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The Role of Healthcare Professionals in Preventing Unintentional Doping in Sport-Assessment of Anti-Doping Knowledge Among Pharmacists in Serbia

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Abstract

Background/Objectives: Pharmacists are well positioned to help prevent unintentional doping, but this role depends on adequate knowledge of anti-doping rules, prohibited substances, and reliable information resources. This study aimed to assess anti-doping knowledge, perceptions, self-perceived competence, and educational needs among pharmacists in Serbia, and to examine whether knowledge differed according to previous anti-doping education and selected demographic and professional characteristics. Methods: A cross-sectional online survey was conducted among 348 pharmacists practicing in Serbia. Anti-doping knowledge was assessed using 11 items, producing a total score from 0 to 11. Descriptive statistics, independent-sample t tests, one-way ANOVA with Bonferroni post hoc comparisons, and multiple linear regression were used. Results: The mean knowledge score was 7.07 ± 2.14 out of 11. Most respondents had received no anti-doping education during university studies (72.4%) or outside formal university education (95.7%). Although 89.4% believed pharmacists play a role in doping prevention, only 8.0% considered themselves adequately trained and 96.0% reported a need for further education. Recognition was lowest for insulin (16.4%) and diuretics (37.6%). Knowledge scores were significantly higher among pharmacists who had received anti-doping education during university studies ($p < 0.001$) and among those who regularly participated in sport or training ($p = 0.007$). Significant differences were also observed across age groups ($p < 0.001$), sex groups ($p = 0.036$) and years of professional experience ($p = 0.015$). Conclusions: Pharmacists in Serbia strongly support a role in doping prevention but have limited formal training and important knowledge gaps. Future anti-doping teaching in pharmacy programs and continuing professional development could cover how to use the Prohibited List, interpret restrictions for specific drug classes, and advise on TUEs, OTC medicines, and supplement-related risks.

Check for updates

Academic Editors: Ryoichi Fujiwara and Frank Yu

Received: 10 October 2026
Revised: 14 November 2026
Accepted: 19 November 2026
Published: 23 November 2026

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Keywords: anti-doping; pharmacists; Prohibited List; pharmacy education; unintentional doping

1. Introduction

The World Anti-Doping Code separates intentional from unintentional doping and identifies education as one of the tools for preventing anti-doping rule violations, especially unintentional ones [1]. The World Anti-Doping Agency (WADA) established a Taskforce on Unintentional Doping, a specific working group, to guide this work [2]. Athletes bear strict liability for any prohibited substance found in their samples, even when exposure is accidental [1]. The World Anti-Doping Code defines 11 anti-doping rule violations (ADRVs), with ADRVs 2.1–2.4 applying only to athletes, while ADRVs 2.5–2.11 apply to both athletes and Athlete Support Personnel [1]. Around 80% of all ADRVs in global sports relate to Article 2.1 (the presence of a prohibited substance or its metabolites or markers in an athlete's sample) [3]. Article 2 of the Code emphasizes that athletes are personally responsible for ensuring no prohibited substances enter their bodies and no banned methods are used, even when exposure is unintentional [1]. Reviews document both health risks associated with performance-enhancing substances [4], including myocardial infarction and cardiomyopathy associated with anabolic–androgenic steroid use [5], and persistent gaps in athletes' knowledge, including poor understanding of dietary supplements and of the substances they use [6].

Unintentional exposure may occur through contaminated or mislabeled dietary supplements and through the use of medicines containing prohibited substances [7,8]. Supplements are a documented risk: 6–9% of doping cases trace to undeclared substances [9], banned agents appear in 14–50% of tested products [10], adulteration frequently goes unlabeled [11,12], and 60–80% of athletes use supplements at all levels of sport [8,10]. Common medicines such as inhaled β2-agonists, systemic glucocorticoids, diuretics, insulin and pseudoephedrine-based cold remedies may be restricted under anti-doping rules, depending on the substance, dose, route of administration and timing [13,14]. Practice-based evidence indicates that anti-doping checks and use of accurate resources may be incomplete during pharmacy counselling [15]. Because sanctions can follow without intent, prevention rests on practical rule literacy among the health professionals who advise on these products [1,7]. Over the counter (OTC) medicines are widely used in self-care across Europe, making accurate medication advice particularly relevant in sport [16]. Accidental exposure to prohibited substances can also occur through contaminated food or contact with substances in the environment. The risk depends on the circumstances of exposure [17].

Pharmacists are among the most accessible medicine experts and routinely give first-line advice on prescription drugs, over-the-counter products, and supplements, which places them well to support clean sport [18,19]. A 2026 meta-analysis using indirect estimation methods reported past-year doping prevalence estimates of 14.1% in multi-sport competitive samples and 15.5% in single-sport recreational samples [20]. International guidance holds that this role needs both pharmacological competence and working familiarity with anti-doping rules and resources [21,22], and dedicated schemes such as Japan's certified sports pharmacist show that standard training may not cover it [22,23]. The International Pharmaceutical Federation (FIP), in its 2025 workforce report, identifies medication management, assessment of drug interactions and supplement counselling as areas in which pharmacists can contribute to athlete care [24]. Reviewing an athlete's treatment and recognizing when specialist advice is needed are practical applications of this role [21,24]. For athletes covered by the World Anti-Doping Code, pharmacists should check

whether medicines or supplements contain prohibited substances. They should also check for any restrictions and whether a therapeutic use exemption is required. For recreational athletes who are not covered by these rules, the focus is on the safe use of medicines and supplements, possible health risks and relevant legal requirements. Whether anti-doping rules apply depends on the athlete's status and the competition they take part in [1,25].

Pharmacists are easily accessible, but athletes do not always turn to them for advice. In a study among university athletes, 37.7% used pharmacists for anti-doping information, and 75.6% considered them a good source of information about prohibited substances [26]. Another study of 98 elite and developing athletes found that 63.3% sometimes asked pharmacists about medications. However, anti-doping agency websites were the most commonly used and trusted sources of information [27]. These findings suggest that pharmacists need adequate anti-doping knowledge, but athletes also need to recognise them as a source of reliable advice.

Research consistently finds a gap between pharmacists' willingness to help and their actual knowledge and confidence. An early French survey found interest in prevention but weak counselling skills [28], and later work across Europe, the Middle East, South Africa, and Australia reported limited familiarity with anti-doping bodies and the Prohibited List alongside clear demand for training [29–32]. Recent studies in Finland, Malaysia, Ethiopia, Canada, and Australia repeat the pattern: pharmacists endorse a preventive role yet report weak knowledge, especially for less familiar categories such as insulin and masking agents [15,33–36]; even sound clinical advice is often incomplete without targeted training [15], and academic reviews note the relevance of sports pharmacy to prevention [37]. A scoping review published in October 2026 likewise identified barriers involving training, confidence, access to reliable information and professional collaboration in pharmacist-led anti-doping services [38].

The Serbian Context

In Serbia, national legislation regulates doping prevention and sets penalties for certain doping-related offences [25]. The Anti-Doping Agency of Serbia (ADAS) carries out anti-doping activities and provides education for athletes and other people involved in sport [39]. Pharmacists can also contribute to doping prevention in their daily practice. Since medicines in Serbia are dispensed through pharmacies [40], pharmacists are in a position to advise athletes on medicines and supplements that may contain substances prohibited in sport [13].

Anti-doping is also covered in pharmacy education in Serbia. According to publicly available curricula, four university pharmacy programs offer elective courses dealing with sports pharmacy or dietary supplement safety [39,41–45]. However, it is not clear how many practising pharmacists have taken these courses or whether they have gained the knowledge needed to give appropriate anti-doping advice.

Research on pharmacists' anti-doping knowledge in Serbia is still limited. An earlier study of 173 pharmacists, published as a conference abstract, found low levels of anti-doping awareness and limited familiarity with the Prohibited List [46]. There is also little information on how well pharmacists recognise specific prohibited substances or whether their knowledge differs according to previous education, familiarity with anti-doping resources and professional experience.

Assessing factual knowledge together with previous education, resource awareness and self-perceived preparedness can help identify priorities for pharmacy teaching and continuing professional development in Serbia.

This study therefore aims to describe pharmacists' anti-doping knowledge, resource awareness, and views of their role; to identify knowledge gaps in drug classes common in practice; and to test whether knowledge varies with prior anti-doping education or training

and with demographic and professional characteristics. We hypothesized that pharmacists with prior anti-doping education or training would show higher knowledge.

2. Materials and Methods

Study design and participants. A cross-sectional survey was conducted to evaluate pharmacists' knowledge, attitudes, and perceptions regarding doping in sport. Eligible participants were qualified pharmacists currently active in professional practice in Serbia. Out of the 8707 members of the Pharmaceutical Chamber of Serbia, 10%—that is, 870 pharmacists—were randomly selected and invited to participate in the survey; 348 completed the questionnaire. The response rate was 40.0%. Respondents were selected at random from the Pharmaceutical Chamber of Serbia's database of all pharmacists, which contains their email addresses. They were contacted via email and, upon providing their consent, were asked to complete a survey.

Review of pharmacy curricula. We examined publicly available curricula and course descriptions from four university pharmacy programs in Serbia (Belgrade, Novi Sad, Niš, and Kragujevac) to identify courses covering anti-doping topics [41–45]. For each relevant course, we reviewed its content, whether it was elective, the semester in which it was offered, and the number of ECTS credits. The information was obtained from official university and faculty websites, which were accessed on 15 October 2026. We also used information from the Anti-Doping Agency of Serbia about its educational activities [39]. Since the review was limited to publicly available documents, we could not verify whether the courses were delivered as described, how many students attended them, or what knowledge and skills students acquired.

Questionnaire and data collection. Data were collected using a structured questionnaire developed for this study and administered online via the SurveyMonkey platform during the 2025 years. The questionnaire comprised three main sections: sociodemographic and professional characteristics; knowledge of doping in sport; and attitudes, self-perceived knowledge, and previous experience related to doping.

The questionnaire collected information on age, sex, education level, years of professional experience, place of employment, regular following of sporting events, and personal participation in sport or regular training. Participants were also asked about previous anti-doping education during university studies and outside formal university education, familiarity with the Prohibited List, awareness of institutions involved in combating doping in Serbia, previous consultations regarding doping, perceived professional role of pharmacists in doping prevention, adequacy of their current training, and the need for further education.

Assessment of anti-doping knowledge. Anti-doping knowledge was assessed using 11 knowledge items covering general anti-doping principles and practical issues relevant to pharmacy practice. These included knowledge of doping-control sample collection, sport- and competition-specific restrictions, unintentional doping, medicines prohibited in sport, the existence of a global Prohibited List, and the potential presence of prohibited substances in over-the-counter medicines, dietary supplements, and herbal preparations. Participants were also assessed on their recognition of selected pharmacological classes that may be prohibited in sport, including insulin, diuretics, glucocorticoids, and β2-agonists.

Knowledge score. A composite knowledge score was calculated by summing correct responses across the 11 knowledge-assessment items, with one point assigned for each correct response and zero points for incorrect or "not sure" responses. The total score therefore ranged from 0 to 11, with higher scores indicating greater anti-doping knowledge. Internal consistency of the knowledge scale was assessed using Cronbach's alpha. Each of the 11 items in the questionnaire was scored on an "all-or-nothing" basis. If a question

consisted of multiple sub-items to be scored, it was counted as a correct answer in the final total only if the respondent answered all sub-items correctly.

Participants additionally self-rated their knowledge across specific anti-doping domains, including doping substances, masking agents, prohibited methods, information resources, effects and health risks of doping substances, Therapeutic Use Exemptions (TUEs), restrictions on systemic corticosteroid use, pharmacology of doping substances, and risks associated with dietary supplements.

Statistical analysis. Statistical analysis was performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, New York, USA). Categorical variables were summarized as frequencies and percentages, while the total knowledge score was presented as mean ± standard deviation (SD). The internal consistency of the 11-item knowledge assessment was evaluated using Cronbach's alpha, including examination of Cronbach's alpha if individual items were deleted. The Kuder–Richardson Formula 20 (KR20) was also used to estimate the reliability of binary measurements, determining whether the items within the test yield the same binary (right/wrong) results across a population of test subjects. Independent-sample t tests or Welch tests where Levene's test is significant compared mean knowledge scores between two groups, including sex, education level, regular following of sporting events, participation in sport or regular training, previous anti-doping education during university studies, and previous anti-doping education outside formal university education. One-way ANOVA with post hoc comparisons (Bonferroni) examined multi-category variables, including age group and years of professional experience. A multiple regression model was used to predict the value of total score of knowledge with predictor variables. The value of Cohen's d and the effect-size correlation (rYl) were also determined when two groups or Partial Eta Squared of three or more groups were compared, in order to show the influence of effect size. The level of statistical significance was $p < 0.05$.

Ethics. Participation was voluntary and anonymous. Completion of the questionnaire was considered to indicate informed consent. The research was approved by the Ethics Committee of the Anti-Doping Agency of the Republic of Serbia (approval number 2026/3/1 dated 13 February 2026).

3. Results

3.1. Characteristics of the Questionnaire

A total of 348 respondents participated in the survey. The questionnaire consisted of three main sections. The first section collected information on the respondents' sociodemographic characteristics. The second section assessed their knowledge of doping, while the third section evaluated their attitudes toward doping and other characteristics related to their previous experience with doping.

The internal consistency of the section assessing pharmacists' knowledge of doping was moderate. Cronbach's alpha was 0.628 for the 11 knowledge-assessment items, while Cronbach's alpha if an item was deleted ranged from 0.570 to 0.696. Cronbach's α of 0.696 is obtained after removing item number 10, specifically the question "Potential sources of prohibited substances for athletes include". These findings indicate moderate internal consistency of the knowledge assessment. Because deletion of individual items did not consistently improve reliability, all 11 items were retained in the composite score. KR20 also was 0.628 for the 11 knowledge-assessment items.

3.2. Characteristics of the Sample

The majority of respondents were between 30 and 50 years of age, although both younger and older respondents were also represented in the sample (Table 1). More than 90% of the respondents were female, with the majority being graduate pharmacists or

pharmacists with a master's degree, while just under 25% were specialists. Regarding length of professional experience, the respondents were almost evenly distributed across the different categories, with both those who had less than 5 years of work experience and those with more than 20 years of experience being represented. Approximately 45% of the respondents reported that they regularly followed sporting events, while almost 40% were involved in sports or exercised regularly.

Table 1. Basic characteristics of the sample.

Characteristic	N (%)
Age group:	
20–29	63 (18.1%)
30–39	126 (36.2%)
40–49	102 (29.3%)
50–59	44 (12.6%)
60–65	8 (2.3%)
>65	5 (1.4%)
Sex:	
Male	33 (9.5%)
Female	315 (90.5%)
Education level:	
Graduate pharmacist/Master of Pharmacy	262 (75.3%)
Specialist pharmacist/Specialist Master of Pharmacy	86 (24.7%)
Years of professional experience:	
<5	78 (22.4%)
5–9.9	73 (21.0%)
10–14.9	70 (20.1%)
15–19.9	52 (14.9%)
>20	75 (21.6%)
Place of employment:	
Hospital pharmacy	18 (5.2%)
Community pharmacy	289 (83.0%)
Pharmaceutical company representative office	3 (0.9%)
Other	38 (10.9%)
Regularly watching sporting events:	
Yes	157 (45.1%)
No	191 (54.9%)
Athlete or regular participation in training:	
Yes	138 (39.7%)
No	210 (60.3%)

3.3. Pharmacists' Anti-Doping Education, Awareness, and Preparedness

The majority of respondents had not received education on doping during their formal education, while an even smaller proportion had received any education on doping outside the formal education system (Table 2). However, approximately 40% of respondents reported that they were aware of the institutions in Serbia responsible for addressing

doping-related issues. Around 22% of respondents stated that they had previously received inquiries from their clients regarding doping, while as many as 42% reported being familiar with the Prohibited List. Although 89% of respondents indicated that pharmacists have an important role in the prevention of doping in sport, only 8% reported having adequate training on this topic. Consequently, as many as 96% of respondents expressed a need for further education and professional development related to doping.

Table 2. Pharmacists' anti-doping education, awareness, and preparedness.

Item	Yes, n (%)	No, n (%)
Previous education on doping in sport during university studies:	96 (27.6%)	252 (72.4%)
Previous education on doping in sport outside formal university education:	15 (4.3%)	333 (95.7%)
Are you aware of any institution in Serbia involved in combating doping in sport:	142 (40.8%)	206 (59.2%)
Familiarity with the Prohibited List:	146 (42.0%)	202 (58.0%)
Previous consultations regarding doping:	79 (22.7%)	269 (77.3%)
A medication previously dispensed may have been used for doping in sport:	162 (46.6%)	186 (53.4%)
Pharmacists have a role in the prevention of doping in sport:	311 (89.4%)	37 (10.6%)
Adequate training to fulfil a role in the prevention of doping in sport:	28 (8.0%)	320 (92.0%)
Need for further education on doping in sport:	334 (96.0%)	14 (4.0%)

3.4. Questions Regarding Knowledge of Doping

The mean number of correct answers per respondent was 7.07 ± 2.14, out of a maximum of 11 correct answers. The mean percentage of correct answers per respondent was 64.24 ± 19.47%.

When analyzing the questions assessing knowledge (Table 3), more than 50% of respondents answered correctly to most questions, except for the final question, which concerned four medications that may be misused for doping purposes. The lowest percentage of correct answers was recorded for insulin, with only 16.4% of respondents answering correctly.

Table 3. Survey of knowledge about doping in sport.

Knowledge Item	Yes, n (%)	No, n (%)	Not Sure, n (%)
The sample collection procedure during doping control involves the collection of urine and blood samples:	307 (88.2%)	17 (4.9%)	24 (6.9%)
Some substances may be prohibited only in certain sports:	169 (48.6%)	66 (19.0%)	113 (32.5%)
Some substances may be prohibited only during competition:	178 (51.1%)	86 (24.7%)	84 (24.1%)
Some athletes may test positive for a prohibited substance unintentionally:	285 (81.9%)	18 (5.2%)	45 (12.9%)
Some medications may be prohibited in sport:	312 (89.7%)	8 (2.3%)	28 (8.0%)
There is a global list of prohibited substances in sport:	174 (50.0%)	70 (20.1%)	104 (29.9%)
OTC medications may contain substances prohibited in sport:	283 (81.3%)	9 (2.6%)	56 (16.1%)
Dietary supplements may contain substances prohibited in sport:	268 (77.0%)	8 (2.3%)	72 (20.7%)
Herbal preparations may contain substances prohibited in sport:	266 (76.4%)	8 (2.3%)	74 (21.3%)
Potential sources of prohibited substances for athletes include:		Selected, n (%)	
Teammates/friends	315 (90.5%)		
Doctors	256 (73.6%)		
Pharmacists	231 (66.4%)		
Sports scientists	241 (69.3%)		
Internet	325 (93.4%)		
Gym	328 (94.3%)		
Veterinarians	211 (60.6%)		

Table 3. *Cont.*

Knowledge Item	Yes, n (%)	No, n (%)	Not Sure, n (%)
The knowledge that the following medications are prohibited in sport:	Correctly identified, n (%)		
Insulin	57 (16.4%)		
Diuretics	131 (37.6%)		
Glucocorticoids	227 (65.2%)		
Beta-2 agonists	185 (53.2%)		

3.5. Self-Assessment of Knowledge About Doping in Sport

When examining the respondents' self-assessment of their knowledge about doping (Table 4), the majority of respondents considered their knowledge in this area to be poor. Only a small proportion of respondents, approximately 10–20% on average, rated their knowledge as good or very good when answering the questions presented.

Table 4. Survey on self-assessment of knowledge about doping in sport.

Knowledge Domain	Very Good, n (%)	Good, n (%)	Limited, n (%)	Poor, n (%)
Knowledge of doping substances:	8 (2.3%)	38 (10.9%)	185 (53.2%)	117 (33.6%)
Knowledge of masking agents:	4 (1.1%)	22 (6.3%)	115 (33.0%)	207 (59.5%)
Knowledge of prohibited methods in sport:	5 (1.4%)	12 (3.4%)	91 (26.1%)	240 (69.0%)
Knowledge of sources of information regarding guides for medications in sport:	4 (1.1%)	31 (8.9%)	121 (34.8%)	192 (55.2%)
Knowledge of the effects of doping substances on sports performance:	16 (4.6%)	66 (19.0%)	157 (45.1%)	109 (31.3%)
Knowledge of health risks associated with commonly used doping substances:	16 (4.6%)	81 (23.3%)	149 (42.8%)	102 (29.3%)
Knowledge of Therapeutic Use Exemptions (TUEs):	7 (2.0%)	39 (11.2%)	125 (35.9%)	177 (50.9%)
Knowledge of restrictions on prescribing systemic corticosteroids before and during competition:	5 (1.4%)	47 (13.5%)	133 (38.2%)	163 (46.8%)
Knowledge of the pharmacology of doping substances:	13 (3.7%)	70 (20.1%)	143 (41.1%)	122 (35.1%)
Knowledge of the risks associated with the use of dietary supplements in sport:	7 (2.0%)	65 (18.7%)	151 (43.4%)	125 (35.9%)

In total, 90.7% of respondents (87 out of 96 who had received education) aged between 20 and 40 stated that they had received education about doping as early as their primary schooling.

3.6. Analysis of Knowledge in Relation to Selected Characteristics

Analysis of the total score on the 11 knowledge-assessment questions (Table 5) showed significant differences across age groups, with the highest mean score observed in the youngest group (Partial Eta Squared = 0.066). Knowledge scores also differed significantly according to sex, with males having significantly higher score values (Cohen's d = 0.350; r_{Yl} = 0.172; mean difference with 95% confidence interval = 0.663 (0.046–1.281)). Knowledge scores also differed significantly according to years of professional experience (Partial Eta Squared = 0.035). Respondents who were athletes or exercised regularly had significantly higher total knowledge scores (Cohen's d = 0.292; r_{Yl} = 0.145; mean difference with 95% confidence interval = 0.611 (0.171–1.051)). Similarly, respondents who had received education on doping during their formal education achieved significantly higher scores

than those who had not received such education (Cohen's d = 0.527; r_{Yl} = 0.255; mean difference with 95% confidence interval = 1.060 (0.603–1.516)).

Table 5. Analysis of knowledge in relation to selected characteristics.

Age Group:		
20–29	7.97 ± 1.50	<0.001 *
30–39	7.25 ± 2.12	
40–49	6.49 ± 2.31	
50–59	6.68 ± 2.12	
Sex:		
Male	7.67 ± 1.61	0.036 # Levene's test $p = 0.020$
Female	7.00 ± 2.18	
Education Level:		
Graduate pharmacist/Master of Pharmacy	7.10 ± 2.17	0.656 # Levene's test $p = 0.172$
Specialist pharmacist/Specialist Master of Pharmacy	6.98 ± 2.05	
Years of professional experience:		
<5	7.54 ± 1.73	0.015 *
5–9.9	7.30 ± 2.15	
10–14.9	7.10 ± 2.28	
15–19.9	6.29 ± 2.34	
>20	6.85 ± 2.12	
Regularly watching sporting events:		
Yes	7.25 ± 2.00	0.150 # Levene's test $p = 0.090$
No	6.92 ± 2.25	
Athlete or regular training:		
Yes	7.43 ± 1.87	0.007 # Levene's test $p = 0.001$
No	6.82 ± 2.28	
Previous education on doping in sport during university studies:		
Yes	7.83 ± 1.83	<0.001 # Levene's test $p = 0.027$
No	6.77 ± 2.18	
Previous education on doping in sport outside formal university education:		
Yes	8.07 ± 1.83	0.064 # Levene's test $p = 0.380$
No	7.02 ± 2.15	

* ANOVA with the Bonferroni correction is a post hoc statistical adjustment used after an analysis of variance (ANOVA) to compare three or more groups; # Independent-sample test or Welch's test where Levene's test is significant.

A result was obtained using multiregression analysis (Table 6), so that significant predictors of the total score were age group (correlation total score with age, r = −0.221, $p < 0.001$), years of professional experience (correlation total score with years of professional experience, r = 0.151, $p = 0.002$) and previous education on doping in sport during university studies. The correlation between age group and years of professional experience was significant: r = 0.915; $p < 0.001$. Younger respondents, those with fewer years of professional experience, and those with prior education regarding doping achieved significantly higher scores; thus, these three variables can be identified as significant predictors influencing the quality of pharmacists' responses.

Table 6. Prediction of the total knowledge score using independent variables—multiple regression model.

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	8.311	0.878		9.467	<0.001
Age group	−0.990	0.288	−0.448	−3.439	0.001
Sex	−0.433	0.380	−0.059	−1.141	0.255
Education Level	0.114	0.277	0.023	0.412	0.681
Years of professional experience	−0.482	0.193	−0.328	2.498	0.013
Regularly watching sporting events	0.264	0.226	0.061	1.166	0.244
Athlete or regular training	0.300	0.234	0.069	1.282	0.201
Previous education on doping in sport during university studies	0.661	0.291	0.138	2.268	0.024
Previous education on doping in sport outside formal university education	0.588	0.562	0.056	1.046	0.296

F = 4.964; df = 8; $p < 0.001$; R = 0.324; R-square = 0.105; adjusted R square = 0.084.

4. Discussion

This study highlights that although Serbian pharmacists strongly support a preventive role in doping control, they lack the formal training and practical knowledge needed to fulfil this role consistently. Nearly three quarters of pharmacists reported that they had no anti-doping education during their undergraduate studies, and almost all pharmacists reported a lack of post-graduate training. However, most of the samples requested additional education. The mean knowledge score was 7.07 ± 2.14 out of 11, indicating overall performance but substantial room for improvement. Taken together, these findings point to a gap between pharmacists' willingness to contribute to doping prevention and the training currently available to support that role.

Females are highly predominant among the respondents in our study, accounting for 90.5%. Based on data from the Pharmaceutical Chamber of Serbia, females account for over 85% of its members; therefore, the sex distribution observed in our sample is expected, which suggests that the data of this study are representative of the population of pharmacists in Serbia.

We reviewed the published curricula from four universities in Serbia and found elective courses covering anti-doping topics at each of them. At the University of Belgrade, Faculty of Pharmacy, Sports Pharmacy is listed in semester VIII of the 2019 curriculum (3 ECTS) [42]. In May 2026, a representative of the Anti-Doping Agency of Serbia (ADAS) delivered a lecture on the basics of anti-doping, doping control procedures, and therapeutic use exemptions (TUEs) as part of this course [39]. At the University of Novi Sad, Faculty of Medicine, the 2021 curriculum lists Safety of Supplementation in Sport as an elective course (3 ECTS). Its content includes doping agents, supplement safety, and related health risks [41,43]. At the University of Niš, Faculty of Medicine, Sports Pharmacy is listed as an elective in semester IX (3 ECTS; 2025 curriculum) [44]. The 2025 course book from the University of Kragujevac, Faculty of Medical Sciences, also lists Sports Pharmacy as an elective carrying 4 ECTS, with enrolment in semester VIII specified as a prerequisite [45]. The Sports Pharmacy syllabi cover prohibited substances, TUEs, and pharmacists' responsibilities when advising athletes [44,45]. The Niš syllabus also covers OTC self-medication and practical communication with athletes [44]. Although these courses are included in the

published curricula, we could not determine how many students attended them or what knowledge and skills they gained.

The coexistence of these findings with dedicated elective teaching raises a question about how widely the available education reaches pharmacists and prepares them for practice. The published curricula document relevant content [41–45], while this survey describes respondents' reported education and preparedness. The findings should therefore not be read as evidence that anti-doping is absent from Serbian pharmacy education.

Our findings align with the limited prior evidence available in Serbia. Antić's survey of 173 Serbian pharmacists, reported as a conference abstract, similarly suggested low familiarity with the Prohibited List and incorrect classification of several commonly encountered substances [46]. Internationally, comparable gaps have been documented in Qatar, Australia, Finland, Malaysia, Ethiopia, and Canada, where pharmacists frequently report insufficient anti-doping knowledge and a strong interest in targeted education [30,32–36]. Practice-based assessment in Sydney further showed that even when pharmacists provide reasonable clinical advice, comprehensive anti-doping counselling and appropriate use of reliable resources may remain incomplete without specific training [15]. A recent Norwegian simulated-patient study provided complementary practice-based evidence: among 296 community pharmacists, 46.6% identified salbutamol as being on the Prohibited List, but only 23.3% provided comprehensive anti-doping guidance [47]. This distinction between recognition and complete counselling reinforces the need for education that extends beyond factual recall to practical application of anti-doping rules and resources.

Table 7 presents selected findings from these studies. The Ethiopian study conducted in Dessie included 28 pharmacists and 33 druggists, which should be considered when comparing its findings with those of studies involving pharmacists only [34]. In Malaysia, 8.1% of pharmacists correctly identified insulin as prohibited in sport. Recognition of diuretics varied across studies: 55.5% in Malaysia, 46% in Canada, and 84% in Australia [32,35,36]. Differences in questionnaires, sampling methods, assessment approaches, and participants' qualifications limit direct comparisons with our findings. The way medicines are supplied provides additional context for these comparisons. In Serbia, medicines are sold only in pharmacies, giving pharmacists an opportunity to advise athletes about anti-doping risks [40]. However, our study did not assess whether this affects pharmacists' knowledge or contributes to the differences observed between countries.

Awareness of key anti-doping resources and institutions was limited. In our sample, 58.0% of respondents reported being unfamiliar with the Prohibited List, and 59.2% reported being unaware of an institution in Serbia involved in combating doping. Only half correctly recognized that a global list of prohibited substances exists. These findings are relevant because effective counselling requires not only pharmacological knowledge but also the ability to locate and interpret authoritative anti-doping information. Similar deficiencies in resource awareness have been reported internationally [15,35].

Responses to individual knowledge items showed a contrast between general awareness of doping risk and knowledge of specific drug classes. Most respondents recognized that medicines (89.7%), OTC products (81.3%), dietary supplements (77.0%), and herbal preparations (76.4%) may involve prohibited substances or anti-doping risk. However, recognition of specific drug classes was substantially weaker: only 16.4% identified insulin and 37.6% identified diuretics, compared with 53.2% for β2-agonists and 65.2% for glucocorticoids. Thus, general awareness of medication-related doping risk did not always translate into correct identification of specific pharmacological categories.

The particularly low recognition of insulin and diuretics is clinically relevant. This may be related to the way these medicines are used in everyday practice. Pharmacists are familiar with insulin in diabetes treatment and diuretics in patients with hypertension or

fluid retention. They may know their therapeutic uses well but have less knowledge of how athletes might misuse them. Insulin may be misused for its anabolic and metabolic effects, particularly in strength and physique sports [48]. Diuretics may be used to reduce body weight rapidly or to mask other prohibited substances [13,49]. Familiarity with these medicines in clinical practice does not necessarily mean that pharmacists recognize them as prohibited in sport.

Table 7. Comparison of anti-doping knowledge and perceived preparedness among pharmacists in different countries.

Country	n	Selected Findings	Ref.
Serbia (present study)	348	Mean knowledge score: 7.07/11 (64.2%); insulin correctly identified: 16.4%; diuretics: 37.6%.	Present study
Qatar	300	Mean score for knowledge of the prohibited status of drugs: 53.2%.	[30]
Australia	135	Diuretics correctly classified: 84%; 29% reported sufficient knowledge to advise athletes.	[32]
Finland	246	Self-assessed knowledge of anti-doping counselling was generally poor or rather poor.	[33]
Ethiopia	61	Mean knowledge score: 4.95/13; insulin identified as prohibited: 19.7%; furosemide: 16.4%.	[34]
Malaysia	384	Median doping-related knowledge score: 52/100; insulin correctly identified: 8.1%; diuretics: 55.5%.	[35]
Canada	342	Diuretics correctly classified: 46%; 85% reported inadequate knowledge to treat and educate patients about performance-enhancing medications.	[36]

Previous education could also play a part in these knowledge gaps. Anti-doping teaching may give more attention to anabolic–androgenic steroids and stimulants than to medicines such as insulin and diuretics. This is only a possible explanation, as we did not examine the content of respondents' previous education or ask them to explain their answers. Interviews or focus groups with pharmacists could help clarify the reasons for these gaps and identify topics that need more attention in future teaching.

Similar gaps were reported among pharmacy professionals in Dessie, Ethiopia, where 19.7% identified insulin and 16.4% identified furosemide as prohibited in sport [34]. In a separate study in Addis Ababa, 36.1% correctly identified diuretics as prohibited substances [50]. Differences in questionnaires and participants' qualifications limit direct comparisons with our findings.

Recognition was higher for glucocorticoids and β2-agonists, but counselling for these medicines remains complex because anti-doping status can depend on route, dose, and timing in relation to competition [13]. For β2-agonists, evidence indicates that performance effects vary according to route and dose [51]. Therefore, simple recognition that a drug class may be restricted is insufficient; pharmacists need practical skills to interpret the Prohibited List in relation to the athlete's medication regimen and competition period.

Respondents also reported limited knowledge across several anti-doping domains. Across most domains, only a minority rated their knowledge as good or very good. The weakest areas were prohibited methods, for which 69.0% rated their knowledge as poor, masking agents (59.5% poor), and sources of information on medicines in sport (55.2% poor). Knowledge of TUEs was also limited, with 50.9% rating it as poor. At the sample level, both the self-ratings and the knowledge assessment indicated gaps; however, we did not examine whether respondents' self-assessments were associated with their individual knowledge scores.

Pharmacists who reported receiving anti-doping education at university had significantly higher knowledge scores than those who did not (7.83 ± 1.83 vs. 6.77 ± 2.18; $p < 0.001$), consistent with our primary hypothesis. However, sports pharmacy-related courses at the four Serbian public universities we reviewed are elective, so students already interested in sport or anti-doping may have been more likely to choose them. We relied on respondents' accounts of their previous education and did not check academic records or ask which courses they had attended. These findings may inform future teaching and its evaluation, but they do not show that university anti-doping education itself led to higher scores.

Respondents who reported anti-doping education outside formal university education also had a higher mean score, although the difference was not statistically significant (8.07 ± 1.83 vs. 7.02 ± 2.15; $p = 0.064$). Only 15 respondents (4.3%) reported such education, limiting the statistical power of this comparison. Future studies should include larger groups of pharmacists who have received this type of education.

Knowledge also differed according to sex, age and professional experience. Respondents aged 20–29 years had the highest mean score, and overall differences between age groups were significant ($p < 0.001$). Differences according to years of professional experience were also significant ($p = 0.015$), with the lowest mean score observed among those with 15–20 years of experience. Because the study was cross-sectional, the lower scores in some older and more experienced groups cannot be interpreted as a decline in knowledge with age or experience. Differences in when and how pharmacists were trained may partly explain this pattern. Also, significant differences were observed by sex. Male pharmacists achieved statistically significantly higher knowledge scores than female pharmacists ($p = 0.036$), although the effect size was relatively small (Cohen's d = 0.350). A study conducted in Dessie, Ethiopia, also reported higher anti-doping knowledge scores among male pharmacy professionals ($p = 0.020$) [34]. However, differences in the study populations and methods of knowledge assessment make direct comparisons difficult. Given that women made up 90.5% of our sample, this finding should be interpreted with caution and further examined in future research. No significant differences were observed by education level/specialist status ($p = 0.656$), or regular watching of sporting events ($p = 0.150$).

Respondents who were athletes or participated in regular training had significantly higher knowledge scores than those who did not (7.43 ± 1.87 vs. 6.82 ± 2.28; $p = 0.007$). Greater personal engagement with sport may be associated with greater exposure to information on medicines, supplements, and anti-doping; however, the cross-sectional design does not allow the direction of this association to be established.

In the knowledge question concerning potential sources of prohibited substances, gyms (94.3%), the internet (93.4%), and teammates or friends (90.5%) were among the most frequently selected response options. These percentages reflect respondents' identification of potential sources rather than the actual frequency with which athletes obtain prohibited substances from them. Therefore, these findings should not be interpreted as evidence of the prevalence of these sources in practice.

Almost half of respondents (46.6%) believed that a medicine they had previously dispensed may have been used for doping, while 22.7% reported previous consultations regarding doping. These findings indicate that doping-related issues already arise in everyday pharmacy practice and further highlight the need for pharmacists to be adequately trained to identify potential risks, provide reliable information, and refer athletes to relevant anti-doping resources.

The national service context also indicates demand for anti-doping advice: in 2025, the Anti-Doping Agency of Serbia (ADAS) reported 969 analyses of athlete samples and 688 expert opinions on medicines and supplements [52]. These figures describe agency activity and do not measure pharmacists' counselling performance.

4.1. Implications for Practice and Education

The results indicate a need for structured anti-doping education for pharmacists in Serbia that combines relevant pharmacology with practical application of anti-doping rules [21,22]. Training should enable pharmacists to identify whether a patient is subject to anti-doping rules, consult and interpret the current Prohibited List, recognize route-, dose-, and timing-dependent restrictions, and identify situations requiring referrals for TUE-related guidance [13,21]. Pharmacist-led reviews of medicines and supplements have also been used to identify potential anti-doping risks among competitive athletes [53].

Continuing professional development remains important because the Prohibited List is updated annually and practicing pharmacists require case-based opportunities to maintain current knowledge [13,22]. International models, including Japan's sports pharmacist training, illustrate how structured education can formalize competence and support consistency in practice [23].

Training should also address counselling about the risks associated with dietary supplements. Contamination, adulteration, and mislabelling of supplements are well documented [8,11,12], while more than three quarters of respondents recognized that dietary supplements and herbal products may contain prohibited substances. Education should build on this general awareness by teaching practical risk-reduction counselling, documentation of product details and batch information where possible, and use of credible verification resources.

Counselling should also explain what a product check can establish. ADAS opinions on supplements assess declared ingredients and do not exclude undeclared contaminants or remove the athlete's responsibility [54]. A favourable opinion on a label should therefore not be treated as a guarantee that the product contains no prohibited substances.

Sports-related cases could be incorporated into existing courses, an approach favoured by pharmacy students in a recent qualitative study [55]. Basic anti-doping competencies could form part of required teaching, with electives providing further depth. These findings may also inform pharmacy education in other countries, particularly training on checking the anti-doping status of medicines and supplements [21,22,38].

Short online modules and case-based workshops could be developed in cooperation with the Anti-Doping Agency of Serbia (ADAS) and pharmacy faculties to address these topics. Based on the recognition rates observed in our study, particular attention could be given to insulin, diuretics, β2-agonists, and glucocorticoids.

Workshops could give pharmacists an opportunity to practise advising athletes about medicines and supplements through role-playing exercises. Knowledge tests and simulated-patient assessments before and after training could help assess changes in their knowledge and counselling skills [15,47]. These workshops could be included in university teaching or accredited continuing professional development courses. Future prospective studies would be needed to determine whether any improvements last over time.

4.2. Limitations and Future Directions

Several limitations should be considered. First, the cross-sectional design identifies associations but cannot establish causality, including whether education or regular participation in sport directly improves anti-doping knowledge. Second, the sample was predominantly female (90.5%) and largely composed of community pharmacists (83.0%), which may limit generalizability to other pharmacy practice settings. The third limit is that the items for this instrument were developed based on practical questions encountered during many years of working with athletes at the Anti-Doping Agency of Serbia. The questions were also tested in a pilot study with a small number of participants, which yielded a similar Cronbach's α value, but the results were not published. The next limitation

is that during the analysis of factors that could influence the final outcome of the study, not all factors were measured—such as personal interest in sports, exposure to doping-related media, workplace policies, etc. Future studies should incorporate all these potential factors that may affect the final result. Another limitation of this study is the attributive appearance of the variables, which for age and years of professional experience is a significant limitation for a more precise analysis of these variables.

The questionnaire was intentionally brief, which limited the depth with which route-, dose-, timing-, and threshold-specific knowledge could be assessed. The 11-item knowledge scale showed moderate internal consistency (Cronbach's $\alpha = 0.628$), which should be interpreted in light of the heterogeneous domains covered by the items. Future studies should further validate the instrument and consider broader, scenario-based assessments aligned with the Prohibited List.

Interpretation of the educational findings is further limited by the scope of the curriculum review. It describes published plans and syllabi for the four pharmacy programs, rather than attendance, teaching delivery or retained competence. The survey did not record respondents' institution, curriculum version or completed electives, and current documents cannot reconstruct all graduation cohorts. Linking documented course exposure to assessed counselling would therefore be needed before attributing the results to particular courses or curricular deficiencies.

Finally, our study relied on self-reported information, which may have been affected by recall and social desirability biases, especially when participants reported their previous anti-doping education and how prepared they felt to advise athletes. Pharmacists' confidence in their own knowledge may also differ from their actual ability to recognize doping risks and provide appropriate advice. Although our questionnaire included 11 questions assessing anti-doping knowledge, these mainly tested whether pharmacists could recognize correct answers rather than how they would use this knowledge in everyday practice. For this reason, neither their reported preparedness nor their scores on the knowledge questions can tell us how well they would advise athletes in a real pharmacy setting. Future studies could use validated knowledge tests together with simulated patients to examine whether pharmacists can identify prohibited substances, find reliable anti-doping information, consider the athlete's individual circumstances and give appropriate advice [15]. A recent Norwegian study [47] used simulated patients and found that pharmacists who recognized a prohibited medicine did not always provide complete anti-doping counselling. This approach could also be useful in future research in Serbia.

5. Conclusions

Pharmacists in Serbia strongly endorse a role in doping prevention, but formal anti-doping education, resource awareness, and self-perceived preparedness remain limited. The mean knowledge score was 7.07 out of 11, with the lowest recognition rates for insulin and diuretics. Knowledge was significantly higher among pharmacists who had received anti-doping education during university studies and among those who regularly participated in sport, while significant differences were also observed across age, sex and professional-experience groups. These findings suggest priorities for future anti-doping education, including practical use of the Prohibited List, class-specific restrictions, TUEs, OTC medicines, and supplement-related risks. Online modules and case-based workshops could be considered within university teaching and continuing professional development, but their effects on knowledge and counselling competence require prospective evaluation.

Cooperation between pharmacists, pharmacy faculties, and the Anti-Doping Agency of Serbia could support the development and evaluation of these educational approaches.

Author Contributions: Conceptualization, N.R. (Nemanja Rancic), Z.V., S.M. and M.V.V.; methodology, M.J., N.R. (Nemanja Rancic), Z.V., S.M. and M.V.V.; software, F.P., M.T., G.M., J.R.O., D.J., N.R. (Nenad Radivojevic)., D.R. and A.J.; validation, M.J., N.R. (Nemanja Rancic), Z.V., S.M. and M.V.V.; formal analysis, M.J., N.R. (Nemanja Rancic), Z.V., M.T., S.M. and M.V.V.; investigation, all authors; resources, M.V.V.; data curation, M.J., F.P., M.T., G.M., J.R.O., D.J., N.R. (Nenad Radivojevic), D.R. and A.J.; writing—original draft preparation, N.R. (Nemanja Rancic), M.T., Z.V., S.M. and M.V.V.; writing—review and editing, N.R. (Nemanja Rancic), Z.V., S.M. and M.V.V.; visualization, M.T.; supervision, N.R. (Nemanja Rancic), Z.V. and M.V.V.; project administration, M.V.V.; funding acquisition, Z.V. and M.V.V. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Ministry of Defense of the Republic of Serbia, grant number MFVMA-MN-P/27-29/12, and the Anti-Doping Agency of the Republic of Serbia.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Anti-Doping Agency of the Republic of Serbia (approval number 2026/3/1 dated 13 February 2026).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author due to the sensitivity of the data.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

ADAS	Anti-Doping Agency of Serbia
ADRV	Anti-Doping Rule Violation
ANOVA	Analysis of Variance
CME	Continuing Medical Education
CPD	Continuing Professional Development
ECTS	European Credit Transfer and Accumulation System
FIP	International Pharmaceutical Federation
OTC	Over the Counter
SD	Standard Deviation
TUE	Therapeutic Use Exemption
WADA	World Anti-Doping Agency

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