (41). A total of 198 participants completed the survey. However, 76 responses were deleted due to too many missing items and apparent inconsistencies in the data set. Some participants could not be categorized as athletes due to missing values in variables like sports, competition experience and national squad membership. The final sample of $N = 122$ male and female athletes (50% male) had a mean age of $M = 24.98 \pm 4.52$ years. Approximately 62% of participants took part regularly in sport competitions, with an average number of annual competitions of $M = 15 \pm 12$. Competitions ranged from national competitions to international championships. About a quarter (27%) of participants were members of a national team. Nearly 56% of athletes participated in team sports (predominantly football, volleyball or handball) while the remaining participants took part in individual sports (predominantly track and field, swimming or cycling).

Instruments

Biographical information

Participants provided demographic information about their age, gender, athletic status, number of yearly competitions and sport league status.

Doping attitudes

The German version of the Performance Enhancement Attitude Scale [PEAS, (42)] was used to measure doping attitudes. The PEAS consists of 17 items (e.g., "Doping is necessary to be competitive") rated on a 6-point Likert rating scale ranging from 1 = "strongly disagree" to 6 "totally agree." The internal consistency (Cronbach's Alpha) of $\alpha = 0.81$ was comparable to the one reported in Folkerts et al.'s (43) systematic review.

Analgesic use intention

The intention to use NSAIDs was measured *via* two scenarios (40). While one scenario presented a favorable situation, the other presented an unfavorable situation in which the use of NSAIDs was set. Participants were asked to rate the likelihood of taking NSAIDs on a 7-point Likert-scale ranging from 0 = "very unlikely" to 6 = "very likely."

The favorable situation was defined by the presence of an attractive good (e.g., glory) and the absence of witnesses.

Favorable situation (low cost)

Imagine the following situation. A young professional football player wants to play in the final point game, the city derby, which is the highlight of the season despite the pain he has suffered due to a previous injury. When warming up, his thigh hurts and he has problems running quickly. In order to participate, he needs to take painkillers. He goes back to the empty locker room where he takes several painkillers in the bathroom.

In contrast, the unfavorable situation was characterized by the presence of witnesses and the absence of an attractive good.

Unfavorable situation (high cost)

Imagine the following situation. A young professional football player wants to play in his team's first pre-season test match despite experiencing pain due to a previous injury. When warming up, his thigh hurts and he has problems running quickly. To participate, he needs to take painkillers. Before the game starts, he pulls out the painkillers in the locker room where his teammates are getting changed and he goes to the bathroom to drink some water.

Competitive anxiety

Competitive anxiety was measured with the German Sport Anxiety Scale [WAI-T: Wettkampfangstinventar, (44)]. The WAI-T assesses three dimensions of competitive anxiety–worry (e.g., "Before a competition, I am worried about choking under pressure."), somatic anxiety (e.g., "Before a competition, my heart is racing.") and concentration disruption (e.g., "Before a competition, it is hard for me to keep my thoughts focused on the competition."). Respondents rated the 12 items on the questionnaire according to a 4-point Likert scale, ranging from 1 = "not at all" to 4 = "very." Internal consistency (Cronbach alpha) of somatic anxiety ($\alpha = 0.88$) and worry ($\alpha = 0.82$) were good. However, Cronbach's alpha for concentration disruption ($\alpha = 0.54$) was too low. Therefore, this scale was excluded from further analyses.

Data analysis

Data were analyzed using SPSS Version 17. Statistical analyses included bivariate Pearson correlations, a univariate repeated measures ANOVA, and hierarchical multiple

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TABLE 1 Mean, SD, min, max and range of independent, and dependent variables.

Variable	M	SD	Min	Max	Range
1. Doping attitudes	32.13	10.20	1	5	4
2. Somatic anxiety	10.84	2.88	4	16	12
3. Worry	10.11	2.73	4	16	12
4. Concentration disruption	7.09	2.03	4	13	9
5. Analgesic misuse in a favorable situation	2.96	1.74	1	6	5
6. Analgesic misuse in an unfavorable situation	2.16	1.42	1	6	5

M, mean; SD, standard deviation; Min, minimum; Max, maximum; Range, range of data set.

TABLE 2 Bivariate Pearson correlations of the predictors and outcome variables.

Variable	1	2	3	4	5
1. Analgesic misuse-favorable situation	-				
2. Analgesic misuse-unfavorable situation	0.62**	-			
3. Doping attitudes	0.26*	0.35**	-		
4. Worry	0.33**	0.22*	−0.02	-	
5. Somatic anxiety	0.18*	0.09	0.08	0.51**	-

*$p < 0.05$, **$p < 0.01$.

regression modeling. The level of significance was fixed at $p < 0.05$. In addition to significance testing, we reported a "two-step-process" with relevant effect sizes and statistical power (1-β) in both hierarchical linear regression models (45). G*Power 3.1.9.2 was used for our analyses.

Results

Descriptive analysis results are presented in Table 1. Correlations between the measured dependent and independent variables are presented in Table 2.

First, we analyzed if doping attitudes were related to NSAID use. Bivariate correlation analyses showed positive significant correlations for both unfavorable and favorable NSAID use conditions.

In a second step, we investigated correlations between the two situations and anxiety. We found positive correlations between the favorable condition and worry and somatic anxiety, and between the unfavorable situation and the worry component of competitive anxiety.

In a third step, we investigated the difference between NSAID use in favorable and unfavorable situations with a univariate repeated measures ANOVA. The mean difference was significant and the effect size was substantial $F_{(1, 121)} = 38.90$, $p < 0.01$, $\eta^2 = 0.24$. Athletes were more likely to use NSAIDs in the favorable than in the unfavorable situation.

Lastly, we investigated the influence of doping attitudes and competitive anxiety on NSAID use in both situations. Prior to conducting the two hierarchical regression analyses, we verified assumptions for regression analysis and considered biasing influences (46). These tests confirmed satisfactory quality of the data set for conducting a hierarchical regression analysis.

Hierarchical regression model for NSAID misuse in a favorable situation

We started with the hierarchical regression model for the dependent variable "analgesic misuse in a favorable situation." In a first block, we added age and gender as possible covariates and participation in competition to control their impact on decision-making [see (47, 48)]. The model did not significantly predict the dependent variable, $F_{change} < 1$, $p = 0.51$. The three variables showed no significant influence on decision-making in a favorable situation (see Table 3). *Post-hoc* power analysis indicated a poor statistical power of $1–\beta = 0.22$, which clearly missed the threshold of 0.80 [see (49)].

We then introduced doping attitude to the model. The second model showed a significant improvement in prediction, $F_{change(1, 117)} = 9.05$, $p < 0.01$, and the explained variance increased to 9%. A *post-hoc* power analysis of the change between the first and the second step with a nominal $\alpha = 0.05$ and the partial $R^2 = 0.07$ showed a statistical power of $1–\beta = 0.85$ which exceeded the convention of 0.80 and represented a substantial gain.

In the last block, we included the two components of competitive anxiety (worry and somatic anxiety) stepwise to the model. Only worry had a significant impact; and the

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TABLE 3 Hierarchical regression model of analgesic misuse in a favorable situation.

Variable	R^2	R^2 Change	B	SE B	β	*t*
Step 1	0.02					
Constant			2.13	0.99		2.16
Age			0.02	0.04	0.05	0.54
Gender			0.05	0.32	0.01	0.14
Competition participation			0.50	0.34	0.14	1.47
Step 2	0.09*	0.07**				
Constant			1.03	1.02		1.01
Age			0.01	0.04	0.02	0.22
Gender			−0.19	0.32	−0.06	0.55
Competition participation			0.50	0.33	0.14	1.53
Doping attitudes			0.80	0.27	0.28**	3.01
Step 3	0.18**	0.09**				
Constant			−0.57	1.07		−0.53
Age			>-0.01	0.03	−0.01	−0.10
Gender			0.04	0.31	0.01	0.12
Competition participation			0.50	0.31	0.13	1.44
Doping attitudes			0.70	0.27	0.24**	2.72
Worry			0.20	0.06	0.31**	3.60

*p < 0.05, **p < 0.01. R^2, Proportion of variation in dependent variable; R^2 Change, Proportion of variation in dependent variable by independent variable; B, Unstandardized regression coefficient; SE B, Standard deviation of unstandardized regression coefficient; β, Standardized regression coefficient; t, T-statistic for regression coefficient.

regression model explained an additional 9% of the variation ($F_{change}(1, 117) = 12.98$, $p < 0.01$). Relevant predictors in the regression model were doping attitudes and the worry component of competitive anxiety. Adjusted explained variance was 15%. The *post-hoc* power analysis of the change between step two and three revealed a satisfying power of $1–\beta = 0.93$.

Hierarchical regression model for NSAID misuse in an unfavorable situation

Following the analysis of NSAID misuse in a favorable situation, we proceeded in the same way for NSAID misuse in an unfavorable situation (see Table 4).

The regression model with age, gender and competition participation showed no significant influence on the independent variable ($F_{\text{change}(3, 118)} = 1.09$, $p = 0.36$). The statistical power of the model was also poor, $1–\beta = 0.33$. Adding doping attitudes ($F_{change}(1,117) = 20.55$, $p < 0.01$) to the model increased explained variance up to 17%. A *post-hoc* power analysis showed a perfect power.

In the last step, we also introduced competitive anxiety to the model in a stepwise manner. The competitive anxiety scale "worry" significantly explained 3% variation of NSAID misuse, $F_{\text{change}(1, 116)} = 4.60$, $p < 0.05$. The total regression model of NSAID misuse in an unfavorable situation explained the adjusted variance of 17%. The power of adding the last predictor was made according to the convention of 0.80.

Discussion

With regard to the first set of research questions, results indicate that the decision to use NSAIDs is moderately correlated with doping attitude. This supports the assumption that the use of NSAIDs is a behavior parallel to doping. This result confirms previous research indicating that doping behavior and NSAID consumption are correlated (22).

With regard to the second research question investigating competitive anxiety, results show that the worry component in particular is associated with NSAID use in both situational conditions. Athletes with a tendency to experience high worry and high somatic anxiety in competitions are more likely to use analgesic substances in favorable situations. Athletes with a tendency to experience only high worry in competitive situations are even more likely to use analgesic substances regardless of the situation. So far, the relationship between anxiety and NSAID use has not been widely investigated. The results of this study contribute to furthering our understanding of the relationship between the two and suggest that NSAID consumption could be related to anxiety reduction (33).

With regard to the third research question, our study results indicate that the immediate situation is relevant for NSAID use. The likelihood of using NSAIDs depends on situational

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TABLE 4 Hierarchical regression model of analgesic misuse in an unfavorable situation.

Variable	R^2	R^2 Change	B	SE B	β	*t*
Step 1	0.03					
Constant			2.43	0.80		3.02
Age			−0.02	0.03	−0.06	−0.65
Gender			−0.05	0.26	−0.02	−0.20
Competition participation			0.40	0.28	0.14	1.45
Step 2	0.17**	0.15**				
Constant			1.14	0.80		1.43
Age			−0.03	0.03	−0.11	−1.21
Gender			−0.33	0.25	−0.12	−1.34
Competition participation			0.40	0.25	0.14	1.59
Doping attitudes			0.94	0.21	0.40**	4.53
Step 3	0.20**	0.03**				
Constant			0.37	0.86		0.43
Age			−0.04	0.03	−0.12	−1.42
Gender			−0.22	0.25	−0.08	−0.89
Competition participation			0.38	0.25	0.13	1.51
Doping attitudes			0.89	0.21	0.38**	4.32
Worry			0.10	0.04	0.18*	2.15

*$p < 0.05$, **$p < 0.01$. R^2, Proportion of variation in dependent variable; R^2 Change, Proportion of variation in dependent variable by independent variable; B, Unstandardized regression coefficient; SE B, Standard deviation of unstandardized regression coefficient; β, Standardized regression coefficient; t, T-statistic for regression coefficient.

conditions. Our study confirms that athletes were more likely to consume NSAIDs in a favorable situation with a lower risk of detection and expected higher benefits. These results are in line with the Low-Cost Hypothesis [for an overview: (38)] and Rational Choice Theory (36). Previous studies of deviant and criminal behavior have shown that if the perceived benefit exceeds the expected risk, the likelihood of different deviant behaviors such as shoplifting, drunk driving, stealing or buying illegal drugs increases, as well [e.g., (40, 50–52)]. Our results are also in line with the expected outcome of the SDCM (27) and the Drugs in Sport Deterrence Model [DSMD, (53)].

We also assumed that anxiety is more strongly related to NSAID consumption if the situation is favorable rather than unfavorable. Looking at the correlations we can see that worry and somatic anxiety were positively related in the favorable situation, whereas only worry was correlated in the unfavorable situation. Results of the regression analysis highlight that in the favorable situation, worry had a significant impact on NSAID use, which explained even more variance than doping attitudes. In the unfavorable situation, worry was also a significant predictor; however, doping attitudes explained significantly more variance regarding impacts on NSAID use. This means that in a situation with little risk of being caught and some incentive, athletes with high somatic anxiety and high worry might cope with the stressful situation by resorting to substance use. In the unfavorable situation, however, substance use among athletes experiencing higher levels of worry is more dependent on whether they also have positive attitudes toward doping and not solely explained by their high worry. These results confirm our hypothesis that the relationship between anxiety and NSAID consumption depends on perceived cost of the situation, whereby anxiety seems to play a larger role if situational costs are low.

Our results suggest that factors contributing to NSAID consumption are associated to those of doping, as is the case with analogous behaviors such as nutritional supplement intake or recreational and illicit drug use (18, 19, 54, 55). Therefore, NSAID use should be considered a gateway for doping, as both share similar underlying mechanisms (18, 55). Furthermore, our results indicate that not only athletes with positive doping attitudes but also athletes with high anxiety are at risk, especially in the favorable situation.

Limitations and future research perspectives

Some limitations need to be discussed with regard to our study. First, we assessed only one situation for consumption of NSAIDs. Although this situation had been extensively pre-tested, future studies should include a variety of situations. Second, this study assessed doping attitudes with an explicit measure. Future studies could assess doping intentions using implicit measures to capture more spontaneous reactions rather than replies based on deliberation (56). Due to the exploratory character we did not include a power analysis beforehand.

We did, however, use G-Power for *post-hoc* power analysis of effect sizes for the included predictors in the hierarchical regression analysis. Future studies should include a priori power analysis for optimal sample size. In addition, we only investigated two personality factors, namely competitive anxiety and doping attitudes. Additional personality factors of relevance should be identified and included in future studies. Ring et al. (57), for example, mention the importance of self-enhancement values, which could be implicated in future research on the impact of situation on the decision to engage in substance consumption. Self-enhancement values can lead to stable and chronic attitudes (e.g., doping attitudes) which impact decision-making. A further limitation is that only two of the three subscales of the competitive anxiety scale could be used due to insufficient reliability.

Practical implications

Our study results have several practical implications especially with regard to doping research and doping prevention. Results indicate that NSAID consumption can be characterized as a behavior analogous to doping and should be considered as a gateway to doping, similar to nutritional supplementation. Accordingly, future studies could employ NSAID consumption as a behavior analogous to doping. While athletes might not be keen to reply to questions involving actual doping behavior, they might be more open to answering questions about NSAID use. Furthermore, our study shows that favorable situations–with expected high glory and low chance of detection–facilitate deviant behavior. Our study results could therefore be used to further specify the elements of the SDCM model by adding additional information about situational factors (e.g., favorable/unfavorable situation). With regard to prevention, our results suggest that situations in which athletes have easy and unsupervised access to substances should be avoided. Furthermore, awareness should be raised that athletes with positive doping attitudes are at risk to consume substances in both unfavorable and favorable situations. It is possible that athletes reflect on their decisions in unfavorable situations and that their decisions to take the substances are not automatic. Thus, training of ethical decision-making is indicated as a feasible approach to prevention (58, 59). Finally, and importantly, prevention efforts should consider focusing on reducing anxiety as anxiety has been shown to be correlated with NSAID consumption.

Conclusion

This study identified that NSAID use can be described as a behavior analogous to doping. Furthermore, the personality factor competitive anxiety, in addition to doping attitudes, was found to be related to NSAID consumption. Therefore, further research should examine whether competitive anxiety is a potential risk factor for doping. The study further highlights that conducting research on doping should consider the situation. That is, different factors influence the decision for NSAID use in unfavorable vs. favorable situations.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

Author contributions

MM designed the study and collected and analyzed the data. KS and MM drafted the manuscript. KS and A-ME conducted additional data analyses. A-ME critically reviewed the manuscript. All authors contributed to the article and approved the final version.

Acknowledgments

We gratefully acknowledge Leipzig University for support with Open Access Publishing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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frontiers | Frontiers in Sports and Active Living

TYPE Original Research
PUBLISHED 24 May 2023
DOI 10.3389/fspor.2023.1106446

OPEN ACCESS

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RECEIVED 23 November 2022
ACCEPTED 02 May 2023
PUBLISHED 24 May 2023

CITATION
Schneider AJ, Oldham AC and Butcher LHG (2023) Anti-doping sciences, abjection and women's sport as a protected category. Front. Sports Act. Living 5:1106446. doi: 10.3389/fspor.2023.1106446

Anti-doping sciences, abjection and women's sport as a protected category

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In this article we explore the relationships amongst anti-doping sciences, 'abjection,' and the protection of 'women's' sport. We introduce three novel concepts: 'abjection bias,' 'abjection potential,' and 'intersectional abjection,' as tools with the potential to provide greater nuance to understanding the context for these contentious issues in contemporary sport. The debate concerning participation in women's sport—especially elite sport—of people who do not fit within traditional definition of 'women' is increasingly fraught with acrimony with anti-doping sciences often recruited as arbitrator. With access to opportunities such as participation at the Olympic Games at stake, emotions run high in arguments that typically centre on inclusion of transgender and gender diverse (TGD) athletes on the one hand and protection of the women's category on the other. While sport theorists have begun the important work of identifying the roots of these problems deep within the structure of modern sport and society itself, they have hitherto paid little attention to the philosophical underpinnings of that structure. Through the lens of feminist critical analysis, we seek, in this paper, to understand the complex role of 'abjection' in framing the current debate in sport and in related anti-doping sciences. From a clear definition of abjection as a perceived existential threat due to violation of the status quo, we introduce the new concepts of 'abjection bias,' 'abjection potential,' and 'intersectional abjection' in order to understand and explain what in common parlance we might call 'gut reaction.' By looking at the few notable previous treatments of sport abjection and highlighting the historical connections between anti-doping sciences and efforts to protect the women's category, we demonstrate that this co-development is, in part, more easily understood in the context of 'abjection.' We conclude that the clarity gained can also help to shed light on current policy decision-making in relation to the question of protecting the women's sport category.

KEYWORDS

anti-doping science, abjection, women's sport, abjection bias, gender diverse athletes, abjection potential, intersectional abjection

1. Introduction

In this article we explore the relationships amongst anti-doping sciences, "abjection," and the protection of "women's" sport. These main ideas will be introduced thematically in the following sections. We begin in **section 2** by examining the concept of "abjection" as a response to perceived existential threats to the *status quo*. We propose the idea of "abjection bias" as a conceptual tool for understanding how abjection arises. In **section 3**, we establish the connection between "abjection" and the "Unnaturalness Argument," itself analogous to

the "Frankenstein factor" from bioethics, and responses to it, through the development and application of anti-doping sciences. In section 4, we look at applications of abjection theory to sport. First, we engage with David Fairchild's application of abjection theory to the topic of doping in sport through the case of Ben Johnson, disgraced Canadian sprinter stripped of Olympic gold after a positive doping test at the Seoul 1988 Olympics. While Fairchild's argument was important as the first to identify abjection in sport, we reject his dangerous suggestion that popular sentiment, the "yuk" factor, might guide anti-doping policy and practice—what we label an "abjection test." Then we engage with Kutte Jönsson's use of abjection theory in the context of (dis)ability in sport. Jönsson identifies a double standard in abjection potential between able-bodied and (dis)able-bodied athletes premised on a pre-existing abjection of (dis)ability. Notably, while the topic of abjection is largely underutilized in sport, Fairchild and Jönsson are not alone; Michael D. Burke's and Terrence J. Roberts' significant 1997 look at the role of abjection in perceptions of female athletes using performance enhancing drugs and Burke's 2001 PhD thesis examining the female athlete as abject are clear demonstration of the applicability of the concept within the field of sport philosophy.

It is our aim here not simply to apply the concept to anti-doping sciences and the protected category of women's sport but to also introduce the novel concepts of "abjection bias," "abjection potential" and "intersectional abjection" that allow for a critical weaving together the various threads presented by Fairchild's (doping) and Jönsson's ((dis)ability sport) applications within a larger framework shedding light on the broad phenomenon of abjection in sport. Linking this with the idea of abjection bias, we posit that Jönsson's double standard is at work more broadly as an example of the tendency to abject what is perceived to be "unnatural", which can include female athletes relative to normative "male" athletes, as well as transgender and gender diverse (TGD) athletes relative to "natural" biological females. In section 5, we explore the history and context of women as a protected category in sport. Section 6 includes some ethical concerns that must be addressed in the attempt to overcome abjection in the development and implementation of policy regarding the pressing issues of doping and TGD athlete participation in the "women's" protected category. We conclude that anti-doping sciences have been used in part in attempts to protect and maintain the category of women's sport and that the concept of abjection can be applied both to doping and perceived violations of sport's traditional gender binary. Our increased understanding of the potential role that the concept of "abjection" has, and continues to play, in these two applications of anti-doping sciences gives us a more comprehensive perspective of this complex human reaction. The clarity gained from understanding this reasoning can also help to shed light on current policy decision-making as well as public and political dialogue regarding the protection of the 'women's category in sport.

2. Abjection and the "abjection bias"

With its roots in psychoanalytical and (post) structuralist theory, abjection was extensively developed by Bulgarian born French philosopher Julia Kristeva in her influential 1980 essay, "Povoirs de l"horreur: Essai sur l"abjection."[1] Kristeva's work has frequently been engaged with through the broad lens of critical theory and particularly in film analysis.[2] For Kristeva, abjection constitutes an absolute rejection of something or someone who appears to violate in some extreme way the established order of things.[3]

> It is thus not lack of cleanliness or health that causes abjection but what disturbs identity, system, order. What does not respect boarders, positions, rules. The in-between, the ambiguous, the composite. The traitor, the liar, the criminal with a good conscience, the shameless rapist, the killer who claims he is a savior. [… Abjection is] immoral, sinister, scheming, and shady (1).

Building on this idea, theorist Barbara Creed wrote that,

> The place of the abject is where meaning collapses, the place where I am not. The abject threatens life, it must be radically

[1]Translated into English in 1982 in part by John Lechte (first chapter only as "Approaching Abjection", *Oxford Literary Review*, 1982, Vol. 5, No. ½ (1982), pp. 125-149) and that same year in full by Leon S. Roudiez (*Powers of Horror: An Essay on Abjection*, Columbia University Press, 1982). We use the Roudiez translation throughout unless otherwise indicated.

[2]Like many late 20th century European philosophers, Kristeva and her ideas have faced increasing scrutiny. While criticisms of the theorist focus on her supporting "a Eurocentric, colonial and orientalist perspective" (James 2021 … James, Julie. "Refusing Abjection: Transphobia and Trans Youth Survivance". *Feminist Theory*, 2021. Vol. 22(1) 109-127 … see also Spivak, Gayatri Chakravorty. *French Feminism in an International Frame*. 1981), abjection theory itself has also been challenged on a more structural basis. Of particular concern is Winfried Menninghous' 2001 critique that Kristeva has not provided a suitably robust theoretical basis upon which the concept of abjection can be explored (Menninghous, Winfried. *Disgust: Theory and History of a Strong Sensation*. Trans. Howard Eiland and Joe Golb. 2003. State University of New York Press. … original German publication 2001). Fortunately, re-readings of Kristeva offered by Katherine J. Goodnow (Goodnow, K.J. *Kristeva in Focus*. 2010. Oxford: Berghahn Books) and Robbie Duschinsky (Duschinsky, Robbie. "Abjection and Self-Identity: Towards a Revised Account of Purity and Impurity". *Sociological Review*. University of Cambridge. Jan. 2013. 61: 709-727) offer a way forward with particular focus on the notions of "purity" and "impurity", both central to abjection theory.

[3]Here we are to understand something like Jacques Lacan's "symbolic" order, which effectively masks the underlying and indiscernible "real". As Shuli Barzilai points out: "Throughout her theoretical writings, Julia Kristeva calls into question the privileged position of the symbolic order in Jacques Lacan's teaching and clinical practice" (Barzilai 1991: 294). Shuli Barzilai (2020), Borders of Language: Kristeva's Critique of Lacan, *Publicatoins of the Modern Languae Association of America, 106* (2). 294-305). DOI: https://doi.org/10.2307/462664

> excluded from the place of the living subject, propelled away from the body and deposited on the other side of an imaginary border which separates the self from that which threatens the self (2).

Abjection, therefore, "draws our attention to the place where meaning collapses", an unknown in-between state of the known (3). As such, we reject the abject from ourselves. That which is abjected (the abject[4]) is situated[5] in a no-place[6] beyond the symbolic order that holds together. The abject cannot—indeed must not—be engaged with beyond the most fundamental instinct that it must be repulsed lest the self be consumed, tainted, collapse into the oblivion of abjection even simply through association with, or contemplation of the abject.

As for the theoretically uncomfortable fact that not everyone experiences feelings of abjection in similar situations, Robbie Duschinsky, in particular, positions Kristeva's "abjection" within a more nuanced relationship with the status quo.

Not all phenomena that we classify as impure is in-between or ambiguous and not all in-between or ambiguous phenomena are impure. Rather […] the impure is that which is constructed as deviating from an essential state of original homogeneity (4). Duschinsky builds on this, pointing to Kristeva's idea of abjection as a perceived violation of integrity. "The breach of integrity," states Duschinsky, "does not primarily invoke purity and impurity by virtue of an ambiguity between self and other, but through evoking an image of the contamination of a prior homogeneity by the intrusion of heterogeneity" (4).

This idea offers a clear approach to the application of abjection theory to sport. In this attempt, we can also look to Duschinsky's own "take" on impurity, that "in Western societies, impurity characterizes by degrees all phenomena that deviate from what is imputed as their *self-identity:* their internal homogeneity and their correspondence with elsewhere." Qualifying this, Duschinsky suggests that

> Western assumptions about essence as a state of internal homogeneity underpinning existent phenomena are shaped by a particular cultural heritage. Purity and impurity, as appeals to self-identity, appear in discourses as diverse as those on the body, sexuality, political corruption, nationalism, waste and rubbish—wherever a qualitatively homogenous essence is taken to underpin existence (4).

With such a framework in mind, in this paper we argue that abjection is at work in official and popular perceptions of, and reactions to, contemporary sport's two most significant issues: doping and questions of inclusion in sex/gender categories. In both situations, abjection seems to arise where violations of a perceived homeostasis precipitates existential crisis. Thus, it may well be asked what role abjection plays in decision making processes designed to protect the status quo in the face of cheaters who dope, break the rules and manipulate their bodies, (dis)able-bodied athletes, women in general, and to those challenging the gender dichotomy within sports.

For conceptual clarity, we propose a new term "abjection bias" to describe what might less accurately be called "gut reaction" in what should be—and ethically must be—a rational process. We suggest the following definition: *the abjection bias occurs when feelings of abjection about an individual, group, action, situation* etc. *uncritically guide the decision-making process. Decisions influenced by the abjection bias might be identified by their reliance on rhetorical, impassioned appeals to a shared sense of disgust/revulsion in order to create metaphorical or real distance between a person's identified group and that which gives rise to the feeling of abjection.*

In this paper we will argue that the abjection bias has played a significant part in shaping responses to perceived threats against "clean sport" and "women's sport." The analysis of the concept of "abjection," and identifying the role of abjection bias, deepens our understanding of responses defending the perceived *status quo*. Indeed, as we explore the nature of abjection and become aware of an abjection bias, we can begin to hope for rational and perhaps novel approaches to disentangling the Gordian knot of contentious issues such the inclusion/exclusion of TGD athletes and the protection of women's sport. Further, we suggest that the idea of abjection bias can help to explain and challenge what some sport philosophers have called the "Unnaturalness argument,"[7] to be explored in the following section.

3. Abjection, the "Frankenstein factor" and the "unnaturalness argument" as used in the anti-doping sciences

Abjection correlates well to the "unnaturalness argument" often put forward that doping is bad because there is something "unnatural" about it.[8] Yet the unnaturalness argument is

[4]From Latin *ab-* (off, away from) and *iacere* (to throw, impel)

[5]Indeed, "situate" may be misleading since someone cannot exactly be said to be placed into a no-place. It may be more correct to say, "exiled" from place all together. The abject as exile is an appealing notion especially given the connotation of being driven out, cast away (a castaway, abject) from the Subject-self and the ordered world.

[6]A literal *utopia*="no place" *vs. eutopia*="good place", a pun due to the similar pronunciation of these Greek words.

[7]It is important here to clarify that challenging the logical validity of the 'unnaturalness argument' on the grounds that it is rooted in bias does not necessarily invalidate everything that it has been used to defend except where claims made under the unnaturalness argument are indefensible by means of more robust argumentation.

[8]There is a seemingly endless range of what exactly might be deemed 'unnatural' when using this argument with regard to doping. While Fairchild points to the method of drug delivery, other aspects might

problematic since it is premised on an unprovable first principle, the nature of what is "natural." Sport philosopher Roger Gardner's description of the "natural" illustrates well this limitation:

> *Any procedures that might* change *or control `the nature of our species'* […] *somehow threaten `our sense of identity, our sense of uniqueness* […]' […] *\such prospects threaten wholly to subvert traditional philosophical paradigms and undermine the standard ethical touchstones of `human nature,' `humanity,' and `rationality;'* […] (5).

As with the analogous "Frankenstein factor," a binary distinction between "natural" and "unnatural" opens the door to abjection bias for anything or anyone threatening the symbolic order of the status quo.[9] The similarities between "abjection" and the "Frankenstein Factor" from the bio-ethics literature is striking and has not been discussed in the literature before. Even as Kristeva was formulating her theory of abjection in the 1970s, Willard Gaylin's used the term "Frankenstein Factor," to describe societal fears surrounding extraordinary new research with significant impact on human beings. For many issues including drug use or DNA research in general, Gaylin proposed it as "an unanalyzed element coloring the debate," (7). This is also analogous to the "yuk" factor, as a metaphor for the physical response that coincides with the recognition of "extreme other."

Historically, there are many ways in which the "unnaturalness argument" has been used in support of anti-doping sciences (5) but it is fair to draw a conclusion that the argument itself is flawed. If we had a sound and consistently used definition of "unnatural" in this context, then perhaps the unnaturalness of those substances, methods, or amounts found to be such could be used to define the practices which are deemed wrong. The fact, however, is that we do not.

Despite these challenges to the various articulations of the "unnaturalness argument," justification for prohibiting substances can and has differed from substance to substance and might even shift as both science and opinions change over time. Thus, some substances might have been considered undesirable due to the mode of introduction in some cases and in others because of the artificial nature of the substance itself, and in still others for reasons beyond the scope of this paper such as risk of harm or violations of the "spirit of sport."

Regardless of the justification of a banned substance, the result and, perhaps most of all, the intent to exceed pre-existing limitations and perceptions of what is humanly possible are perhaps most central to the question of abjection bias and the "Unnaturalness argument." Gardner captures this idea well, saying that,

> the gained enhancement is viewed to be beyond the athlete's human capabilities. It would seem that we are opposed to such enhancement because […] we wish to view the athletes as the counterparts not of gods but of demigods. This is conditioned by the ambiguous character of their deeds which we wish to view as superhuman but definitely not nonhuman. Elite athletes exceed what average human beings are capable of achieving […] It is along these lines that we may wish to argue against substance-acquired capabilities: they permit athletes to transcend the boundary of humanness (5).

Thus, "natural" and "unnatural" attempts to mean what is "natural" or "unnatural" for us as human beings. The primary concept in terms of which "natural" had to be defined was that of a human or a person. If we do not have a consistent view of what it was to be human, we cannot define what is natural or unnatural. Deciding what it is to be human is logically prior to determining what is, or is not, an "unnatural' practice.

However, at the intuitive level these arguments struck a chord, particularly for the view of female athletes using steroids. These arguments were based on the claim that the banned practice threatened the essence of the athlete's humanity, and for women, it was their "womanhood" that was threatened. As mentioned above, in the bioethics literature this idea fits well with Willard Gaylin's terminology of the "Frankenstein Factor", used to describe societal fears of the effects of things like bio- technology and drugs in general (6). The "Frankenstein Factor" theme is related to the "artificial" construction (or manipulation) of a hybrid human being.[10] For female athletes, the response is usually negative and often worse, because it was viewed as turning them into men. This response was highlighted in early anti-doping educational materials. In the case of its application to the athlete, doping is viewed manipulating them beyond a natural human being.

Thus, although the "Unnaturalness Argument" has been robustly challenged on many fronts, it has persisted as a central rationale in anti-doping policy and messaging. We propose that abjection is at least in part responsible.

It is important to note, that such criticisms of the "Unnaturalness Argument" are not to argue in favour of doping,

include from the motivation for its use (*e.g.* gaining an unfair advantage) as well as the resulting physical changes (*e.g.* gains in strength, speed, stamina that is more than normal for a human) and even undesirable side-effects of drug use (*e.g.* negative impacts on sexual function as can be the case with anabolic steroids). For women especially, the physical transformation that replaces traditional 'female' qualities with 'male' ones (*e.g.* gains in musculature) are frequently cited as aspects of an 'unnaturalness argument' against the use of drugs in sport.

[9]Inversely, the existence of individual, group or even systemic abjection bias might fertilize the ground in which the unnaturalness argument can take root and flourish.

[10]It is important to note that this theme is not always viewed negatively, for example, transhumanists believe that the human race can evolve beyond its limitations by mean of science and technology with desirable superhuman properties that should help to improve the human condition.

but rather to point out first, the inherent weakness of the "Unnaturalness argument" and second, despite this logical fallacy, that any distinction between "natural" and "unnatural" strengthens abjection bias against the latter. For these reasons, officially sanctioned/leveraged abjection of doping or dopers—as we shall see in the next section with Ben Johnson—has been a convenient expedient in the fight not just to protect "clean" sport,[11] but also to protect "women's" sport.[12]

4. Sport abjection: Fairchild on doping, Jönsson on (Dis)ability sport, "abjection potential," and "intersectional abjection"

4.1. Fairchild's "abjection test" rejected

David Fairchild was the first to apply the concept of abjection to sport in his 1989 paper "Sport Abjection: Steroids and the Uglification of the Athlete." Fairchild focused on the fall from grace of Canadian sprinter Ben Johnson to argue that the idea of "abjection" can help us understand our (over) reactions towards doping in sport, a practice that challenges prevailing notions of order and purity. "Such an understanding," he suggested, "may enhance the possibility of developing rationally defensible policies governing the use of such substances and practices" (7).

While this objective seems to resonate with our own, we reject Fairchild's conclusion that abjection might serve as a barometer of public sentiment to direct policy concerning right and wrong behaviors.

> This essay has suggested that the concept of abjection may illuminate certain issues arising from substance abuse in sport, perhaps including an appreciation of argument types appropriate for justifying prohibitions on substance use. Specifically, justifications for regulating substances must proceed from the recognition that the use of most substances for which prohibitions are sought generates common, vigorous, public disapproval (7).

In appealing to "common sense," Fairchild's "abjection test" continues in a long history of *a priori* argumentation positioning as "natural" the *status quo* and as "unnatural" challenges to that established order. In other words, fertile ground for abjection bias to run amok, as shown in the previous section's overview of the "Unnaturalness argument" and its (mis)uses in anti-doping theory. Thus Fairchild's "abjection test," in its reliance on the "Unnaturalness argument," must be rejected in favour of a more rational and nuanced understanding.[13] Even though Fairchild's conclusion is flawed—as we demonstrate below—he presents a good example of the "mechanics" of sport abjection in his analysis of Ben Johnson. Fairchild tries to explain the logic of doping-related abjection through i) the boundary of the body; and ii) the limits of the body. For the boundary of the body, he makes an inner/outer distinction, where things like "spittle, blood, milk, feces, urine or tears" (7), once they have been passed, cannot enter the body without abjection. "The deliberate reinsertion into the body, through ingestion or injection, of substances that have traversed the body"s boundaries is both an abrogation of the fundamental inner/outer distinction that determines our own clean selves and a culturally revolting practice" (7).

Abjection is worse for athletes because they are exemplars, with whom we identify. "Their participation in certain culturally revolting behaviours leads to an especially dramatic form of "abjectification" (7). Significantly, Fairchild also points to a broader social context within which abjection is wielded as a means of separating clean from unclean, citing Kristeva"s phrase "the simple logic of excluding filth" (7).

While Fairchild can be justly criticized for his reliance on the "Unnaturalness argument," we suggest that his work's significance lies primarily in the connection of the concept of abjection to the official and popular reaction to Johnson's doping revelations. To put things into perspective, Fairchild was writing at a time immediately following what has more recently been called "the dirtiest race in history" (8). Johnson had stunned the world with his incredible performances and captured Gold in the 100 meter final at the Seoul 1988 Olympic Summer Games. Yet in the very moment of glory he tested positive for a banned performance enhancer. Johnson had doped, and what's more, once caught, he admitted to years of systematic drug use to gain a competitive advantage.[14]

[11]The official abjection of Johnson seems to have served a clear purpose: the re-establishment of symbolic order. If restoring perceptions of order is the goal, then only the tallest poppies need be cut down as an example to the rest.

[12]In some sense, officially sanctioned or directed abjection represents an Orwellesque 'group-think' in the abjectification process. The role of authority in what might be termed 'official abjection 'also begs the question of whether and to what extent the consuming flame of abjection bias might be stoked, steered or perhaps even stamped out through official action.

[13]A big problem with Fairchild's position is that while abjection bias gives rise to a tendency to abject that which existentially challenges the *status quo*, it does not necessarily follow that the *status quo* is morally or ethically justifiable. *e.g.* homosexuals at many times historically and even today in many places. It is unacceptable that we uncritically accept this reaction—much less allow it to direct policy. Such a sense of abjection in itself can be used to justify any number of mistreatments visited upon non-conforming individuals or communities.

[14]It is interesting to note that while the majority of competitors in that 100m Olympic final race would at various points afterwards face doping sanctions themselves or have since admitted to doping at those Games. Yet at those Games and in that situation, only Johnson's drug use was officially

> Following his admission, Johnson was banned from further Olympic competition, suspended from his national team, and in September, 1989 stripped by the International Amateur Athletic Federation (IAAF) of various titles, medals won, and records set in non-Olympic competition dating back to 1981 (7).

Many, including Fairchild, were trying to make sense of what had just happened. "In the span of just a few months," he wrote to introduce the concept of abjection, "Johnson has lost more than just his stature as a body beautiful. Our initial fascination has turned to revulsion, and he has been declared a track nonperson. We have abjectified him" (7).

Fairchild's idea of applying abjection to sport is picked up by Burke and Roberts in 1997, who similarly apply it to the case of doping in sport, but specifically in relation to women. One major contribution that they make, and one that further cements the links between Fairchild's application of abjection and that of | Jönsson (2017) explored just below, is in positioning the source of abjection within a broader societal context.

Whereas Fairchild suggests that the legislation banning drug use is driven by our, that is, the sport community's, revulsion of the drug user's *athletic* body, we will suggest that at least part of the force behind the drug ban is due to our abhorrence of the drug user's social body (8).This understanding of athletes as embodying identities beyond sport (*e.g.,* sexed bodies, gendered bodies, racialized bodies, (dis)abled bodies, in other words "socially constructed bodies"), opens up the door to two concepts that we will develop in the remainder of this section: "abjection potential" and "intersectional abjection". *Jönsson's "double standard" acknowledged, and two new concepts proposed: "abjection potential" and "intersectional abjection"*

After Fairchild (7), Burke and Roberts (8), and Burke (9), Kutte Jönsson (10) provides what might be the only other sustained academic application of abjection theory to sport. While Fairchild looks at abjection through the lens of the boundary-transgressive, "unnaturalness" of injecting performance enhancing substances into the body to explain the abjectification of Canadian sprinter Ben Johnson, Jönsson focuses instead on the subject's inability to fully remove themself from the threat of the abject in the form of the (dis)abled elite athlete. His 2017 work on abjection and parasport is significant in the introduction of the idea of a double standard in how we experience abjection in relation to able-bodied versus (dis)able-bodied athletes.

By framing his discussion of the term "freak show" as a description of the non-normative, unnatural ((dis)abled) bodies of Paralympians, Jönsson applies the idea of abjection to Paralympians and Olympians alike as similarly disturbing what can be considered a "normal" human.

> In relation to sports, and elite sports in particular, there is another point to make in regards to this, something that has to do with the irony of elite sports. And that is that elite sport *in itself* may be seen as a producer (and not just a container) of abjects. In many ways one can claim that elite athletes in themselves, with or without taking performance enhancing drugs (as in the case of steroid users), they become "abnormal" according to a social constructivist view (11); Jönsson's emphasis).

Yet, drawing a cultural distinction between perceptions of able-bodied and (dis)able-bodied individuals, Jönsson acknowledges a double standard, that "as long as [able-bodied] athletes follow "the rules," and as long as they do not challenge the commonly defined notion of good taste, they will never be classified or diagnosed as abjects […] Can the same be said about current Paralympians? Probably not" (11). The different standard to which athletes of diverse abilities are held in the popular imagination is also evident in their being viewed and discussed as (dis)abled first and elite athletes second.[15]

Jönsson's identification of this double standard is important in analytically separating abjectionable behaviour (*e.g.*, "freakishly" exceptional athletic ability) performed within the rules by otherwise "normal" individuals (*e.g.,* able-bodied elite athletes) and similar behaviour performed by individuals who are in some way not considered "normal" (*e.g.,* a Paralympic gold medalist). In these examples, following Jönsson's rationale, we are unlikely to consider the Olympic gold medalist abject, but we may well—are even likely to—consider as abject the Paralympic gold medalist standing on the same podium just a few weeks later.

For Jönsson this comes back to "an established conception of what "bodily perfection" means, a conception that seems to be deeply imbedded not least within the ideology of the Olympics" (11). "[W]hen it comes to able-bodied athletes we usually tend to see the freakishness of outstanding performances as something admirable in itself" (11).

Jönsson concludes that the "Paralympics represent something different from the Olympics. In other words, it seems much easier to connect disability sport to the term freak show [and, we might add, feelings of abjection] than able-bodied sports" (11). As abjects, society seems content that these athletes simply be able to compete against each other. Yet, attempts to bridge the divide between (dis)

confirmed; the extent of his abjection, therefore, seems to have been in part a means of restoring public confidence in the sport establishment's ability to enforce the rules and ensure 'clean' sport. In other words, abjection bias at work in the heavy handed response to a visible instance of non-conformity while turning of a blind eye on a wider doping problem and don't-ask-don't-tell culture that perpetuated the symbolic order.

[15]Hyphenated or contracted descriptive terms like "para-athlete", "para-sport" and even "Paralympian" emphasize the distinction between normative sport as an able-bodied domain. "Para" is a prefix from Ancient Greek meaning something "alongside", but also "beyond", which positions (dis)abled athletes as something other than normal and unnatural, especially in terms of the technological and pharmacological adaptations that allow for participation in elite sport.

able-bodied and able-bodied sport reveal the extent of abjection bias against para-athletes. Take the famous example of South African Paralympic champion, Oscar Pistorius, who lobbied to compete in the "able bodied" Olympic Games. Despite a level of abjection due to his circumstances as a para-athlete, the unnaturalness, particularly of his prosthetic legs, can be viewed as central to his further abjection. He was ultimately denied the chance to race with the fastest (able-bodied) Olympians for arguments that were also, in part, based on fair play and competitive advantage, the reaction in some ways parallels Ben Johnson's. For Pistorius, what we accepted and celebrated (the use of the prosthetic Cheetah blades for example, in the "freakshow" Paralympic context where "freaks" (abjects) are merely competing against other "freaks" and "tolerably" abject on that grounds) was transformed into something that we revile as "unnatural" on an entirely different level when that same "freak of nature" seeks to use his "unnatural", "artificial", "Frankenstein" adaptations to compete with a "normal" human. "As Jönsson points out, elite athletes are never really "normal". Thus, Usain Bolt for example, while theoretically abjectionable on the grounds that he was the fastest human in the world at that time, yet as he was perceived to be following the rules, he retains his "body beautiful" status. Pistorius' abjection becomes all the greater by daring to challenge that "natural" human ability. This link is further strengthened by the moniker "technology doping" that is often applied to the phenomenon of creating an unfair or "unnatural" advantage through ability-improving para-sport technology such as Pistorius' "cheetah blade" prosthetic legs. The case is similar for TGD athletes, whose biological and/or hormonal "advantages" are conflated with doping.[16]

Taking this one step further we suggest that all behaviours or characteristics that challenge the *status quo* possess a certain "abjection potential." The activation or realization of this potential, to a greater or lesser degree, depends on the circumstances of the individual or group engaged in the behaviour or action. Further, we propose that the idea of individual or group circumstances, or intersecting identities, impacting an individual's experience of abjection, or likelihood of abjection, also opens the door to a theory of "intersectional abjection."[17]

These concepts help us to identify abjection bias stemming from pre-conceived notions of what constitutes "normal" and hence desirable. "We still consider the athletes with artificial limbs to be essentially undesired," states Jönsson, "in that they still will be representing a dimension in the human condition most people consider to be connected to emotions of horror" (11). Once again, the connection to the bioethics' "Frankenstein factor" here are clear. We also suggest the presence of abjection bias as a major factor in the implicit acceptance of the unnaturalness argument.

As we will demonstrate in the next section, it is not just doping or (dis)ability that elicits feelings of abjection in this way. Abjection bias, and with it Jönsson's double standard, can be identified in the debate about what constitutes a "woman" for the purposes of sport. Individuals who do not conform to prevailing cultural attitudes about sex and gender are, by their very (perceived) unnaturalness, sites of abjection. Thus, just as for persons with (dis)abled bodies, individuals transgressing sex/gender norms already face abjection bias and that pre-existing bias seems to activate elite sport's abject potential in a way similar to elite athletes who dope.

5. Context for women's sport as a protected category

Before looking more specifically at the potential abjection bias's role in official and public abjection of women, transgender and gender diverse (TGD) athletes, it is important to understand the history of the complexity of the establishment and maintenance of women's sport as a protected category. The connections between anti-doping sciences and the "protection" of women's sport are numerous; this has frequently led to the conflation of protecting "women's" sport with protecting "clean" sport, a distinction obscured further by abjection bias. The clarity that can be gained from understanding this history can help to shed light on particular aspects of current policy decision-making.

The debate about women's place in competitive sport has roots in antiquity where women were not permitted to take part or even watch the Olympic Games. Two millennia on, at the first modern Olympic Games at Athens 1896, although women could spectate, they were similarly barred from competing. As things changed—slowly—with the inclusion of some women's and even mixed events at Paris 1900, the debate around policing who was, and who was not, a woman for the purposes of sport began in earnest.

[16]Although unrelated to his sporting accomplishments, in his life "after" sport, in retirement Pistorius was convicted for homicide in the shooting death of his girlfriend. It would be interesting to investigate the role of abjection and his status as a Paralympian in media and legal portrayals of Pistorius during and after the trial.

[17]I appears that the concept of 'intersectional abjection' has been mentioned (but not elaborated upon) only a few times: in the context of literary studies (Lee, 2014), and decolonisation (Mir, 2018; Padilla, 2021). The authors of the current paper believe this idea has potential to be more fully developed in and beyond the sport context. (Seulghee Lee (2014),"'Other Lovings': Abjection, Love Bonds, and the Queering of Race," UC Berkeley Electronic Thesis and Dissertations. https://escholarship.org/uc/item/0mw1p6xm); (Carolta Mir (2018), "Dossier for Critical Preservation and Re-use of Casa del Mutilato", Decolonizing Architecture Advanced Course, Palermo, June 2018, https://www.daas.academy/wp-content/uploads/2020/01/10QueeringFascist_compressed.pdf); (Alexis Padilla (2021), "Decoloniality, Embodiment and Othering Emotionality: Decoding and Countering the Inter-Imperialist Foundations of Intersectional Abjection," Revista Latinoamericana de Estudios sobre Cuerpos, Emociones y Sociedad. N°37. Año 13. Diciembre 2021-Marzo 2022. Argentina. ISSN 1852-8759. pp. 89-99. https://dialnet.unirioja.es/servlet/articulo?codigo=8238041)

Researchers, who for the most part were men, —from the bourgeoning fields of biological science and medicine, were prominent voices in discussions on the "protection" of women's sport taking place within the IOC and other governing bodies of international sport in the early 20th Century (12). Policies linked to practical action to protect women's sport started in the late 1930s. The creation of these policies and practices coincided with the views of Avery Brundage, President of the IOC from 1952 to 1972. Raising sex verification concerns in a 1936 letter addressed to Henri de Baillet-Latour, then IOC President, Brundage, then head of the American Olympic Association (precursor to the United States Olympic Committee), wrote,

> […] *I do know that the question of the eligibility of various female (?) athletes in several sports has been raised because of the apparent characteristics of the opposite sex. Recently considerable publicity was given* […] *to the case of an English athlete who after several years of competition as a girl announced herself (?) to be a boy* (13).

This position is important to note for the purposes of this discussion for two reasons. One, it is clear that Brundage, whose voice was an increasingly powerful one within the Olympic movement, viewed such activity as a form of cheating, similar to doping. The second reason is that, historically, connections between doping and sex verification, in particular specific comments by Brundage, seem to combine two distinct claims: first, a concern about masculinization of female athletes; and second, a concern about male athletes pretending to be female.

It has been well established that in Brundage's tenure at the IOC's helm, beliefs about female athletes and sport were often conflated with, and confused by, societal concerns about sport participation causing masculinization (14). This confusion has contributed to complicating attempts, even now, to assess the need for protection of the women's category in sport. As it happened, Brundage was concerned enough to recommend,

> […] *that all women athletes entered in the Olympics be subjected to a thorough physical examination to make sure they were 100% female* […as] *athletes who recently competed in European track events as women were later transformed into men* (15).[18]

Responding to the concern of protecting women's sport, the International Association of Athletic Federations (now World Athletics) created a formal sex verification process in 1937. There is, however, some evidence of "physical examinations" before this date (16). This new rule was implemented in the "protests" section of the IAAF policy, where it states that, if the "protest concerns questions of a physical nature, […] physical inspection be made by a medical expert" (17). Thus, the decision-making and justificatory power fell upon the experts from the medical/biological sciences.

Significantly the authority over sex verification remains to this day the remit of medical "sport sciences." Given the increasing role granted to these same medical experts by the IOC and IAAF to deal with the threat of doping, beginning in the 1950s and 60s (12), the confusion and conflation of these two issues is unsurprising. As the issue of sex verification progressed, the governing bodies of sports shaping anti-doping and sex testing policies did not address complex ethical concerns creating obstacles in the pursuit of relying purely on medical science to determine what constitutes "natural" sex/gender (12). The pursuit of sex verification through medical science was catalyzed by the entrance of the Soviet Union (USSR) in the Olympic Games in 1952; not only raising geopolitical power struggles in international sport, but also, at the same time, presenting dominating, powerful and muscular Soviet women in sport. Concern was soon noted by IOC and related officials, that not only were the Soviets using athletes doped with performance enhancing substances and practices, but they were also entering "abnormal" women, with the goal of dominating the medal podium in the Olympic Games (18, 19). "Red "Wolves" in skirts" American journalist, Frank True, called them in 1966, summing up well what we can see as "Western" abjection in the face of the Soviet challenge to the patriarchal myth of female fragility. "If the Commies hadn"t been guilty of substituting men for women in the first place, the new rule of the IAAF wouldn"t have been necessary" (20). In their uncritical translation of contemporary Western values, regarding binary sex/gender boundaries, into universal sport policy, these concerns, and subsequently increased focus on sex verification, clearly illustrate the similarities to Fairchild's "abjection test." The notion of natural sex/gender variation and the challenge it posed to the *status quo* was rejected (abjected) to confirm the established order of things. As long as female athletes with traditionally "masculine" features disrupt the perceived sex/gender norms, rule makers, and others, faced an internal conflict. The resulting conflict resolution was as follows: these muscular strong dominant athletes look more like males than females, therefore, these athletes must not be women. Perceived as "unnatural" and existing beyond the symbolic order, they are thus abjected. We can also see Jönsson's double standard at work, unlocking for women, but not men, the innate abjection potential of participation—and more specifically performance—in elite sport. Further, we can see in this the enduring echo of antiquated understanding of women's inferiority summed up well in Cynthia Freeland's feminist critique of Aristotle:

> Aristotle says that the courage of a man lies in commanding, a woman's lies in obeying; that "matter yearns for form, as the female for the male and the ugly for the beautiful"; that

[18]Brundage's use of the word 'transformed' is interesting for multiple reasons. First is the more recent use of the same prefix 'trans' as shorthand for 'transgender' or someone who has 'transitioned' from one gender to another (often by means of pharmaceuticals and/or surgery). It also connects us back to the 'Frankenstein Factor' and the oft-feared role of science in superseding the 'natural' order of things and hence raising the specter of abjection.

> women have fewer teeth than men; that a female is an incomplete male or 'as it were, a deformity': which contributes only matter and not form to the generation of offspring; that in general 'a woman is perhaps an inferior being'; that female characters in a tragedy will be inappropriate if they are too brave or too clever" (21)[19]

The inability of Brundage, and many others, to admit to the possibility of "masculine" looking women led directly to the institution of sex/gender verification and framed the debate as it continues to this day. Hence the medical/sport scientists have not only retained authority to determine who is allowed in the woman's sport category, often based on a medicalized sex-binary; but also the power to define what counts as "unfair advantage" in sport requiring the protection of the women's sport category, as was their responsibility in the realm of doping.

6. Protection of women's sport: transgender and gender diverse (TGD) athletes

This abjection of women relative to men is fundamental to our argument that Jönsson's double standard—and therefore abjection bias—both sustains, and is itself sustained, by the abjection of women simply because they are not men, and hence pose an enduring threat to normative maleness. This is in line with our definition of the abject as that which causes existential crisis by its non-conformity with the perceived *status quo*. But women athletes face a double abjection process; first, because they are not men, and second, because they are not normal women either.

The abjection process in the discussion of the protection of the women's sport category becomes even more complicated for transgender and gender diverse (TGD) individuals. We see a separate source of abjection in the transgression of the boundary between the traditional male versus non-male (*viz.* "female") sex/gender binary. Thus, the determination of who is, and who is not, a woman athlete is simultaneously central to the binary differentiation of sex/gender both as a means of abjection of woman relative to normative "man," but also the abjection of TGD individuals in the process of protecting normative "woman" against threats to the binary's symbolic order. Kimberlé Crenshaw's theory of intersectionality is clearly applicable (22) TGD athletes, particularly when seeking to compete in the women's category face abjection uniquely because they inhabit an identity that is—in the traditionally normative sense—simultaneously not a woman (non-biological sex female)-and not a man (-non-socio-cultural man).

While testosterone thresholds, which can be considered an outgrowth of anti-doping sciences, are currently the primary method to determine eligibility to compete in the women's category in many sports, the IOC and World Athletics have historically used biology and, in particular, chromosomes (female sex biologically determined by sex chromosomes XX). The eligibility criteria for fair play are, for the most part, about biological advantages. They have argued that the women's sport category was designed to protect those with a biological disadvantage (XX) in many sports and that sport sciences continue to demonstrate these facts (*e.g.*, world records in many sports, oxygen uptake, lung volume, muscle mass, *etc.* comparing men and women). The tested/exclusive category exists to protect women athletes who are deemed "naturally" disadvantaged from the competitive advantage of men and "unnatural" women. Currently, a significant issue is that there is no category for "legally determined women" (non biological females that have been recognized as women by the laws of their country) with naturally occurring above-average testosterone levels. Two related issues are: a) that of intersex individuals, whose biological sex includes both male and female; and b) that of retained "male advantage" despite pharmacological intervention to reduce testosterone levels in transgender individuals who have gone through male puberty and subsequently transitioned to become female.

Although they do not use the term "abjection," Antoine Rajkovic and colleagues explain well the link between TGD individuals and what we would argue, includes abjection. They identify main ideas such as the "pathologization" of TGD individuals because of "sexual deviation" as well as the terrible drive in many times and places for removal of TGD individuals through "treatment" or even "eugenics" (23).[20]

Along with the challenge presented by intersexuality and sex variation, the question of transgender athlete participation has become—as well as doping—one of sport's most significant, and divisive, issues. This seems applicable to the question of TGD participation in sport. On the one hand, TGD athletes are seeking to participate within the standard model available (e.g., intersex and trans women wish to participate in the protected exclusive category "women"). This status quo in the rules and practices of sport that, where sex segregation rules exist, women compete with women, men with men primarily for reasons of fairness. Yet, there are two questions that tend to arise. These are distinct questions, although they are connected and sometimes conflated.

First, are TGD individuals who identify as "women" actually women athletes for the purposes of sport competition? And, who gets to decide? Legally in some places and instances, the answer is, yes. This has become a political question especially in socially conservative-leaning jurisdictions where the question of the legitimacy of transgender identity and gender reassignment are hotly debated with the authorities frequently adopting that stance that trans women are different from "natural" women—sometimes called "natal women". This, of course, opens the door to abjection bias and falling into the now familiar trap of

[19]Plato is a rare example of challenge to this prevailing view as pointed out in Schneider 2000.

[20]These are extreme forms of what in our paper might be called "radical exclusion" as in elimination, thus an ultimate form of abjection.

complacency in the face of Jönsson's double standard as well as complicity in the framing of policy by means of Fairchild's "abjection test".

Mizuhu Takemura, in "Gender verification issues in women's competitive sports: An ethical critique of the IAAF DSD regulation," reviews the work of Camporesi and McNamee, "On the eligibility of female athletes with hyperandrogenism to compete: athleticism, medicalization and testosterone" (24). Takemura argues that these authors thoroughly examined the ethical problems inherent in the hyperandrogenism regulations of IAAF through the cases of Dutee Chand and Caster Semenya, focusing on the Camporesi and McNamee's question: "For the purpose of international competition, how ought one to define femaleness or womanhood?" (24). Although agreeing with Camporesi and McNamee that the gender distinction based on the steroid values, as adopted by IAAF and IOC, falls into the trap of medical reductionism, Takemura rejects their proposal that eligibility could be determined by legal recognition as a woman in one's home country. Takemura (2020) points out that although it may seem reasonable for anyone legally recognized as a woman to be able to compete as a female athlete, by using the legal definition of woman, the question of maintaining fair play remains, in that, how are we to determine how athletes with gender identity disorder should be dealt with in the context of fair competiton?[21] In the case of the Olympic games, the sports competitions are international events, but legal procedures for a sex change differ among countries and some countries do not even legally acknowledge sex changes, so athletes from such countries would have no remedies (24). Thus, Takemura concludes that the simple legal answer is at least as limited as the simple biological answer. So, arguments that assume that "gender identity" is taken to be already subsumed under the category of "sex" have serious limitations for human rights purposes. However, one could argue that, even if one rejects the legal status argument, gender identity could be positioned within interpretations of the *Olympic Charter* under the sixth principle of "or other status" and under protections against discrimination on the basis of "birth." But it still remains the case that the rules designed to protect the women's category of sport, were designed for biological females which were deemed traditionally "normal" women and disadvantaged in competition in sport against biological males.

Thus, the second major question that must be addressed is: Are TGD individuals, who wish to compete in "women's" sport, unfairly advantaged relative to those who were born with "normal" XX chromosomes and assigned the gender "female" at birth? There is a growing body of scientific evidence showing that there is likely a physiological advantage (25). Whether and to what extent that advantage can, and more importantly, should, be pharmacologically mitigated is an ongoing debate.[22] Fundamental to both questions is the lack of adequate competition space within sport's current sex-binary (women's sport on one hand and men's sport on the other) for women beyond the traditional weak-woman versus strong-man paradigm.

International sport bodies have moved away from direct means of sex-testing or "gender verification" (notably chromosomal) in recent years due to legal scrutiny of what has been challenged as an overly invasive and discriminatory practice. This move has meant that new methods of proving eligibility for participation in the protected "women's" category have had to be adopted. The IOC itself has attempted to strike a middle path that balances the traditional structure, in line with a recent ruling by the Court of Arbitration for Sport that "it is reasonable and proportionate to divide athletes into male and female categories" (26), while at the same time placing the responsibility of determining and enforcing qualification criteria on individual sports (27). and/or the laws of individual countries.

As identified by Takemura (24), a major complication with this approach is the international (and in some cases such as the United States, intra-national) patchwork of legal recognition of who is and is not a "woman". Legal status can also be at odds with sports bodies who test levels of blood serum testosterone for qualification for inclusion in the women's category. Thus, we see the perplexing situation of "legally determined women" who are deemed ineligible and banned from competition due to high testosterone levels. Some have argued that from a human rights perspective, the default should be inclusion and not exclusion, particularly with regard to legally determined women with naturally occurring high testosterone levels. It has been argued (28) that this would require "doping down" to compete in the women's category. Anti-doping sciences would be required to test for evidence of this process. "Doping down" can be just as bad morally, as "doping up". Caster Semenya lost her appeal to the Swiss Supreme Court to compete in the 800 metres against the World Athletics (formerly IAAF) regulations, passed in 2018, targeting intersex athletes who were born with both X and Y chromosomes (the traditional biological male sex pattern), and much higher levels of testosterone than the average biological female range. It is important to note that World Athletics did acknowledge that these regulations are discriminatory, but "do not exceed what is necessary in order to achieve equality of opportunity between male and female athletes, and are therefore proportionate" (29) to try to preserve fair play in the protected women's sport category.

Semenya's open defiance to the World Athletics policies and CAS ruling and refusing to "dope down" to comply with these regulations so she can compete in the women's category for the 800 meters, challenges Jonsson's double standard by reminding us of our common humanity. "I am very disappointed by this ruling," she stated in response to a dismissal of her appeal of the

[21]Even medicalized terminology such as 'disorder' implies 'unnatural' and thus contributes to abjection bias against those not conforming to the established 'natural' order.

[22]Schneider 2020 has argued that 'doping down' is as morally suspect as 'doping up.'

CAS decision to the Swiss Federal Tribunal, "but refuse to let World Athletics drug me or stop me from being who I am […] endangering our health solely because of our natural abilities puts World Athletics on the wrong side of history" (30). This echos a statement by international advocacy group, Human Rights Watch, claiming the regulations amount to "policing of women's bodies on the basis of arbitrary definitions of femininity and racial stereotypes" (31). The courts have ruled that it is a question of protecting the competitively disadvantaged traditional biological XX chromosomal women athletes. So, on the one hand, no qualifying athlete should have to "dope down" (or "dope up") to compete. On the other hand, as Doriane Lambelet Coleman, former elite 800 meter runner and law professor claims, the Swiss Court ruling recognizes that "sex equality in competitive sport is a legitimate goal" and that "separating athletes in competition by biological sex traits is the only way to achieve this goal, given the physical advantages associated with male puberty and testosterone levels in the male range" (32).

There is no doubt that the debate will continue to be intense on this pressing issue, as it will be regarding doping, and that the anti-doping sciences will continue to be involved. Ultimately, however, abjection bias must itself be abjected if we hope to achieve meaningful and lasting progress that respects the human rights of all. In this, we must be willing to explore solutions beyond the *status quo* to ensure that sport is as inclusive as possible *and* as fair as possible.

7. Conclusion

In this paper we have argued that the concept of "abjection," can help us to understand: i) the more extreme negative reaction that arises from seeing athletes who dope; ii) the even stronger reaction when it is female athletes who are doping; iii) that ii) is also historically tied to the conflation of doping and sex verification; and iv) that anti-doping sciences, in part, have been utilized, and still are, by sport administrators to help to maintain the perceived status quo.

Starting with a definition of the "abject," as that which existentially challenges perceptions of symbolic order, we introduced the idea of "abjection bias" to conceptualize the perpetuation of attitudes to the "unnatural" that can occur in the absence abjection awareness. Through an examination of previous approaches to abjection in sport, we identified and rejected "Fairchild's abjection test" as an acceptable policy making tool. We acknowledged the role of "Jönsson's double standard" in explaining how individual and societal abjection bias leads to unequal perceptions of members of different groups, namely people with disability, women, and TGD individuals. Furthermore, we introduce the phrase "abjection potential" to clarify Jönsson's idea that elite competition carries with it an innate abject quality, whose realization depends on the identity of the individual or group in question. Furthermore, we suggest that these ideas open the door to a new theory of "intersectional abjection." A brief history of these problems and the protection of the women's category in sport highlighted the connections and conflation between aspects of sex/gender verification and anti-doping sciences. It remains a very contentious issue, and just because we are able to identify abjection, it does not solve the problem of fairness, but it is important to understand some of the conceptual underpinning in order to make progress on it.

By understanding the historical role of medical and sport science both in identifying the sex/gender questions as a "problem" of "unnaturalness," and the power granted these fields to determine appropriate "solutions," we begin to grasp the conceptual and real link between doping and sex/gender in sport. We can also see the role of abjection bias in the development and implementation of policies and procedures aimed at the protection both of "clean" sport and "women's" sport. It is important to note that much of the conceptual discussion on the topic of gender and doping has been tied to sport science and biological premises and paradigms, which, as we have shown, can be subject to abjection bias. The clarity gained from understanding this reasoning and the role of abjection and abjection bias can help shed light on current policy decision-making in relation to the protection of women's sport.

Data availability statement

Publicly available datasets were analyzed in this study. Further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for this study in accordance with the local legislation and institutional requirements.

Author contributions

All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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