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Article

Use of doping substances in sport. Information and availability on the Internet

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Abstract: Dietary supplements are commonly used among athletes. The Australian Institute of Sport (AIS) groups supplements into 4 categories, being group D considered by the World Anti-Doping Agency (WADA) as prohibited supplements. The online availability of four doping substances: oxandrolone, dehydroepiandrosterone (DHEA), androstenedione and *Tribulus terrestris*, purchased from Spain, Puerto Rico, Canada, USA, Ukraine and Russia was evaluated. The characteristics of the websites, the countries the webs sold to, the pharmaceutical forms offered and the recommendations for its use were analyzed by using a computer tool designed *ad hoc*. There were significant differences between countries in the number of webpages that sold the products (Chi-square test, $p<0.05$). Oxandrolone was available for purchase mainly in Spain (27.12%) and Ukraine (26.58%), coming from websites dedicated to sports (77.26%). For DHEA, most of the pages were located in Canada (23.34%) and Russia (21.44%). *Tribulus terrestris* was the compound with the highest number of web pages. In the case of androstenedione, none of the pages for its sale requested prescription. Products such as androstenedione or DHEA are claimed to enhance sports performance or for sports use without providing details. The results showed that a limited number of Internet sites request prescriptions. Most of the doping substances are purchased from the country where they are requested. Athletes should be encouraged to consult health professionals about which supplements are suitable for their type of training and sports objectives.

Keywords: doping substances; athletes; Internet availability; oxandrolone; dehydroepiandrosterone (DHEA); androstenedione; *Tribulus terrestris*

1. Introduction

The use of supplements among athletes has increased in recent years [1–3]. Their use makes it possible to cover deficiencies derived from ingestion, but also to improve body composition, performance and recovery processes [4–6]. The latter are essential in athletes due to the increased physical demands [7].

On the other hand, the World Anti-Doping Agency (WADA) defines doping as: "the commission of one or more anti-doping rule violations as provided for in sections 1 to 11 of Article 2 of the Code" [8]. These sections mention the concept of prohibited substances, metabolites or markers that may be present in the athlete's sample. These substances are included in the Prohibited List of the World Anti-Doping Code. The requirements to be incorporated into this category are three: 1. it has the potential to optimize performance; 2. it has an actual or potential risk to the athlete's health; 3. it violates the competitive spirit as expressed in the Code [9].

On the other hand, the Australian Institute of Sport (AIS) [10] has implemented a classification of supplements into 4 groups. The categories refer to the characteristics of the supplements, but also to the degree of scientific evidence and

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the safety or risk in their consumption. Group A represents supplements that have demonstrable scientific evidence in specific situations following protocols for intake [9]. While group D describes supplements that are banned for consumption or possess a risk of contamination with other substances that would determine a positive doping test [9].

This group D includes, among others, oxandrolone, dehydroepiandrosterone (DHEA), androstenedione and Tribulus terrestris, substances that are detected in anti-doping controls and used by athletes to increase their performance at the risk of their health [4], hence the interest in studying them. These substances belong to category D according to AIS, particularly to the subgroup called prohormones and hormone boosters [10] and in the sports field are considered by WADA as doping substances [9], (although *Tribulus terrestris* does not appear on the WADA list and is therefore not specifically banned, it is, however, often found in multi-ingredient products that contain banned ingredients or have a high risk of being contaminated). The first substance is an anabolic steroid, oxandrolone, first synthesized in 1962 [11]. This supplement has an anabolic to androgenic ratio of 10:1 [11]. Its use is approved for the preservation of lean tissue in catabolic conditions, such as sarcopenia [12].

Androstenedione is a steroid hormone intermediate in the production of estrogen and testosterone. Due to its relevance in the intrinsic synthetic pathways of androgens, it is used among athletes to achieve a change in body composition, whether it is a decrease in

fat mass or an increase in muscle mass [13]. On the other hand, the favorable anabolic effects of androstenedione are inconclusive [14,15], but the adverse effects such as reduced sperm count, impotence, and gynecomastia are conclusive [16].

As mentioned above, these substances have been effective for the treatment of chronic diseases such as sarcopenia [11,17], hepatic cancer but in the sports field they have not presented conclusive or effective results. [13,14].

In view of this, the aim of this study is to estimate the availability and accessible information on the Internet about the sale of doping substances, specifically about oxandrolone, dehydroepiandrosterone (DHEA), androstenedione and *Tribulus terrestris*, as well as to assess the athlete's ability to understand the labeling of each of the substances they contain. Secondarily we will estimate if the sale occurs in certain countries, which would mean that there is greater tolerance to its sale depending on the State and its regulations are in line with international laws and the WADA Regulations.

It is known to the authors that there is no research on doping substances and their acquisition through Internet sites. In previous research, the analysis of doping substances is focused on the motivations for their consumption [18,19] and/or on the advice given by trainers [20] or pharmacists [21,22]. Our hypothesis is that athletes can acquire doping substances in certain countries without a (medical) prescription, and from sites that do not always come from laboratories.

2. Material and methods

The study was carried out by a multidisciplinary working group that included pharmacology experts (pharmacology professors from the University of Leon, Spain: M.S., J.J.G., M.J.D., A.M.S., R.D., C.L., R.P. and M.N.F.), two expert in sports medicine (physiotherapy professors from the University of Leon and the University of Basque Country, Spain: J.S-C. and S.A.) and a member with expertise in cybersecurity (School of Industrial, Informatics and Aerospatiale Engineering: J.F.G.). J.F.G. developed the search software and programmed the searches. Pharmacology experts reviewed and evaluated by pairs the data obtained. Any potential disagreement was resolved by all members. The searches and the data evaluation took 15 days.

2.1. Design

Cross-sectional study, being an observation at a point in time of the online availability of the four compounds that can be used as doping substances selected in this study: oxandrolone, dehydroepiandrosterone (DHEA), androstendione and *Tribulus terrestris*, and bought from the following countries: Spain, Puerto Rico, Canada, USA, Ucraine and Russia. The selection of these countries corresponds to the monitoring carried out by WADA in October 2022 [23] in some agencies in the countries of Russia, Ukraine, Puerto Rico, two countries that host the Review and Compliance Committee (CRC) and the International Federation of Bodybuilding and Fitness (IFBB) in Canada and Spain respectively and the United States of America, due to the number of athlete [24,25] and by the annual revenue from the sale of sports supplements with more than 1.4 billion annual revenues [16]. It was decided to analyze these supplements because they are the frequent consumption options chosen by athletes, and whose intake is often associated with improvements in sports performance, either by increasing muscle mass [26], their effects on sex hormones [27] or for their

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participation in inflammatory processes and antioxidant action [28]. For this purpose, using the computer tool designed, it was simulated to be a purchaser of these products from each of the countries. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement was used to report data [29] and the checklist included in the supplementary material (see Appendix A).

2.2. Data obtained from the website pages analyzed

The following characteristics of the websites found were assessed: number of pages that did not connect, number of pages that sold that compound, number of pages that sold any other of the compounds evaluated and which of them; type of page, that is, if it was a specific sports page, if it was a supermarket, a pharmacy or a parapharmacy, if it was dedicated to the sale of nutritional supplements, a laboratory, pages that sold any type of product, or any other type of page. In addition, it was checked whether they sold only within their own country, whether they sold to the whole world or to several countries. For each of the four compounds studied, we also evaluated: the pharmaceutical forms offered, e.g., whether they were for oral, parenteral or other routes of administration; what the product was recommended for; and whether any type of prescription was required for purchase.

2.3. Search engine

To gather all the information, we needed from the Internet we used our experience in previous related research, adapting our software and masking our global location using VPN.

We gathered seeds using a modified version of our crawler and IMN Search Engine Extractor v32, adapted from our previous research. We found two major inconvenience to overcome: mandatory continuous scrolling SERP's configuration and (also mandatory) omitted related results.

On the one hand, we found problems when working with Google regions in which continuous scroll search (a new feature from Google active since December 2022) was available (United States). Results in those areas are loaded in batches, ten by ten, while the user scrolls down; when reaching one hundred results, the whole search results page reloads, and the user must start scrolling again (the same results) although this time more results are offered (typically, around two hundred max). Even if the search engine can be set up so continuous scroll is deactivated, it doesn't work, and the option to set "maximum results per page" is overridden by this setup (as stated by Google itself). All this makes search extremely costly to automate (we don't get all results in one click, we have to scroll for them to load), and we had to rely on Selenium to do so, simulating the user scrolling down to the bottom of the SERP until no more results were loaded.

On the other hand, SERP showing (initially omitted) related results is no longer an option, but an automatic action once last page of results (or last batch of results - for continuous scrolling regions - and yes, this problem goes on top of the previously detailed one for that region) is loaded in the browser. In our experience, loading related results is almost never useful (Afterall, Google itself had omitted them for a reason): most (if not all) of them are duplicated, or pertain to the same domain of other results, and are thus irrelevant. Showing related results artificially boosts results offered by the engine from (usually) two to up to five times the number of original results, so a little bellow one hundred quickly becomes several hundred; however, as expected, these results were highly undesired, and we didn't find a fix for this behavior (since it is on Google's side and now it's a compulsory functionality of the search engine), so we had to make additional scripts and software changes to wait for them to load and then purge the results, limiting seeds to one by domain.

As for the VPN to use, we checked several alternatives: ExpressVPN, NordVPN, Surfshark (all of them requiring payment, although ExpressVPN has a free trial period), Tunnel Bear, Urban VPN, or Windscribe (offering a free subscription), just to name a few. Tunnel Bear is a decent and free VPN popular within the Internet community, especially in Reddit forums. It offers servers in 49 countries and comes with 500 MB/mo bandwidth. It provides a wide server network, military-grade encryption, and a zero-log policy, making a decent free VPN. Windscribe is another interesting alternative, offering higher bandwidth (10 GB/month) but fewer world servers (10 countries). ExpressVPN and NordVPN are more robust, limit-free, and reliable (major drawback with free options is that they either sell your data or bloat you with adds - or both) options, as long as you pay for the subscription.

We had to discard free options since neither of them included all the servers we were interested in in their free subscription, but Windscribe does for their Pro (paid) version. Among the payed options we checked, NordVPN offered all the countries we were looking for, and Urban VPN (free) offered all but one (Puerto Rico), so we went for the latter. To get Puerto Rico's data, we used Google's region option, which is less representative of the real scenario: Google's

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offering country-specific results to someone really being at the country since he/she is using a local ISP versus Google offering country-specific because you ask it for; in the first case, is on their own interest to do so (so they will probably do it to the best they can), while on the other hand it's just a user's request. Even if that's the case, we found results obtained to be reliable and useful for our research in this scenario.

2.4. Statistical analysis

All information was collected in a Microsoft Excel 2016 and statistical analysis was carried out using SPSS version 24. The results obtained were expressed as frequencies and percentages. The chi-square test was performed to compare the number of websites found after carrying out the searches of the four products evaluated in the different countries considering their characteristics and the countries they shipped to. $P \leq 0.05$ was taken as the level of significance.

3. Results

Tables 1 to 4 include the analysis of the websites found in which oxandrolone, DHEA, androstendione and *Tribulus terrestris*, respectively, may be acquired from the different countries. After the search, the software designed for the study located a total of 3745 websites possibly selling the compounds selected for the study, with similar values for each of the 4 products. Subsequently, the pages were reviewed and those that either did not connect or did not sell the product were eliminated (most of them were pages with information about the product or pages of laboratories that made analytical determinations of the compound). Finally, there were a total of 1702 pages that did sell some of the compounds, the most numerous being those offering *Tribulus terrestris* (725 sites).

A total of 860 websites were found for oxandrolone (Table 1). The countries from which the most possible pages to buy the product appeared were Puerto Rico (24.07%) and Spain (22.09%). However, once the websites that did not connect or did not sell this compound (57.56% of the pages) were eliminated, the countries from which the highest number of pages available for purchase were Spain and Ukraine (27.12% and 26.85% of the websites selling oxandrolone, respectively). Statistical analysis revealed significant differences between countries (Chi-square test, $p<0.05$) and that there were the following subsets of homogeneous proportions: Puerto Rico and Canada; Spain and Russia; Puerto Rico and USA; USA and Russia. In 6.05% of them it was also possible to purchase any of the other compounds evaluated, the most frequent being *Tribulus terrestris*. As for the type of site where oxandrolone could be purchased, the majority (77.26%) were sites dedicated to sports, whether they were sports stores themselves or sites dedicated solely to nutrition or sports pharmacology. This percentage was highest when searching from Ukraine (92.86%) and lowest from Canada (40.00%). Most of the sites sent the order only to their own country (60.82%). For sites located from Russia and Ukraine this percentage was much higher (80.00% and 95.92%, respectively) and the lowest value corresponded to sites found from the USA (10.26%). Most sites from the USA served the whole world (84.62% of the sites). Only 3 sites in Canada and 5 in the USA asked for a prescription to be able to buy it. Practically all the products offered were for oral administration; in the pages found from Puerto Rico and Ukraine, you could get 1 presentation for parenteral administration and in Canada, USA and Ukraine, in the form of a powdered chemical product. As for what oxandrolone was recommended for in the web pages, the majority (86.85%) indicated its use for sports, stating that it increased muscle mass, strength, endurance and performance in sports.

Table 1. Analysis of websites found in which oxandrolone may be acquired from the different countries.

		Spain	Puerto Rico	Canada	USA	Russia	Ucraine
Characteristics of the web pages reviewed	**Number of web pages reviewed**	190	207	102	115	115	131
	Do not connect*	25[b]	62[a]	45[a]	26[b]	52[a]	9[b]
	Do not sell the product	66	86	37	50	13	24
	Sell the product*	99[b]	59 [a, c]	20[a]	39 [c, d]	50 [b, d]	98
	Also sell other product: *	16	18	3	9	2	4
	• **DHEA**	10	10		6	1	2
	• **Androst endione**	1		3	3		0
	• **Tribulus**	10	16	3	5	1	3

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Type of web pages selling the product	**Sports**	60	51	8	28	44	91
	Supermarket						
	Pharmacy	2	3	6	2	3	3
	Parapharmacy	8					
	Dietary supplements	19	1		2		
	Laboratory	5	3	5	2	1	2
	Store	5	1	1	5	2	2
Shipping countries	**Only the own country**	48	24	12	4	40	94
	Worldwide	42	21	6	33	3	3
	Several countries	9	14	2	3	7	1
Prescription required				3	5		
Route of administration	**Oral**	99	59	18	36	50	97
	Parenteral		1				2
	Other			2	3		1
Recommended use of the product**	**1**	92	48	12	35	49	81
	2	2	22	4	18	5	21
	3		8	2	16	2	8
	4	5	7	3	4	2	2
	5		3	3	1	3	4
	6			2	3		
	No description	6	9				15

* Significant differences (Chi-square test, $p<0.05$). Each letter of the superscript denotes a subset whose proportions do not differ significantly from each other ($p<0.05$).

**1.- Sport: increase in muscle mass; increased strength, endurance and performance; 2.- Burns fat (to lose body fat); 3.- Hormonal activity: increased growth hormone; 4.- Increased appetite, weight gain in some pathologies; 5.- Relief of bone pain, improves well-being; 6.- Research.

As mentioned above, Table 2 summarizes the data obtained for DHEA, for which a total of 935 pages were found. Most of them were located by simulating the search from Canada (28.13%) and from Russia (18.40%). After reviewing these websites, we found that 59.36% of them did sell the compound and the countries from which the largest number of pages were available for purchase were also Canada and Russia (22.34% and 21.44% of the websites, respectively). In this case, there were also significant differences between countries (chi-squared test, $p<0.05$), with the subsets of homogeneous proportions being: Spain, Puerto Rico and Canada; Spain, Puerto Rico and Ukraine; Puerto Rico and Ukraine; USA and Russia. Some 37.75% of the websites also offered one of the other compounds evaluated, the most frequent being, as in the previous case, *Tribulus terrestris*. Of the total number of websites offering DHEA, 29.73% were dedicated to the sale of dietetic products and 23.96% to sports. However, if each country was evaluated independently, there were differences between them. In Spain, Puerto Rico and the USA, those dedicated to dietetic products predominated (51.22%, 38.00% and 70.00%), while in Russia and the Ukraine the majority of sites were dedicated to sports (54.72% and 55.71%, respectively) and in Canada they were mainly laboratories (35.48%). There were specific cases of other types of sites, such as aesthetic clinics or veterinary clinics. As for where the orders were sent, most of the sites only sent them to their own country (68.83%), with the highest percentages, once again, corresponding to sites located in Russia (98.32%) and Ukraine (98.57%). Only 2 sites from Canada and 5 from the USA required a prescription to purchase it. Practically all the websites located that offered DHEA were for oral administration, only 3 pages (1 from Puerto Rico, 1 from USA and 1 from Ukraine) had products for parenteral administration and a small percentage (4.24%) sold formulations for topical administration. The indications for this compound, as reported by the different web pages, were very varied, highlighting that it was useful for sports (45.95% of the web pages), for the improvement of disorders related to sexual hormones (32.61%) and as an anti-aging product (27.21%). In the different countries evaluated, these indications were similar.

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Table 2. Analysis of websites found in which DHEA may be acquired from the different countries.

		Spain	Puerto Rico	Canada	USA	Russia	Ucraine
Characteristics of the web pages reviewed	Number of web pages reviewed	151	86	263	147	172	116
	Do not connect*	14[b]	7[b]	37[a]	8[b]	38[a]	26[a]
	Do not sell the product	55	28	92	29	15	20
	Sell the product*	82 [a, b]	50 [a, b, c]	124[a]	110 [d]	119 [c, d]	70 [b, c]
	Also sell other product: *	61 [b, c]	37 [b, c]	79[a]	73[b]	58 [a, c]	45 [a, b, c]
	• DHEA	4	7	11	5	3	2
	• Androstendione				1	1	
	• Tribulus	61	37	79	73	58	45
Type of web pages selling the product	Sports	5	8	12	4	65	39
	Supermarket	1	2	5		5	
	Pharmacy	3	2	13	4	2	3
	Parapharmacy	3	6	5		38	
	Dietetic products	42	19	8	77		19
	Laboratory			44	3		
	Store	28	12	17	20	9	9
	Other		1	20	2		
Shipping countries	Only the own country	58	26	51	61	117	69
	Worldwide	18	10	46	40	2	1
	Several countries	6	14	27	9		
Prescription required				2	5		
Route of administration	Oral	82	49	124	106	119	70
	Parenteral		1		1		1
	Other			1	4		2
Recommended use of the product**	1	35	36	34	26	65	59
	2	20	24	26	24	39	48
	3	8	9	8	2	19	12
	4	34	14	44	41	15	3
	5	10	9	4	12	1	3
	6	16	16	6	4	1	3
	No description		5		2		10

* Significant differences (Chi-square test, $p<0.05$). Each letter of the superscript denotes a subset whose proportions do not differ significantly from each other ($p<0.05$).

**1.- Sport: increased physical capacity, accelerated growth of muscle mass; 2.- Sex hormones: increased sexual function, impotence, fertility treatment in women, maintaining hormonal balance; 3.- Regulation of the immune system, reduction of inflammation; 4.- Anti-aging, improvement of memory, mood and sleep; 5.- Improvement of health: cardiovascular, bone, nervous system; 6.- Promotes metabolism, weight loss.

In the case of androstenedione (Table 3), 926 pages were found, most of them from Puerto Rico (24.30%) and Spain (23.76%), but only 57 of them offered this product for sale. In this case, the vast majority of the websites found by the software were dedicated to carrying out analyses to determine this compound in biological samples. The countries from which there were more possibilities to acquire this product were the USA and Canada (36.84% and 22.81% of the websites selling androstenedione, respectively). After statistical analysis, it was found that there were significant differences

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between countries (chi-square test, p<0.05), with the subsets of homogeneous proportions being: Canada and USA; Canada, Russia and Ukraine; Spain and Puerto Rico. Some 4.64% of them also offered one of the other products. This compound was mostly sold by pages belonging to laboratories (33.33%). In Puerto Rico and Russia, it was mainly offered on pharmacy websites (66.67% and 40.00% of the sites, respectively). For this compound, the websites that sold it mostly shipped it worldwide (66.67%), except for those located in Russia and Ukraine, which only shipped it within their country (80% and 100%, respectively). None of the websites selling androstenedione required a prescription to purchase it. Most of the products offered (57.90% of the websites) were the chemical compound itself in powder form (mainly Canadian and USA websites), and in the rest of the websites, it was available for oral administration. None of the sites offered parenteral formulations. The chemical was intended for research purposes, and the rest of the products offered were recommended to increase muscle mass and strength (29.82% of the sites) or to increase testosterone levels (26.32%).

Table 3. Analysis of websites found in which androstendione may be acquired from the different countries.

		Spain	Puerto Rico	Canada	USA	Russia	Ucraine
Characteristics of the web pages reviewed	**Number of web pages reviewed**	220	225	134	119	126	102
	Do not connect*	25[b]	25[b]	12 [a, b]	5 [a]	17 [b]	11 [a, b]
	Do not sell the product	192	197	109	93	99	84
	Sell the product*	3[c]	3[c]	13 [a, b]	21[a]	10[b]	7[b]
	Also sell other product:	3	2	10	18	6	4
	• **Oxandrolone**	1		10	17		2
	• **DHEA**	1			16	6	5
	• **Tribulus**	3	2	8	12	4	3
Type of web pages selling the product	**Sports**	1		1	3	2	2
	Supermarket						
	Pharmacy	1	2			4	2
	Parapharmacy					1	
	Dietary supplements					1	1
	Laboratory	1	1	12	17	2	
	Store				1		2
Shipping countries	**Only the own country**	1	2	1		8	7
	Worldwide	2	1	12	21	2	
	Several countries						
Prescription required							
Route of administration	**Oral**	2	2	1	3	8	7
	Parenteral						
	Other	1	1	12	18	2	
Recommended use of the product**	**1**	2	1	1	1	6	6
	2	1	1		3	4	6
	3		1	12			
	No description				14		1

* Significant differences (Chi-square test, p<0.05). Each letter of the superscript denotes a subset whose proportions do not differ significantly from each other (p<0.05).

**1.- Sport: increase muscle mass and strength; 2.- increase testosterone levels; 3.- Research.

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Tribulus terrestris was the compound for which a greater number of web pages were located as can be seen in Table 4, with a total of 1024 web pages, as well as a greater percentage of these offering this product (70.80%). The countries from which a greater number of pages to buy the product were located were Russia (22.17%) and Spain (19.14%). Once we selected those that effectively offered this compound, we were able to verify that they were also located from these countries (21.38% for each of them).

Significant differences were found between countries (chi-square test, $p<0.05$), the subsets with homogeneous proportions being: Canada, Russia and Ukraine; Spain, Puerto Rico and USA. In 24.02% of the pages also offered one of the other compounds evaluated.

The web pages offering this product were mostly dedicated to sports (39.17%), this percentage being much higher in Russia and Ukraine (73.55% and 72.41%, respectively).

In the USA and Puerto Rico, it could be purchased mainly from dietary product pages (61.84% and 31.29%, respectively). A total of 58.90% of the sites only served the order within their country. As in the previous cases, the highest percentages were observed in the pages found from Russia and Ukraine (78.71% and 96.55%, respectively). From the USA, sales were mainly to the whole world (44.74% of the sites). Only 10 sites in the USA required a prescription to buy it. Regarding the form of administration, practically all the sites sold it for oral administration. A few cases were found in which seeds of the plant were offered. Some 68.70% of the websites offered the compound for improvements in sports and 44.60% indicated that it increased male hormone levels and sexual function, these percentages being very similar in all countries.

Table 4. Analysis of websites found in which *Tribulus terrestris* may be acquired from the different countries.

		Spain	Puerto Rico	Canada	USA	Russia	Ucraine
Characteristics of the web pages reviewed	Number of web pages reviewed	196	186	179	92	227	144
	Do not connect*	5 [b, c]	8[c]	22[a]	0[b]	42[a]	28[a]
	Do not sell the product	36	38	48	16	31	26
	Sell the product*	155[b]	140[b]	109[a]	76[b]	155[a]	90[a]
	Also sell other product: *	20[a]	40[c]	27[a]	27[b]	84[c]	48[b]
	• Oxandrolone	3	4	1	2	2	3
	• DHEA	20	38	27	26	82	48
	• Androstendione	1			1		1
Type of web pages selling the product	Sports	49	26	27	5	114	63
	Supermarket	1	2	3			
	Pharmacy	32	27	7	2	2	2
	Parapharmacy	13	5	1		7	2
	Dietary supplements	41	55	5	47	23	11
	Laboratory	3			1	2	
	Store	16	25	27	21	7	9
	Other			39			
Shipping countries	Only the own country	71	85	35	30	122	84
	Worldwide	25	35	43	34	9	3
	Several countries	59	20	28	12	4	
	Unkown			3		20	
Prescription required					10		
Route of administration	Oral	152	140	106	76	155	90
	Parenteral						

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	Other	3		3			
Recommended use of the product**	**1**	85	79	67	69	118	78
	2	49	47	37	14	110	65
	3	2	10	3	3	16	17
	4	10	10	22	1	23	24
	5	2	6	11	6	12	13
	6	2	8	15	1	4	
	No description	10				12	12

* Significant differences (Chi-square test, $p<0.05$). Each letter of the superscript denotes a subset whose proportions do not differ significantly from each other ($p<0.05$).

**1.- Sport: stimulates the growth of muscle tissue, accelerates recovery after exercise, increases strength and endurance; 2.- Increases male hormone levels, promotes sexual activity; 3.- Accelerates fat burning, hypoglycemic; 4.- Improvement of physical and mental stress; 5.- Improvement of renal and cardiovascular function; 6.- Anti-inflammatory and immunostimulant.

4. Discussion

It was hypothesized that athletes can acquire these doping products on the Internet from pages that do not always come from laboratories, as well as from other countries that do not always require a prescription. The variables that were analyzed allowed us to know; 1. the availability of acquiring doping substances in the same country or in other countries; 2. the type of web page; 3. the information with which these substances are marketed, e.g., forms of administration and recommendations for use.

It is essential to distinguish between the concepts of doping substances and dietary supplements. The first concerns drugs included in the Prohibited List of the World Anti-Doping Code that are intended to enhance performance [30]. While the dietary supplement is a product that complements a balanced diet that have a nutritional or physiological effect in simple or combined form [30]. The analysis of doping substances, and in particular those of DHEA and *Tribulus terrestris* requires that unintentional doping be explained, this refers to the unintentional use of prohibited substances due to the consumption of any supplement containing prohibited substances [3,31]. Taking these definitions into account, the supplements analyzed are included in the WADA prohibited list [9].

In the USA, 3.0% of young people have used doping substances, specifically anabolic androgenic steroids [32]. In addition, a 60% consumption of dietary supplements is reported by athletes [24]. Following along these lines, a study [30] estimates that between 6% and 9% of anti-doping rule violations are originated by the intake of contaminated dietary supplements.

In the case of the substances tested, oxandrolone, this synthetic analog of testosterone, was mostly available on sports-oriented Internet sites, which shipped the order mainly in the country itself. Only 8 out of 860 sites requested a prescription. Its main form of administration was oral, followed by parenteral (Puerto Rico and Ukraine) and to a lesser extent in powder form (Canada, USA and Ukraine). 77.26% of the sites marketing this product were dedicated to sports or for purposes such as sports nutrition and pharmacology. Regarding the nutritional claims, these were the increase of muscle mass, strength and endurance. Oxandrolone is used to preserve or restore muscle mass [33], often used in the treatment of catabolic disorders such as Duchenne's dystrophy [34], injuries associated with loss of muscle mass and strength [12,35] improving strength [36] and exercise tolerance [37]. Therefore, the nutritional claims with which this product is offered are not incorrect; the explanation behind these benefits is the stimulating action on the protein synthesis of peripheral myelin. This is why oxandrolone is used in demyelinating lesions and diseases [38].

In the case of DHEA, the sites that commercialized it were dedicated to the sale of dietary products (29.73%) and related to sports (23.96%). In addition, these sites offered some of the other supplements such as *Tribulus terrestris* and their recommendation ranged from sports use (45.95 %), benefits in disorders associated with sex hormones (32.61 %) and anxiety (27.21 %). Its administration was mainly oral, followed by parenteral and topical.

Its inclusion in the WADA list of banned substances [9] is due to performance enhancements due to increased testosterone [39–41], although its use is advised because of the effect on the lipid profile in women after 3 months of administration [42]. As is the case with *Tribulus terrestris* this substance is often present in dietary supplements without being noted on the label [41]. Despite the fact that DHEA administration is combined with testosterone and its precursors such as androstenedione [43], *Tribulus terrestris* can also be purchased on the Internet sites where its sale takes place.

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The results for androstenedione showed, on the one hand, that these were pages dedicated to analyzing this product in analytics. On the other hand, the main countries dedicated to its sale were the USA and Canada. Particularly, in the USA the use of androstenedione has become popular since a baseball league player admitted to using it [16]. Likewise, in the case of this doping substance, none of the Internet sites required a prescription. It should be noted that androstenedione is frequently prescribed in sarcopenia in older adults for the purpose of improving quality of life [44]. Since it is a precursor of testosterone, its consumption facilitates the increase of muscle mass as well as the performance in the training sessions [16]. It is sold as an anabolic agent [45] and is used as a supplement for bodybuilding to improve performance [16]. In the results, it was observed that recommendations for its consumption are associated with increasing muscle mass and strength (29.82%) or to increase testosterone levels (26.32%). Androstenedione, unlike oxandrolone, was mainly marketed in laboratories (33.33%) and pharmacies (66.67% in Puerto Rico and 40% in Russia). Its main form of presentation was in powder form (57.90%) followed by oral administration.

From the analysis of the results for *Tribulus terrestris* it is highlighted that only 10 pages out of 1024 required a prescription. The pages from which this product could be obtained were mostly sports pages (39.17%). The information provided on the benefits of its consumption were the increase of male hormone levels and sexual function in 44.60% of the Internet pages and in 68.70% as improvements in sports performance without specifying in which aspects. *Tribulus terrestris* is frequently used by bodybuilders and athletes because it can improve testosterone concentrations, at least according to the information provided by the labels [46,47]. Its physiological effect is due to an increase in the anabolic and androgenic action of testosterone [48]. From the results it is understood that the main mode of administration was oral and to a lesser extent as seeds. Evidence in studies has shown improvements in certain biomarkers in active adults but research on the potential effect on muscle damage, anti-inflammatory and on hormonal biomarkers is lacking [49].

Misinformation and the easy availability of these substances favor the increase in consumption. Thus, another study (19) highlighted that the main source of information at the time of purchasing supplements came from friends or the media and to a lesser extent from professional advice. Also, in the case of professional athletes, 28% of them have consulted a physiotherapist about their use, but 18% acknowledged that they use supplements without seeking professional support (20). There is research [21,22] that showed pharmacists as a source of information in the selection and purchase of products.

On the one hand, some of these substances have demonstrated their efficacy in certain pathologies (e.g., liver cancer [14], sarcopenia [12]), but, on the other hand, the Australian Institute of Sport [10] places these supplements in category D prohibiting their consumption either because they lack sufficient scientific support to justify their consumption or because of the risk of contamination at the time of doping control (DHEA [41], *Tribulus terrestris*). In a study [30] the supplements most susceptible to contamination were exposed, and in the samples doping substances were found in 23% of the dietary supplements sold through a Dutch website. This information becomes more relevant when one considers that 3% contained concentrations in amounts that resulted in serious adverse effects. In another study [3] the range of contamination was from 12 to 58%, which favors unintentional doping due to the omission on labels of some doping substances found in supplements.

Emphasis should be placed on ergonutritional education on which supplements are allowed, but also on the proper way to select them, e.g., brands, modes of administration, timing of ingestion [21]. This last point refers to the contamination of ingredients. The risks of their consumption do not extend to a sanction by the WADA [9] but also to adverse health effects [16].

5. Conclusions

The consumption of doping substances is routine among athletes, who use them with the intention of improving performance. From this study it is concluded that: only a limited number of sites per doping substance requested prescription. Particularly in the case of androstenedione, none of the sites requested a prescription. The claims for its consumption refer to performance benefits and increases in muscle mass, strength and endurance. Most of the dopaje substances are purchased from the country where they are requested, but it is possible to purchase them from outlets outside one's own country. *Tribulus terrestris* was the compound found in the largest number of Internet pages.

6. Practical Applications

Finally, it should be considered that beyond the implications of their consumption in sport, they have clear detrimental effects (e.g. cardiovascular, hormonal imbalances). Athletes should be encouraged to consult health

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professionals (sports physicians and/or nutritionists) about which supplements are suitable for their type of training and sports objectives, and which brands to select to avoid unintentional intake of these doping substances.

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