Polish Annals of Medicine

Journal homepage: https://www.paom.pl

Research Paper

Unintentional doping: What do athletes know about it?

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ARTICLE INFO

Article history
Received: November 20, 2024
Accepted: December 16, 2024
Available online: June 3, 2025

Keywords
knowledge
athletes
unintentional doping
awareness among athletes
anti-doping education

Doi
https://doi.org/10.29089/paom/197438

ABSTRACT

Introduction: The issue of doping remains a significant challenge in the realm of sports, undermining the fundamental principles of fair competition and prompting extensive countermeasures at the organisational level. Unintentional violations of anti-doping regulations have emerged as a growing concern, often arising from a lack of awareness or inadvertent exposure to prohibited substances.

Aim: The aim of the study was to evaluate the knowledge of athletes about unintentional doping and identify the factors that influence their level of knowledge.

Material and methods: The survey was questionnaire-based (questionnaire tested for readability and comprehension). The study involved 384 adult athletes, including students of the Academies of Physical Education in Poland and individuals connected to online sports forums. Statistical analysis was performed using the Statitica 13.3 software ($\alpha = 0.05$).

Results and discussion: The results obtained by the respondents in the knowledge test conducted in this study indicate that those with sufficient (n = 174; 45.3%) and insufficient knowledge (n = 149; 38.8%) dominated among the surveyed individuals. Athletes with a medical or health science background were approximately 6.5 times more likely to test positive than those without such a background, and athletes at the national or international level were almost 3 times more likely to test positive than recreational athletes.

Conclusions: There is a relationship between athletes' level of awareness regarding unintentional doping and their education and status in the sport. The findings may prove beneficial in the development of more effective doping education programs.

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1. INTRODUCTION

Sport in the 21st century is characterized by continuous development, striving for better results, the use of new technologies, and performance-enhancing substances. Companies that specialize in the sale of dietary supplements are meeting the expectations of their customers/athletes by introducing 'improved' dietary supplements or food products to the market. It is essential that all means used conform to the 'spirit of sport,' defined as the pursuit of excellence in a manner consistent with ethical principles. Doping is defined as the commission of one or more violations of anti-doping rules, primarily concerning prohibited substances and methods in sport, according to the World Anti-Doping Agency (WADA).[1]

Doping is a much widely discussed issue in the world of sport, acknowledged as a violation of fair competition, and the Polish Anti-Doping Agency has taken significant steps to combat it. In 2022 alone, the agency conducted 220 educational campaigns and 750 control actions, resulting in the collection of almost 2500 control samples.[2] The International Standard for Education (ISE),[3] introduced in 2021, aims to promote awareness among athletes and sports professionals about the principles of clean sport, the dangers of doping, and the consequences of anti-doping violations. WADA also supports national anti-doping organizations in crafting and executing educational strategies by offering training programs, instructional resources, and the Anti-Doping Education and Learning platform (ADEL).[4]

The Prohibited List is an international mandatory standard for prohibited substances and methods, forming the part of the World Anti-Doping Program. WADA structures conduct annual consultations to update this list. The prohibited substances and methods fall into three categories: (1) prohibited at all times, (2) prohibited only during competitions, and (3) prohibited only in certain sports. Substances or methods prohibited at all times are strictly forbidden, both during and out of competitions. Substances prohibited during competitions include compounds that athletes are forbidden to use from 23:59 on the day before the competition in which the athlete is scheduled to participate until the end of the competition and the sample collection process. WADA may grant exceptions for defining competition time for individual sports.[5]

Doping is not always a conscious pharmacological aid. However, the number of cases of unintentional doping has been steadily increasing over the past two decades.[6] It is important to note that the negative consequences of unknowingly using prohibited substances by the WADA are not limited to possible adverse health effects. A positive anti-doping test may result in a severe disqualification penalty for an athlete.[7,8]

Unintentional violation of anti-doping regulations is most commonly caused by the consumption of dietary supplements contaminated or adulterated with doping agents. It is a well-known fact that athletes consume dietary supplements, with reported usage ranging from 51% (Norwegian athletes) to 98% (Canadian athletes), and even reaching 100% in some disciplines.[9] Reports indicate that the level of contamination of supplements with undeclared substances has been systematically increasing from 10%–25% in 2015 10%–38% based on research from 2021.[11] According to estimates from 2005–2013, 6.4% to 8.8% of reported doping cases were caused by the use of dietary supplements. However, due to the significant increase in the consumption of dietary supplements, it is challenging to apply these data to the current situation.[9,10] Prohormones and anabolic-androgenic steroids are among the most commonly detected compounds in supplements, despite the lack of declaration by the manufacturer regarding their presence.[12,13] In Europe, the safety testing of dietary supplements is the sole responsibility of the manufacturer.[14] WADA does not conduct routine testing of nutritional supplements and recommends limiting their use to a minimum. Additionally, there are no specific recommendations available regarding the intake of certain products. The recommendations of national scientific bodies should be followed when using dietary supplements. The Australian Institute of Sport (AIS) classification of dietary supplements and their ingredients in terms of safety for athletes is particularly noteworthy and recommended by WADA. According to the AIS classification, there are four groups of dietary supplements and their components in terms of their safety for athletes. Group A includes recommended supplements and substances with supportive effects during exercise, such as whey protein, caffeine, and creatine. Group B includes supplements that are recommended for athletes but require additional studies to confirm their effectiveness, for example antioxidants, collagen, ketone supplements, and carnitine. Group C comprises supplements whose beneficial effects has not been confirmed by scientific research, such as branched-chain amino acids (BCAA), magnesium, and tyrosine. Group D comprises supplements that are prohibited or not recommended for athletes, such as ephedrine, herbal stimulants, colostrum, and Maca root.[15]

It is important to consider that a positive result in an anti-doping test may not necessarily indicate the use of performance-enhancing substances, as it may also be caused by the consumption of certain medicinal preparations (e.g. those containing pseudoephedrine), animal-derived food, or plant products (e.g. those containing morphine, cocaine or tetrahydrocannabinol THC). However, it is crucial to thoroughly investigate any positive test results to ensure fair play and maintain the integrity of the sport (Table 1).[16–21]

2. AIM

The aim of the study was to evaluate the knowledge of athletes about unintentional doping and identify the factors that influence their level of knowledge. This publication is intended to raise athletes' awareness of the risks associated with products that are commonly used in everyday life and the possibility of inadvertently violating the anti-doping rules.

Table 1. Causes of unintentional doping.[16–21]

Product	Characteristics
Poppy (*Papaver somniferum*)	Possible positive test for morphine and codeine
Coca tea (*Erythroxylon coca*)	Positive for cocaine (2–36 h after drinking)
Products with hemp oil or hemp seed added (*Cannabis*)	Positive for THC; risk of THC accumulation in adipose tissue (up to 5 weeks after last exposure)
Maize and its products + other cereals with infection by *Fusarium* fungi	Production of the mycotoxin - zealarenone, which is metabolized to the prohibited zearanol
Tonic	Presence of quinine - there is the possibility of a questionable test result for heroin (quinine may be used in the production of heroin)
Meat	Positive for the presence of group substances: – S1 (e.g. nandrolone) – S3 (e.g. clenbuterol)
Food products containing food additives: E280–E283	Positive for efaproxiral (M2)
Food products rich in resveratrol	Positive result for the presence of S4 substances
Soy and products rich in phytoestrogens	Increased concentrations of estrone and estradiol
Antitussives, or cough suppressants with codeine	Risk of detecting morphine in urine
Contraceptives, remedies for gynecological disorders containing norethisterone	Risk of 19-norandrosterone detection
Medicines with ibuprofen	Low risk of a false positive test for cannabinoids, benzodiazepines or barbiturates after acute or chronic ingestion of these drugs
Preparations with pseudoephedrine	Positive for pseudoephedrine or cathine
Antibiotics (fluoroquinolones and rifampicin)	Low probability of a false positive test result for opioids
Antihistamines with levomethamphetamine / brompheniramine	False positive test for methamphetamine

Comments: THC – tetrahydrocannabinol.

3. MATERIAL AND METHODS

3.1. Study group

The study involved adults aged 18 and above who participate in sports, as defined by Polish law as any physical activity that, through occasional or organized participation, improves physical and mental condition, develops social relationships, or achieves sports results at all levels (Article 2, paragraph 1).[22] The athletes participating in the study were divided into four distinct groups based on the World Anti-Doping Code:

(1) athletes engaging in recreational sports without remuneration who do not belong to a sports club/association,
(2) athletes engaging in recreational sports without remuneration who belong to a sports club/association,
(3) national-class athletes (who receive remuneration for engaging in sports)
(4) international class athletes (receiving remuneration for their sport).[1]

The study involved 384 adult athletes, comprising of 178 women and 206 men. The survey participants included students from selected Academies of Physical Education in Poland and individuals associated with online sports forums. The minimum size of the representative sample (N_{min}) was confidently determined to be 384 individuals. This calculation was based on data from the Statistics Poland for the year 2021, taking into account the percentage of people who exercise regularly (20% of adult Poles) and the number of adults in Poland (22,835,400 adults).[23,24]

3.2. Research tool

The survey was questionnaire-based and conducted between January and July 2023. The study used a self-administered questionnaire that included questions on sociodemographic data (gender, age, place of residence, and education, including education in medical or related sciences), sporting activity (type of sport, training experience, sports status, and frequency of participation in competitions), and the problem of doping in sport (participation in anti-doping controls, attitude towards doping, self-assessed knowledge of doping general statement on knowledge of the concept of unintentional doping).

Furthermore, the questionnaire comprised 19 items related to doping in sport. In formulating the questions designed to assess knowledge of doping, the authors drew on educational materials from the websites of anti-doping organisations, namely WADA and POLADA, as well as materials accessible on the AIS website. The questions addressed the following areas: the definition of unintentional doping; the consequences of its detection; the role of foods, dietary supplements, and medications in potential anti-doping violations; the AIS guidelines; the concept of an athlete's biological passport; and the framework for therapeutic exemptions, among other related aspects. A score of one point was awarded for each correct answer in the knowledge test, with a maximum possible score of 19. Positive results were defined as a number of correct answers that were greater than 50% (10 points). The results of the doping knowledge test were classified as follows:

– score of ≥ 17 points – very good;
– score of 14–16 points – Good;

– score of 10–13 points – Satisfactory;
– score of <10 points (less than 50% points) – Fail.

The questionnaire on knowledge of doping in sport was tested for readability and comprehension. In total, 52 subjects repeated the knowledge test an average of 50 days after the first administration. reliability of the test-retest was acceptable, with a Pearson correlation coefficient of 0.85. Internal consistency reliability was confirmed by a calculated α-Cronbacha value of 0.79.

3.3. Statistical analysis

Statistical analysis was performed using the Statistica 13.3 software (StatSoft Poland, Krakow, Poland).

Quantitative data were presented as median (Me) with lower and upper quartile values (Q1–Q3), while counts (n) with percentages (%) were used to describe qualitative data. The normality of the distribution was assessed by using the Shapiro-Wilk W test, histograms and curve parameters such as skewness and kurtosis. The significance level of $\alpha = 0.05$ was applied.

To assess the significance of differences between qualitative variables, the χ^2 test was conducted. The Wilcoxon signed-rank test (P_W) was used to determine the relationship between respondents' self-assessed knowledge and their actual knowledge of doping.

Logistic regression analysis was conducted by categorizing the results of the unintentional doping knowledge test into two groups. A score exceeding 50% of the maximum score achievable was set as the cut-off point. Scores equal to or greater than 10/19 points were considered positive, while scores below 10/19 points were considered negative. Significant factors for a negative score were identified through univariate logistic regression analyses, which were then used to construct the multivariate model. Variables with $P < 0.1$ in the LR test were included in the model. Variables with $P < 0.05$ on the Wald test (P_{Wd}) were determined to significantly increase the chance of a negative test result. The model fit was evaluated through the Hosmer–Lemeshow test ($P_{H\text{-}L}$) and the area under the ROC curve plot (AUC).

4. RESULTS

4.1. Characteristics of the study group

The average age of all study participants was 25.0 years (23.0–30.0). Women were on average 1 year younger than men: 25.0 (23.0–30.0) vs. 26.0 (23.0–30.0) respectively ($P_\chi<0.05$). There were 198 (51.6%) respondents living in cities with a population of 100,000–250,000, constituting the highest proportion of respondents, which was also evident in the group of women (46.6%) and men (55.8%) ($P_\chi>0.05$). Additionally, the largest group of athletes (n = 204; 53.1%) had a secondary education, with 50.6% of women (n = 90) and 55.3% of men (n = 114) ($P_\chi>0.05$). These findings suggest a consistent trend among the athletes, indicating a reliable pattern. The respondents had an average training seniority of 10.0 years (7.0–14.0). Men had a longer seniority of 12.0 years (Q1–Q3: 8.0–16.0) compared to women who had a seniority of 8.0 years (Q1–Q3: 6.0–12.0). The length of physical activity ranged from 1 to 34 years.

Among the surveyed athletes, it was found that the majority of them (n = 294, 76.6%) did not possess a degree in medical or health sciences. It is worth noting that the largest group of respondents (n = 112, 29.2%) were involved in athletics. The category with the lowest number of participants was mixed sports (n = 17; 4.4%). This category included individuals who reported practicing multiple sports, such as 'basketball and athletics,' 'running+gym,' and 'other' (n = 17; 4.4%). The 'other' category encompassed sports such as

Table 2. Characteristics of the study group in relation to sports data, by gender.

	Total n (%)	Gender		χ^2
		Female n (%)	Male n (%)	
Education in medical and health sciences				
Yes	90 (23.4)	43 (24.2)	47 (22.8)	$\chi^2 = 0.1$; $df = 1$ $P > 0.05$
No	294 (76.6)	135 (75.8)	159 (77.2)	
Sports discipline				
Athletics	112 (29.2)	66 (37.1)	46 (22.3)	
Combat sports	63 (16.4)	20 (11.2)	43 (20.9)	
Team sports	105 (27.3)	31 (17.4)	74 (35.9)	
Water sports	24 (6.3)	14 (7.9)	10 (4.9)	$\chi^2=32.9$; $df=7$ $P < 0.05$
Cycling sports	28 (7.3)	15 (8.4)	13 (6.3)	
Power sports	18 (4.7)	9 (5.1)	9 (4.4)	
Mixed sports	17 (4.4)	12 (6.7)	5 (2.4)	
Other	17 (4.4)	11 (6.2)	6 (2.9)	
Training seniority (years)				
1–6	82 (21.4)	60 (33.7)	22 (10.7)	
7–8	72 (18.8)	36 (20.2)	36 (17.5)	$\chi^2 = 43.5$; $df = 4$ $P < 0.05$
9–12	92 (24.0)	38 (21.3)	54 (26.2)	
13–15	70 (18.2)	30 (16.9)	40 (19.4)	
>15	68 (17.7)	14 (7.9)	54 (26.2)	
Sports status				
Amateur athlete, without a club	68 (17.7)	40 (22.5)	28 (13.6)	
Amateur athlete, in a club	150 (39.1)	71 (39.9)	79 (39.3)	$\chi^2 = 10.2$ $df = 3$ $P < 0.05$
Athlete of national class	146 (38.0)	55 (30.9)	91 (44.2)	
Athlete of international class	20 (5.2)	12 (6.7)	8 (3.9)	
Frequency of participation in sports competitions				
Once a year or less frequently	36 (9.4)	19 (10.7)	17 (8.3)	
Once every few months	108 (28.1)	51 (28.7)	57 (27.7)	$\chi^2 = 7.6$ $df = 3$ $P > 0.05$
Once a month	79 (20.6)	45 (25.3)	34 (16.5)	
Several times a month	161 (41.9)	63 (35.4)	98 (47.6)	

ski jumping, squash, tennis, ice skating, and roller skating. According to the data analysis, it can be concluded that the majority of respondents participated in sports recreationally and were members of a sports club (n = 150; 39.1%). This was followed by national class athletes (n = 146; 38.0%). The data on the frequency of athletes' participation in competitions revealed that the largest group participated several times a month (n = 161; 41.9%) (Table 2).

4.2. Self-assessment of the knowledge of respondents about unintentional doping

In this study, it was important to assess the participants' self-assessment of their knowledge regarding unintentional doping in sport. The majority of respondents (n = 186; 48.4%) rated their knowledge as good, while only a small number of participants (n = 12; 3.1%) rated their knowledge as insufficient. According to Table 3, it was found that factors such as gender, sport practiced, and training seniority did not have a significant impact on respondents' self-assessment of knowledge on unintentional doping.

However, it was observed that the proportions of each level of self-assessment of unintentional doping knowledge varied significantly based on education level, possession of a degree in medical or health sciences, and sports status (Table 3).

Table 3. Self-assessment of the knowledge of respondents about unintentional doping in sports

	Self-assessment of knowledge on unintentional doping in sports				
	Fail *n* (%)	Satisfactory *n* (%)	Good *n* (%)	Very good *n* (%)	χ^2
Total	12 (3.1)	170 (44.3)	186 (48.4)	16 (4.2)	
Gender					
Female	5 (2.8)	82 (46.1)	84 (47.2)	7 (3.9)	$\chi^2 = 0.50$ $df = 3$ $P = 0.9$
Male	7 (3.4)	88 (42.7)	102 (49.5)	9 (4.4)	
Educational level					
Primary education	2 (25.0)	3 (37.5)	3 (37.5)	0	
Professional education	0	18 (62.1)	11 (37.9)	0	$\chi^2 = 22.4$ $df = 9$ $P < 0.05$*
Secondary education	6 (2.9)	93 (45.6)	99 (48.5)	6 (2.9)	
Higer education	4 (2.8)	56 (39.2)	73 (51.0)	10 (7.0)	
Education in medical and health sciences					
Yes	1 (1.1)	27 (30.0)	52 (57.8)	10 (11.1)	$\chi^2 = 22.7$ $df = 3$ $P < 0.0001$
No	11 (3.7)	143 (48.6)	134 (45.6)	6 (2.0)	
Sports discipline					
Athletics	6 (5.4)	45 (40.2)	55 (49.1)	6 (5.4)	
Combat sports	1 (1.6)	33 (52.4)	27 (42.9)	2 (3.2)	
Team sports	1 (1.0)	51 (48.6)	50 (47.6)	3 (2.9)	
Water sports	0	11 (45.8)	12 (50.0)	1 (4.2)	$\chi^2 = 24.0$ $df = 21$ $P = 0.3$*
Cycling sports	3 (10.7)	13 (46.4)	12 (42.9)	0	
Power sports	0	5 (27.8)	11 (61.1)	2 (11.1)	
Mixed sports	0	5 (29.4)	10 (58.8)	2 (11.8)	
Other	1 (5.9)	7 (41.2)	9 (52.9)	0	
Training seniority (years)					
1–6	5 (6.1)	40 (48.8)	35 (42.7)	2 (2.4)	
7–8	4 (5.6)	33 (45.8)	33 (45.8)	2 (2.8)	$\chi^2 = 15.6$ $df = 12$ $P = 0.2$*
9–12	2 (2.2)	45 (48.9)	43 (46.7)	2 (2.2)	
13–15	1 (1.4)	26 (37.1)	38 (54.3)	5 (7.1)	
>15	0	26 (38.2)	37 (54.4)	5 (7.4)	
Sports status					
Amateur athlete, without a club	6 (8.8)	34 (50.0)	25 (36.8)	3 (4.4)	
Amateur athlete, in a club	4 (2.7)	71 (47.3)	72 (48.0)	3 (2.0)	$\chi^2 = 25.6$ $df = 9$ $P < 0.01$*
Athlete of national class	2 (1.4)	62 (42.5)	75 (51.4)	7 (4.8)	
Athlete of international class	0	3 (15.0)	14 (70.0)	3 (15.0)	

Comments: * the analysis did not include the value of 0.

4.3. Assessment of the knowledge of respondents about unintentional doping, based on survey results

According to the survey results, it was found that 45.3% of the respondents (n = 174) had a sufficient level of knowledge about unintentional doping. On the other hand, 38.8% of the respondents (n = 149) had an insufficient score, while 15.6% (n = 60) had a good score. It is worth noting that only 1 respondent (0.3%) had a very good score.

Furthermore, the study did not find any significant correlation between gender and the respondents' level of knowledge on unintentional doping. The study has identified notable variations in the levels of knowledge regarding unintentional doping among all other variables. Individuals with higher education, a degree in medical/health sciences, longer training experience (>12 years), and those practicing sports professionally were found to have the highest levels of knowledge on unintentional doping (Table 4).

The data suggests that there is a notable variance between the average level of respondents' self-assessment of knowledge (Me = 3.0; Q1–Q3 = 2.0–3.0) and the average level of knowledge determined by the survey results (Me = 2.0; Q1–Q3 = 1.0–2.0). It is worth noting that athletes rated their knowledge higher than the test results indicated (P_W < 0.0001), which may indicate a potential gap in understanding that could be addressed through further investigation.

Table 4. Assessment of the knowledge of respondents about unintentional doping in sports

	Assessment of knowledge on unintentional doping in sports				
	Fail *n* (%)	Satisfactory *n* (%)	Good *n* (%)	Very good *n* (%)	χ^2
Total	149 (38.8)	174 (45.3)	60 (15.6)	1 (0.3)	
Gender					
Female	70 (39.3)	82 (46.1)	25 (14.0)	1 (0.6)	$\chi^2 = 1.8$ $df = 3$ P =0.6*
Male	79 (38.3)	88 (42.7)	35 (17.0)	0	
Educational level					
Primary education	3 (37.5)	5 (62.5)	0	0	
Professional education	20 (69.0)	8 (27.6)	1 (3.4)	0	$\chi^2 = 31.3$ $df = 9$ $P < 0.05$*
Secondary education	91 (44.6)	86 (42.2)	27 (13.2)	0	
Higer education	35 (24.5)	75 (52.4)	32 (22.4)	1 (0.7)	
Education in medical and health sciences					
Yes	10 (11.1)	51 (56.7)	28 (31.1)	1 (1.1)	$\chi^2 = 47.9$ $df = 3$ $P < 0.0001$*
No	139 (47.3)	123 (41.8)	32 (10.9)	0	
Sports discipline					
Athletics	51 (45.5)	46 (41.1)	14 (12.5)	1 (0.9)	
Combat sports	22 (34.9)	28 (44.4)	13 (20.6)	0	
Team sports	36 (34.3)	53 (50.5)	16 (15.2)	0	
Water sports	6 (25.0)	12 (50.0)	6 (25.0)	0	$\chi^2 = 32.2$ $df = 21$ $P < 0.05$*
Cycling sports	19 (67.9)	6 (21.4)	3 (10.7)	0	
Power sports	5 (27.8)	7 (38.9)	6 (33.3)	0	
Mixed sports	3 (17.6)	12 (70.6)	2 (11.8)	0	
Other	7 (41.2)	10 (58.8)	0	0	
Training seniority (years)					
1–6	43 (52.4)	32 (39.0)	7 (8.5)	0	
7–8	30 (41.7)	32 (44.4)	10 (13.9)	0	$\chi^2 = 15.6$ $df = 12$ $P = 0.2$*
9–12	43 (46.7)	38 (41.3)	10 (10.9)	1 (1.1)	
13–15	19 (27.1)	38 (54.3)	13 (18.6)	0	
>15	14 (20.6)	34 (50.0)	20 (29.4)	0	
Sports status					
Amateur athlete, without a club	41 (60.3)	24 (35.3)	3 (4.4)	0	
Amateur athlete, in a club	69 (46.0)	65 (43.3)	16 (10.7)	0	$\chi^2 = 25.6$ $df = 9$ $P < 0.01$*
Athlete of national class	35 (24.0)	73 (50.0)	37 (25.3)	1 (0.7)	
Athlete of international class	4 (20.0)	12 (60.0)	4 (20.0)	0	

Comments: * the analysis did not include the value of 0.

Table 5. Determinants of the positive result obtained by respondents in the unintentional doping survey (multivariate logistic regression, progressive stepwise method).

Dependent variable-knowledge of unintentional doping	Determinant -predictor	OR** (95%CI)	P_{Wd}
Model fit: $P_{H\text{-}L}$ = 0.91; AUC = 0.718			
Positive test result for unintentional doping	Education in medical and health sciences (yes/no*)	6.45 (3.18–13.09)	<0.0001
	Sports status (national or international athlete / recreational athlete*)	2.98 (1.87–4.74)	<0.0001

Comments: P_{Wd} – Wald test; $P_{H\text{-}L}$ – Hosmer-Lemeshow test; AUC – area under curve ROC; *reference group (OR=1.0); ** OR standardised to the variables included in the model; CI – confidence interval.

4.4. Evaluation of the relationship between athletes' knowledge of unintentional doping and selected characteristics of the study group

The multivariate regression analysis suggests that education in medical or health sciences and athlete status have a significant impact on a positive test result for unintentional doping knowledge. Athletes with a degree in medical or health sciences had a 6.5 times higher odds of a positive test result compared to those without such education, and national or international class athletes had almost 3 times higher odds than recreational athletes (Table 5).

5. DISCUSSION

Doping in sport is a global problem that affects various sports disciplines worldwide. Sports organisations such as the International Olympic Committee (IOC) and the WADA are making efforts to monitor and combat this phenomenon. The most commonly used doping substances are reported to be anabolic steroids, growth hormones, erythropoietin (EPO) and various types of stimulants. It is estimated that many athletes of all ages and disciplines try to cheat the system. Doping is not limited to professional athletes. Increasingly, young athletes with aspirations for their future careers are under pressure to achieve good results at any cost. Therefore, educational programs aimed at young people are extremely important in preventing doping. In addition, eldery athletes striving to maintain physical fitness may also be tempted to use prohibited substances. According to WADA report on Anti-Doping Rule Violations (ADRVs), the sports disciplines with the largest number of ADRVs include: athletics, cycling and weightlifting. In 2020, the number of ADRVs was 672, of which 135 were reported in the Russian Federation, 59 in India and 57 in the USA, with the remaining countries having a lower number of such cases.[25]

Analysis of our own results showed that satisfactory levels of doping knowledge prevailed, including unintentional doping, while up to approximetely 40% of the respondents had an inadequate level of knowledge. The study conducted by Morente-Sanchez et al.[26] among 1324 Spanish football players also showed a very low level of doping knowledge, with the majority of footballers not knowing the List of Prohibited Substances (97.4%) and not being able to explain what the abbreviation WADA stands for (94.5%). The authors conclude that the basic lack of knowledge among footballers clearly reinforces the idea of implementing a comprehensive anti-doping education program. Similar conclusions were reached by Ozkan et al.,[27] who tested the level of knowledge about drug and doping use and nutritional supplements among 202 elite Turkish athletes. The results showed that Turkish athletes have a low level of knowledge about doping and therefore adequate education in this area is necessary. Doping controls are essential, of course, but well-designed educational programs, which do not require a significant financial resource, can bring far better results.

This study has also shown that the average self-assessment of athletes' knowledge of subconscious doping is relatively high and does not reflect their actual level of knowledge. This fact should alert athletes to the need for further education in this area, while anti-doping organizations should intensify their work to educate athletes and those who work with them (including doctors, nutritionists or physiotherapists). Similar conclusions were reached by Orr et al.,[28] who conducted a survey in 2009–2010 on knowledge of the WADA Prohibited List and sports performance-enhancing substances. A total of 1925 Australian athletes participated in the survey and the majority of them (75%) felt that they were moderately (50%) or well (25%) informed about doping, with more than half (53%) reporting that they had received previous education on this subject. The results obtained regarding knowledge about selected ergogenic substances showed, that the majority of athletes had a moderate level of knowledge of their positive effects (49% correct on average) and a low level of knowledge of their negative effects (29% correct on average).

An important aspect of the conducted study was to assess the factors influencing the higher probability of a positive test result for doping in sport. The analysis showed that the likelihood of a positive result was significantly higher for professional (national and/or international) athletes than for recreational athletes. Similar conclusions were reached by Chan et al.,[29] who observed a correlation between an athlete's higher sporting level and awareness and knowledge of subconscious doping. The authors of this study concluded that athletes with higher awareness were less likely to report

their intention to dope and were significantly more likely to pay attention to the composition of the food they consumed. In contrast, Murofushi et al.,[30,31] who investigated the knowledge of Japanese college athletes, found that the level of knowledge about doping increased with the athlete's sporting status. However, the authors pointed out that the knowledge of elite athletes (national and international) was still too low, considering their abilities and access to anti-doping educational materials.

The study found a correlation between knowledge about doping in sport and education in the field of medical and health sciences. Athletes with background education in one of the above-mentioned scientific areas were more likely to achieve a positive result in the doping knowledge test than those without such education. Voravuth et al.[32] conducted a study on unintentional doping knowledge among 384 pharmacists in Malaysia. The survey was conducted using a questionnaire and the results indicate that pharmacists, who have medical education, possess a moderate level of knowledge about doping. Furthermore, the authors noted a concerning lack of knowledge among the respondents regarding the potential consequences of doping. This is particularly worrying given that the surveyed professional group should be responsible for educating and advising athletes on prohibited substances.

Effective monitoring of food and dietary supplement production is critical to preventing athletes' unintentional use of banned substances. Key challenges include product contamination with pharmacological agents, inaccurate ingredient declarations, and regulatory inconsistencies across countries. Solutions include enforcing strict regulations, such as the EU Directive 2002/46/EC,[33] and adopting certification systems like Informed-Sport,[34] which ensure products are tested for prohibited substances. Manufacturers must enhance transparency through accurate labelling and rigorous supply chain oversight. Sports organisations, including the WADA, contribute by promoting education and offering verification tools like the Global DRO database.[35] Exemplary practices include NSF International's certification of supplements in the U.S.[36] and the Australian Institute of Sport's classification system.[15] Collaboration among regulators, manufacturers, and sports organisations is essential to ensure supplement safety, protect athlete health, and uphold clean sport principles.

Despite increasing accessibility to anti-doping education through global initiatives by the WADA and national efforts such as those by the POLADA, significant barriers persist in effectively disseminating knowledge. Research indicates that anti-doping education is often introduced too late, leaving young athletes unaware of doping risks early in their careers.[37] While tools such as the Anti-Doping Education and Learning platform (ADEL) are available, their use is limited due to insufficient promotion and difficulty accessing reliable information.[38] Informal sources, including peers, trainers, and social media, frequently supplant professional education, leading to incomplete or non-compliant information dissemination. The complexity of anti-doping regulations, such as the list of prohibited substances and therapeutic use exemptions (TUEs), further challenges athletes, who often struggle to understand and apply these rules. Additionally, the lack of tailored educational programmes limits their effectiveness across diverse athlete groups, including professionals, amateurs, and youth. Discrepancies in anti-doping regulations across sports organisations, the absence of translated materials in athletes' native languages, and time constraints from rigorous training and competition schedules further exacerbate the issue.[39,40]

However, it is important to note that this study has limitations. While specific inclusion criteria were not formulated due to the lack of similar studies in Poland, except for the physical activity of the respondents, it would be beneficial to further analyze the determinants of knowledge. This could be achieved by focusing on sports with the lowest level of knowledge about doping, such as cycling, athletics, or combat sports. To limit the large variation in the study group, it is also recommended to include the duration of physical activity as an inclusion criteria.

5. CONCLUSIONS

Based on the results, it can be concluded that:

(1) The average level of knowledge among respondents regarding doping in sports, with particular emphasis on unintentional doping, was relatively low. In fact, almost 40% of athletes obtained a negative result;
(2) There was a significant difference between the respondents' self-assessment of their knowledge and their actu-al level of knowledge;
(3) Education in medical and health sciences, as well as the athlete's higher sporting status, had a significant im-pact on the outcome of the doping knowledge test.

The results of the present study, while not identifying clear reasons for the knowledge gaps on doping, are nevertheless indicative of an inadequate level of education in this area. The convergence of the results obtained with scientific reports from other countries allows one to conclude with a high degree of probability that the development and implementation of appropriately tailored educational programmes will be of key importance in raising the level of awareness and reducing the problem of unconscious use of doping. Such programmes must be mandatory, as the voluntary nature of these activities significantly limits their effectiveness. Furthermore, it is essential to implement stricter supervision of the production of food and dietary supplements, particularly in terms of control and appropriate label-ling of products that could potentially be contaminated with banned substances. These measures are an integral part of the strategy against the unwitting use of doping, thus supporting the principles of clean sport.

Conflict of interest

None declared.

Funding
None declared.

Ethics
It was not necessary to obtain the approval of a bioethics committee as the study was a survey. This study is not considered a medical experiment and, therefore, does not require approval from a bioethics committee, according to Polish regulations.[41] The study adhered to all the standards of good research practice, including those set out in the Declaration of Helsinki. Participation was voluntary and anonymous. The authors did not use any data that could identify the participant.

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