Analysis of the doping control test results in individual and team sports from 2003 to 2015

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Abstract:

Previous investigations using questionnaires and personal interviews have found that the incidence of doping misconduct might be different among different sports disciplines. However, there is no sport-specific information about the proportion of adverse and atypical findings in samples used for doping control despite the objectivity of this analysis to analyse the use of banned substances among sports. The aim of the present investigation was to assess the differences in the frequency of adverse analytical and atypical findings among sports reported by WADA accredited laboratories. For this purpose, the Testing Figures Reports made available by the World Anti-Doping Agency from 2003 to 2015 were analysed, specifically to examine the number of samples and percentage of adverse/atypical findings in individual and team sports. A total of 1,347,213 samples were analysed from the individual sports selected for this investigation from 2003 to 2015 and 698,371 samples were analysed for disciplines catalogued as team sports. The individual sports with the highest proportion of adverse/atypical findings were cycling (3.3 ± 1.0%), weightlifting (3.0 ± 0.6%), and boxing (2.9 ± 0.6%), while the team sports with the highest proportion were ice hockey (2.2 ± 0.5%), rugby (2.0 ± 0.5%), and basketball (2.0 ± 0.5%). Sports such as gymnastics and skating had a proportion of adverse/atypical findings lower than 1.0% in the years studied. In conclusion, the incidence of adverse/atypical findings was not uniform across all sports disciplines. The different proportions of adverse/atypical findings among sports suggest a greater use of banned substances and methods related to sport-specific idiosyncrasy. This information may be valuable for national and international anti-doping organisations to detect sports with a higher risk of doping misconduct.

Keywords: elite athlete, attitude, type of sport, banned drugs, anti-doping.
1. Introduction

Since the creation of the World Anti-Doping Agency (WADA) in 1999, one of the main objectives of the international anti-doping community has been to reduce the gap between the “forces” that act in favour of doping in sports and the procedures employed by the anti-doping authorities to assess the use of prohibited substances and methods. Although several important steps have been taken in these eighteen years, this objective seems to be far from being fully achieved because at present the use of banned substances by elite athletes from different sports disciplines is a certainty [1-3].

Determining the prevalence of doping is important for all the entities involved in sports organisation but it is particularly crucial to gauge the effectiveness of anti-doping policies. Even though it is virtually impossible to identify the exact prevalence of doping in sports, various analyses have identified the incidence of intentional doping to be between 14–57% [4-7]. Some of these investigations have used the randomised response technique, which allows the athlete to maintain anonymity, but the accuracy of these investigations based on personal input from athletes is limited by the necessity for truthfulness [8], objectivity and complete knowledge of athletes’ doping misconduct [9]. In contrast, the use of doping control test results has revealed that the percentage of samples containing banned substances has remained relatively stable at ~2.0% before [4] and after [10] the creation of the WADA. The assessment of the prevalence of doping in sports using the results of doping tests is an objective and robust method but it suffers from the limitations of the small detection window which exists for specific prohibited substances [11] - those that are only found at the time of sample collection, the analytical capability of WADA-accredited laboratories at the time of analysis, and an inability to discern the legal use of prohibited substances for therapeutic purposes.

The identification of doping prevalence in particular sports can aid in the management and implementation of plans for doping control tests specifically adapted to each sports discipline that eventually will improve the effectiveness of current anti-doping policies. Doping in athletics, as measured by surveys, can be up to 57% [5], with the athlete’s nationality being one of the major factors affecting prevalence in this sport [12]. Likewise, doping prevalence seems high in cycling since the use of doping agents is recognised by a high proportion of cyclists [13], although this is not always the case [14]. On the contrary, all the players in the 32 football teams classified for the World Cup Brazil 2014 were tested out of competition and there was no reported intended doping in any of the more than 1,000 samples analysed [15]. It has also been found [16] that speed and power athletes have been more frequently offered banned substances, followed by endurance athletes, and participants in sports that require motor skills, and team sports, although none of the athletes have admitted ever using banned substances. These outcomes coincide with previous investigations that have reported that those practising individual sports were more prone than team sports counterparts to be involved in doping attitudes [17] and agreed with statements related to the benefits of doping [18]. Athletes practising individual sports that require motor skills might be less influenced by doping practices than in other “more physical” individual sports [3] while athletes, cyclists and weightlifters presented a higher knowledge of anti-doping rule violations that counterparts from other Olympic sports [19].

Thus, the prevalence of doping has been assessed in several sports but the information is scarce and the athletes’ samples and the methodologies employed to assess the prevalence of doping in each sport preclude an objective comparison among sports disciplines. Thus, the aim of the present investigation was to assess the differences in the prevalence of doping among sports by analysing the frequency of adverse/atypical findings reported by WADA accredited laboratories. To strengthen the scope of the analysis, we have included information on samples analysed and the frequency of adverse/atypical findings over the course of 13 years.
2. Materials and Methods

The data included in this investigation have been gathered from the Testing Figures Reports made available annually from 2003 to 2015 by WADA. These Testing Figures Reports can be accessed from the WADA website and they contain information about the number of samples analysed, the percentage of adverse and atypical findings and the most commonly found drugs in urine and blood samples, among other analyses.[20] During the period included in this investigation, WADA accredited laboratories analysed a total of 3,103,974 samples to determine the presence of a prohibited substance or its main metabolites or markers in athletes of both Olympic and non-Olympic sports. The current investigation presents an ad hoc analysis of the samples corresponding to 17 individual sports (Aquatics, Athletics, Boxing, Canoe/kayaking, Cycling, Fencing, Gymnastics, Judo, Rowing, Shooting, Skiing, Skating, Taekwondo, Tennis, Triathlon, Weightlifting and Wrestling) and 7 team sports (Basketball, Football, Handball, Hockey, Ice Hockey, Rugby and Volleyball) that were part of the Olympic program in the analysed period (Rugby only from 2012). For this investigation, only complex team sports were labelled as “team sport”, while other individual disciplines known as that have collective events (known as simple and aggregated team sports, including athletics, swimming, cycling, rowing, etc [21]) remained labelled as “individual sport” because most of the samples analysed came from the individual disciplines. As it was impossible to analyse all the sports included in the reports -more than 100 sports disciplines-, the above-mentioned individual and team sports were selected because they accounted for at least 1,000 samples per year in all the years examined.

The Testing Figures Reports have evolved from 2003 to 2015 presenting more information about doping every year. However, we have used the data provided in 2003 as the basis for the analysis because we wanted to increase the statistical power of the study by including thirteen anti-doping sample analyses. In the reports from 2003 to 2007, the current two types of “non-negative” results were merged: a) adverse analytical finding, when the laboratory detected in the athlete’s sample a substance and/or a marker and/or a metabolite of the substance that was included in the list of prohibited substances; b) atypical finding, when the parameters measured by the laboratory showed a discrepancy with the previous results of the same athlete, if any, or with standardised mean values. Of note, the analyses did not include information about Therapeutic Use Exemption and thus, adverse and atypical findings did not necessarily end in anti-doping rule violations. Finally, the blood samples collected for the Athlete’s Biological Passport were not included in this analysis because this type of samples had not been obtained during the whole period that was analysed.

2.1. Statistical analysis

The data were electronically extracted from the Testing Figures Reports and entered into a database designed for the purposes of this research. After this, mean ± standard deviation for each Olympic sport (individual or team sports) were obtained from the total of the years investigated (2003-2015). The normality of each variable was initially analysed with the Shapiro-Wilk test. A one-way analysis of variance was used to detect differences in the number of samples analysed and in the frequency of adverse plus atypical findings. Bonferroni post-hoc analysis was then employed to identify differences among sports in these variables. The data were analysed with the statistical package SPSS version 20.0 (SPSS Inc., Chicago, IL, USA). The significance level was set at p < 0.05.

3. Results

A total of 1,347,213 samples were analysed from the individual sports selected for this investigation from 2003 to 2015 with an overall frequency of adverse/atypical findings of 1.6 ± 0.9%.

In the team sports examined, the number of samples analysed was 698,371 while the overall frequency of adverse/atypical findings was similar to individual sports (1.7 ± 0.6%; p < 0.05). Figure 2 -upper panel- depicts the average number of samples analysed per year in all individual sports. Specifically, athletics was the individual sport with the highest number of samples analysed per year (p < 0.05), followed by cycling, aquatics and weightlifting. The remaining individual sports
presented a lower number of samples analysed per year than the above-mentioned sports (p < 0.05), all of them with less than 5,000 samples per year during the studied period. The lower panel in Figure 1 depicts the average in the proportion of adverse plus atypical findings in individual sports from 2003 to 2015. Cycling (3.3 ± 1.0%), weightlifting (3.0 ± 0.6%), and boxing (2.9 ± 0.6%) were the sports with the highest proportion of adverse/atypical findings while the remaining disciplines presented a significantly lower proportion of samples categorised as adverse/atypical (p < 0.05). Sports such as gymnastics (1.0 ± 0.4%) and skating (0.9 ± 0.5%) had the lowest proportion of adverse/atypical findings in the years studied.

Figure 1. (A) Number of samples analysed and (B) percentage of adverse and atypical findings in these samples in individual sports. The data are mean ± SD for each sport between 2003 and 2015. CYC = Cycling; WEI = Weightlifting; BOX = Boxing; TRI = Triathlon; WRE = Wrestling; ATH = Athletics; JUD = Judo; SKI = Skiing; TAE = Taekwondo; TEN = Tennis; CAN = Canoe/kayaking; FEN = Fencing; AQU = Aquatics; ROW = Rowing; SH = Shooting; GYM = Gymnastics; SKA = Skating. (*) Different from CYC at p<0.05. (†) Different from WEI at p<0.05. (‡) Different from BOX at p<0.05. ($) Different from all the remaining individual sports at p < 0.05.

Figure 2 contains information on the average number of samples analysed -upper panel- and proportions of adverse plus atypical findings -lower panel- in team sports from 2003 to 2015. Football was the team sport with the highest number of samples analysed per year (p < 0.05), followed by rugby and basketball. Ice hockey, handball, hockey and volleyball, on average, accounted for less than 5,000 samples per year. Regarding the percentage of adverse/atypical findings, ice hockey (2.2 ± 0.5%), rugby (2.0 ± 0.5%), and basketball (2.0 ± 0.5%) presented a higher proportion than volleyball and football (p < 0.05).
Figure 2. (A) Number of samples analysed and (B) percentage of adverse and atypical findings in these samples in team sports. The data are mean ± SD for each sport between 2003 and 2015. ICE = Ice Hockey; RUG = Rugby; BAS = Basketball; HAN = Handball; HOC = Hockey; VOL = Volleyball; FOO = Football. (*) Different from ICE at p<0.05. (†) Different from RUG at p<0.05. (‡) Different from BAS at p<0.05. ($) Different from all the remaining team sport at p < 0.05.

4. Discussion

The goal of this investigation was to evaluate the number of samples analysed and the proportion of adverse/atypical findings found in some of the most popular individual and team sports by using data on samples analysed by WADA-accredited laboratories between 2003 and 2015. To standardise the data during this period, we used the information provided in the Testing Figures Report of 2003 that grouped all the non-negative results - i.e., adverse plus atypical findings - in the same category. The main outcomes of this investigation are: a) cycling, weightlifting, and boxing (~3.1 ± 0.7% as an average for these sports during the examined period), were the individual sports with the highest percentage of adverse/atypical findings from 2003 to 2015, despite athletics and aquatics being the sports with highest number of samples analysed per year. b) in team sports, ice hockey, rugby and basketball (~2.1 ± 0.5% as an average for these sports) presented the highest proportion of adverse/atypical findings despite the fact that, in comparison to these team sports, more than double the number of samples were analysed per year in football. These data suggest that the prevalence in the use of banned substances is not uniform across all sports, with some sports showing, on average, a higher proportion of adverse/atypical findings.

The number of samples analysed per year does not seem to be the primary anti-doping strategy that drives a greater proportion of adverse/atypical findings in a specific sport, as has been previously suggested in recent research that included all the doping control test results analysed for...
13 years [10] Yet other causes might be responsible for the differences in the frequency of banned substances found among sports. Probably, a higher prevalence of misconduct related to doping abuse is the main factor responsible for the higher proportion of adverse/atypical findings in some sports which suggest that doping is not a phenomenon of the same magnitude in all sports. Interestingly, although the magnitude of the prevalence of doping is much higher when measured with anonymous surveys against doping control tests, the sports with the highest prevalence of doping coincide in these two types of analysis [5,13,15-17]. In any case, it should be highlighted that some sports are submitted to a far greater number of anti-doping controls (football, athletics, cycling, aquatics, etc) and thus, their proportions of non-negative findings might be partially biased because of the testing of a greater number of athletes [22].

In individual sports, there is no a clear explanation for the higher proportion of banned substances in cycling, weightlifting, and boxing when compared to the remaining disciplines. From a physiological standpoint, the physical capabilities linked to success in these three disciplines are quite different, with dissimilar involvements of muscle strength, muscle power and endurance among them. It is probable that, within individual sports, cyclists would choose different substances and methods to illicity improve their performance compared to athletes who depend primarily on strength and power, such as weightlifters and boxers. However, the information about the substances more commonly detected in each sport has been made available by WADA only since 2014 and further research is necessary to correctly determine the most abused substances in each sport. Athletics deserve a separate assessment: a recent report has revealed that almost half of elite athletes recognised the use of banned substances/methods in the year before two major athletics events celebrated in 2011 [5] while the proportion of adverse/atypical findings in athletics under the current analysis with adverse/atypical findings was 1.6 ± 0.3% from 2003 to 2015 (1.0% in 2011). The discrepancies in these figures might indicate a low effectiveness of anti-doping testing to unequivocally detect doped athletes-despite more than 24,000 samples analysed per year in athletics-or an overestimation of the prevalence of doping when using questionnaires. Further investigations are warranted on this topic to accurately assess the prevalence of doping in athletics and other sports.

Regarding team sports, all of them share a common intermittent nature in which high-intensity actions are combined with short periods of recovery and thus, success is driven by a reliance on anaerobic and aerobic metabolic pathways. However, the team sports with the highest proportion of adverse/atypical findings (ice hockey, rugby and basketball) are team disciplines in which contact between players is allowed and thus a high body mass, and particularly a high body muscle mass, may be a key factor for success in specific playing positions. Lastly, the frequency of adverse/atypical findings is higher in individual than in team sports probably due to the higher impact that doping -applied individually- has on single vs. collective sports. These outcomes measured by doping control tests confirm that the risk of doping is higher in endurance and power sports and lower in motor skill demanding sports, as previously suggested by questionnaires [16].

Previous research has established [2,4] that the most accurate way of estimating the prevalence of doping in elite sports is using a combination of anonymous questionnaires, specifically the survey technique called the "randomised response technique". Others [3] have recommended a combination of qualitative and quantitative measurements, using interviews, questionnaires and, ideally, less-invasive biomedical tests (e.g. based on hair or salivary samples) to assess prevalence of doping in sports. However, these two multidisciplinary perspectives [3,4] are useful for the assessment of the prevalence of doping in research with only a limited number of participants, their application to large populations being very complex. Besides, the athlete's knowledge to correctly identify doping misconduct can affect the outcomes of these types of investigations and there is still a high influence of those who cheat about their doping behaviours [9]. The current analysis does not contain individual information directly obtained from athletes beyond the evidence provided by the analysis of the samples, and thus it precludes, in part, the understanding of the motives and attitudes behind doping misconduct. However, it depicts a robust scrutiny of all the samples analysed for anti-doping purposes from 2003 to 2015 which strengthen the generalisation and utility of the results here presented. With this background, it is safe to conclude that some sports, such as cycling, weightlifting, boxing (individual sports), rugby, ice hockey and basketball (team sports) presented a slightly higher frequency of banned substances detected in their athletes' samples and
thus, it is reasonable to conclude that these sports have a higher use of prohibited substances. In any case, the issue of intended or unintended doping in these sports should be addressed in further investigations, because of the high proportion of dietary supplements used in sports with the presence of doping substances [23] and the poor and biased knowledge of doping that athletes present [3,13,19].

As it was mentioned in the methodology employed for this analysis, the adverse and atypical findings presented in this investigation did not necessarily ended in anti-doping rule violations, because some of the substances detected might have been used for therapeutic purposes under the Therapeutic Use Exemption protocol (TUE) or the adverse/ataypical findings might end in the absence of a formal sanction. Since 2013, the WADA is also making public a report that relates the number of adverse/ataypical samples with the proportion of anti-doping rule violations. In these reports, the overall proportion of adverse/ataypical findings that ended in an antiodoping rule violation was 64 ± 1%, with approximately 10 ± 2% exemptions due to TUEs, and with the remaining samples without sanction or pending of a final decision. Again, the conversion of a laboratory adverse/ataypical finding into an antiodoping rule violation depends of the sport. For example, from 2013 to 2015, 85.5 ± 4.6 and 84.8 ± 1.5% of the adverse/ataypical findings found in wrestling and weightlifting finally ended in and antiodoping rule violations while this proportion was only 23.3 ± 14.3% in gymnastics. In team sports, the sports with the highest conversion of adverse/ataypical findings into antiodoping-rule violations was rugby (69.8 ± 5.5%) followed by volleyball (69.3 ± 23.7%). Thus, the data included in this investigation is useful to assess the use of banned substances in different sports but the study of the difference in the percentage of antiodoping rule violations among sports requires further analysis.

5. Conclusions

In conclusion, the prevalence of adverse/ataypical findings found by WADA-accredited laboratories was not uniform in all sports disciplines from 2003 to 2015. Some specific sports had higher proportions of adverse/ataypical findings that suggests a greater use of banned substances and methods due to their idiosyncrasy rather than other physiological explanations. This information may be valuable for national and international anti-doping organisations to improve the policies used to reduce the prevalence of doping in sports and to detect specific sports with a higher risk of doping misconduct. Specifically, this information could aid in obtaining a more informed athlete population and the implementation of test distribution plans adapted to the sport disciplines that will lead to the establishment of much more “intelligent” testing policies.

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References


