

Article

Processes in Doping System: Quantification Reports in Mixed Martial Arts Fighters

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Abstract: Mixed martial arts (MMA) has always been surrounded by controversy due to the unusual muscle development of its participants, so it is crucial to know the strategies that have been implemented to reduce doping cases. The main purpose of this paper is to describe the various cases of doping detected by USADA in UFC MMA participants. In addition, strategies that are being developed to reduce cases of positive doping are proposed. From the UFC USADA database, doping cases were extracted, obtaining the substance or substances involved; the formula, physiological effect and the athletes involved; the dates of the sampling; if it was out of competition or in-competition and the sanction time. The substances that were most involved were found to be Ostarine (22), Clomiphene (9), Diuretics (10) and Stanozolol (9). Some sanctions were diminished because they were treated with contamination of supplements (cases of Ostarine) and cases of contamination of meat (Clomiphene). When contaminated supplements were reported, they were added to the list of high-risk supplements maintained as part of USADA's online dietary supplement safety education and awareness resource—Supplement 411. There were also cases in which positive doping could be avoided through the early report of therapeutic use exemptions. The methodology that the USADA has implemented allows us to register the athletes with positive doping, check the risk of the supplements before being bought and provide a teaching portal. These efforts are necessary to implement in all countries in which MMA is practiced, avoiding the participation of doped martial artists.

Keywords: doping; mix martial arts; contamination; sanction; violation; sports; MMA



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1. Introduction

Science has witnessed advancement in the use of new substances that allow MMA competitors to have advantages, so it is necessary to determine their prevalence, as well as the substances involved, the punishments generated and the divisions of the fighters where more cases are found, as this way, we can improve regulations and strategies to decrease doping cases [1,2]. The history of doping in sports is not recent, and has led the World Anti-Doping Agency (WADA) to constantly develop guidelines to motivate competitors to follow the true meaning of sport, so that they can comply with the rules, without non-sporting advantages, based on effort and preparation before each competition. These guidelines were extended to other sports and to global competitions such as the World Cup [3], the Olympic Games [4] and even regional tournaments such as the Champions League [5] and the tour de France [6]. To date, approximately 700 sports organizations have accepted the World Anti-Doping Code.

The WADA code expresses that doping is defined as *the occurrence of one or more of the following anti-doping rule violations* [7]:

- a. The presence of a prohibited substance or its metabolites or markers in an athlete's sample.
- b. Use or attempted use by an athlete of a prohibited substance or a prohibited method.
- c. Evasion, refusal or failure to submit to sample collection by an athlete.
- d. Whereabouts failures by an athlete.
- e. Tampering or attempted tampering with any part of doping control by an athlete or other person.
- f. Possession of a prohibited substance or a prohibited method by an athlete or athlete support person.
- g. Trafficking or attempted trafficking of any prohibited substance or prohibited method by an athlete or other person.
- h. Administration or attempted administration by an athlete or other person to any athlete in-competition of any prohibited substance or prohibited method, or administration or attempted administration to any athlete out of competition of any prohibited substance or any prohibited method that is prohibited out of competition.
- i. Complicity or attempted complicity by an athlete or other person.
- j. Prohibited association by an athlete or other person.
- k. Acts by an athlete or other person to discourage or retaliate against reporting to authorities.

Since its inception, mixed martial arts (MMA) have been related to doping reports. However, it is not a uniform process, so it has been possible to detect various types of negative analytical results as well as various types of sanctions. One relevant aspect is to know what the change in the performance of the fighters was by comparing the results before and after the positive doping. The Ultimate Fighting Championship (UFC) brand has seen spectacular growth in recent years, becoming the market leader, making MMA the first sports competition to reopen during the COVID-19 pandemic, namely in Abu Dhabi [8].

The UFC's business growth generated that the audience set their sights on all the details of the event and UFC fighters, always having the performance and physical structure of some fighters as a recurring theme. Suspicion and unofficial accusation of use of banned substances was common, although there was not such strict control until June 2015, when the UFC began the anti-doping program hand in hand with the United States Anti-Doping Agency®(USADA). This means that the UFC granted the USADA full authority to execute testing, sanctions, investigation and education, allowing for the development of programs and policies to ensure proper compliance among fighters, coaches and associated gyms.

The present study seeks to fill the knowledge gap on the results of the 7 years of operation of the UFC anti-doping program, which will also allow us to improve regulation and decrease cases. We will describe the different substances that have been reported as responsible for positive doping in mixed martial arts, as well as the sanctions and profile of the competitors sanctioned.

2. Methodology

2.1. Study Design

The current study is descriptive research which aims to analyze the reports of doping rule violations realized by the USADA UFC anti-doping program until September 2022. The source of the information is published in the official USADA UFC anti-doping program (<https://ufc.usada.org/testing/results/sanctions> (accessed on 1 October 2022)).

2.2. Collection of Data

The database reports the first finding and sanction on 25 November 2015. The most recent report is from 22 September 2022. The information collected on the fighters includes their name, nationality, age, weight class, current ranking, current record, date of anti-doping rule violation (ADRV), type of ADRV and length of suspension. Additionally,

the formula of substance, physiological effect of substance and dates of the sampling were obtained.

3. Results

3.1. Substances and Competitors Linked to Doping

3.1.1. 1-Androstenedione (Figure 1)

Physiological effect: Androgen prohormone of 1-testosterone (4,5 α -dihydro- δ 1-testosterone), a derivative of dihydrotestosterone (DHT) [9]. Provides a significant, continuous, cumulative and lasting physical advantage in sports competitions by creating larger and stronger bones, greater muscle mass and strength and increased circulating hemoglobin.

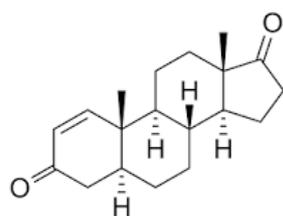


Figure 1. Chemical structure of 1-androstenedione. Formula: C₁₉H₂₆O₂.

- Fighters involved in doping with 1-androstenedione.
 1. Lyman Good was initially sanctioned for testing 1-androstenedione in a test carried out on 14 October 2016; however, after Good delivered information to USADA about the dietary supplement product he was using at the time of the sample collection, it was established that this was the result of contamination. Sanction time: 6 months (reduced due to contamination).
 2. Justin Ledet was initially sanctioned for testing 1-androstenedione in a test carried out on 12 January 2017; however, after Ledet delivered information to USADA about the dietary supplement product he was using at the time of the sample collection, it was established that this was the result of contamination. Sanction time: 6 months (reduced due to contamination).

3.1.2. Amphetamine and Dextroamphetamine (Figure 2)

Physiological effect: Central nervous system (CNS) stimulant [10]. Amphetamines do not generate additional physical and mental energy. They are characterized by distorting the user's perception of reality and impairing judgment, which can cause an athlete to participate with injuries, which can lead to worse injuries and endanger others.

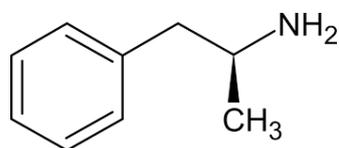


Figure 2. Chemical structure of amphetamine. Formula: C₉H₁₃N.

- Fighters involved in doping with amphetamine and dextroamphetamine.
 1. Miles Johns tested positive for amphetamine and dextroamphetamine. The report was released 21 July 2022. Sanction time: Public Warning.

3.1.3. Anastrozole (Figure 3)

Physiological effect: This is a non-steroidal aromatase inhibitor used to treat breast cancer in postmenopausal women [11]. Additionally, it generates increased aggressive-

ness, sometimes resulting in criminal behavior called “Roid Rage” (angry and aggressive behavior caused by anabolic steroids use).

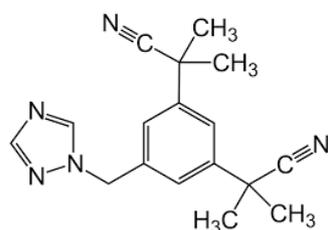


Figure 3. Chemical structure of anastrozole. Formula: C₁₇H₁₉N₅.

- Fighters involved in doping with anastrozole.
 1. Matheus Nicolau tested positive for anastrozole following an out-of-competition test conducted on 13 October 2016.
Sanction time: 1 year.
 2. Marcos Rogerio de Lima tested positive for anastrozole and hydrochlorothiazide. Reported released 23 April 2018. Then, USADA demonstrated that this was due to contamination.
Sanction time: 6 months (reduced due to contamination).
 3. CB Dolloway tested positive for anastrozole following an out-of-competition test conducted on 19 December 2018.
Sanction time: 2 years.
 4. Chase Sherman tested positive for anastrozole following an in-competition test conducted on 13 May 2020.
Sanction time: 9 months.
 5. Vinicius Moreira Castro tested positive for anastrozole following an out-of-competition test conducted on 25 September 2020.
Sanction time: Public Warning.

3.1.4. Arimistane (androsta-3,5-diene-7,17-dione) (Figure 4)

Physiological effect: Increased testosterone levels [12]. It generates increased aggressiveness, sometimes resulting in criminal behavior called “Roid Rage” (angry and aggressive behavior caused by anabolic steroids use).

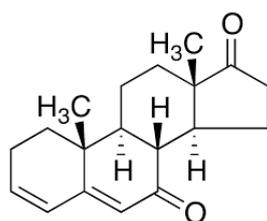


Figure 4. Chemical structure of arimistane. Formula: C₁₉H₂₄O₂.

- Fighters involved in doping with arimistane.
 1. Yaozong Hu tested positive for arimistane following an out-of-competition test conducted on 9 March 2019.
Sanction time: 10 months.

3.1.5. Boldenone (Figure 5)

Physiological effect: An agonist of the androgen receptor [13]. It is used to increase muscle mass and strength.

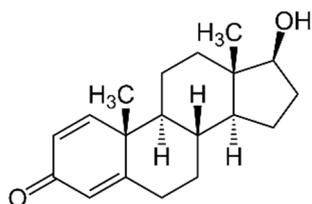


Figure 5. Chemical structure of boldenone. Formula: $C_{19}H_{26}O_2$.

- Fighters involved in doping with boldenone.
 1. Azamat Murzakanov tested positive for boldenone following an out-of-competition test conducted on 2 September 2017. Sanction time: 2 years.
 2. Bharat Vijay Kandare tested positive for boldenone following an out-of-competition test conducted on 23 July 2018. Sanction time: 2 years.
 3. Ivan Shtyrkov tested positive for boldenone following an out-of-competition test conducted on 27 March 2019 and 3 April 2019. Sanction time: 2 years.
 4. Michel Prazeres tested positive for boldenone following an out-of-competition test conducted on 9 March 2019. Sanction time: 2 years.
 5. Bruno Arruda da Silva tested positive for boldenone following an out-of-competition test conducted on 27 May 2019. Sanction time: 2 years.

3.1.6. Cardarine (Figure 6)

Physiological effect: This is a PPAR δ receptor agonist [14]. It helps to increase fat-burning capacity.

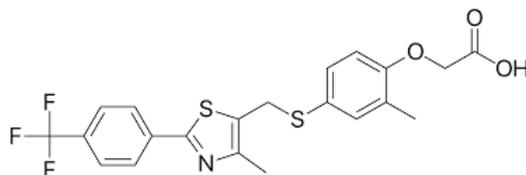


Figure 6. Chemical structure of cardarine. Formula: $C_{21}H_{18}F_3NO_3S_2$.

- Fighters involved in doping with cardarine.
 1. Vince Murdock tested positive for cardarine following an out-of-competition test conducted on 6 July 2019. Sanction time: 20-Month Suspension—Sanction Reduced.

3.1.7. Clenbuterol (Figure 7)

Physiological effect: Selective beta-2 adrenergic receptor agonist used in the treatment of asthma [15]. It has potent anabolic and lipolytic effects on muscles and is used by athletes to improve exercise performance.

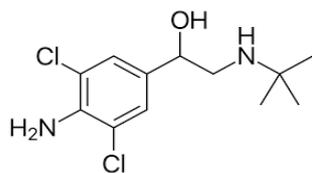


Figure 7. Chemical structure of clenbuterol. Formula: $C_{12}H_{18}Cl_2N_2O$.

- Fighters involved in doping with clenbuterol.
 1. Francisco Rivera tested positive for clenbuterol following an out-of-competition test conducted on 23 July 2016. Then, Rivera tried to deceive USADA, wanting to make them to believe that the result was caused by a sample of contaminated meat, but he failed.
Sanction time: 4 years.
 2. Ning Guangyou tested positive for clenbuterol following an out-of-competition test conducted on 19 May 2016. Then, USADA reviewed all of the evidence, demonstrating very low parts per billion concentrations of the prohibited substance in the athlete's sample, concluding that the presence of clenbuterol in the athlete's sample very likely resulted from clenbuterol-contaminated meat consumed in China.
Sanction time: None (by contamination).
 3. Augusto Montano tested positive for clenbuterol following an out-of-competition test conducted on 19 May 2016. Then, USADA reviewed all of the evidence, demonstrating very low parts per billion concentrations of the prohibited substance in the athlete's sample, concluding that the presence of clenbuterol in the athlete's sample very likely resulted from clenbuterol-contaminated meat consumed in Mexico.
Sanction time: None (contamination).
 4. Li Jingliang tested positive for clenbuterol following an out-of-competition test conducted on 18 May 2016. Then, USADA reviewed all of the evidence, demonstrating very low parts per billion concentrations of the prohibited substance in the athlete's sample, concluding that the presence of clenbuterol in the athlete's sample very likely resulted from clenbuterol contaminated meat consumed in China.
 5. Brandon Moreno tested positive for clenbuterol following an out-of-competition test conducted on 7 August 2017. Then, USADA reviewed all of the evidence, demonstrating very low parts per billion concentrations of the prohibited substance in the athlete's sample, concluding that the presence of clenbuterol in the athlete's sample very likely resulted from clenbuterol contaminated meat consumed in Mexico.
Sanction time: None (contamination).

3.1.8. Clomiphene (Figure 8)

Physiological effect: Ovulation induction and testosterone replacement therapy [16]. It elevates serum testosterone and gonadotropin levels in healthy men, so it can be abused as a performance-enhancing drug.

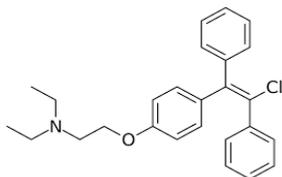


Figure 8. Chemical structure of clomiphene. Formula: $C_{26}H_{28}ClNO$.

- Fighters involved in doping with clomiphene.
 1. Brock Lesnar tested positive for clomiphene and its metabolite, 4-hydroxyclophiphenol following an out-of-competition test conducted on 28 June 2016, and an in-competition test conducted on 9 July 2016, at UFC 200. Lesnar was not removed for UFC 200.
Sanction time: 2 years.
 2. James Mulheron tested positive for clomiphene and its metabolite, hydroxyclophiphenol, following an out-of-competition test conducted on 10 November 2016. As a result, Mulheron was removed from the card for the UFC Fight Night event in Shanghai, China, scheduled for 25 November 2017.
Sanction time: 1 year.

3. Michał Oleksiejczuk tested positive for clomiphene following an in-competition test conducted on 30 December 2017. Oleksiejczuk was not removed for UFC 219; then, Nevada State Athletic Commission (NSAC) on 13 March 2018 overturned Oleksiejczuk's victory at UFC 219 to a no-contest.
Sanction time: 1 year.
4. George Sullivan tested positive for clomiphene following an out-of-competition test conducted on 14 January 2017.
Sanction time: 1 year.
5. Roman Dolidze tested positive for clomiphene following an out-of-competition test conducted on 12 March 2019.
Sanction time: 1 year.
6. Nick Roehrick tested positive for clomiphene following an out-of-competition test conducted on 8 August 2017.
Sanction time: 1 year.
7. Jesse Taylor tested positive for clomiphene following an out-of-competition test conducted on 22 August 2017.
Sanction time: 1 year.
8. Michel Prazeres tested positive for clomiphene following an out-of-competition test conducted on 27 August 2021, 16 September 2021, 15 October 2021, and 2 November 2021.
Sanction time: 4 years.
9. Zviad Lazishvili tested positive for clomiphene in-competition on 23 October 2021 and out-of-competition on 5 November 2021.
Sanction time: 10 months.

3.1.9. Cocaine (Figure 9)

Physiological effect: SNC stimulant [17]. It distorts the user's perception of reality; for example, an athlete may perceive an increase in performance and a decrease in fatigue versus a real decrease in performance in strength and endurance activities during the fight.

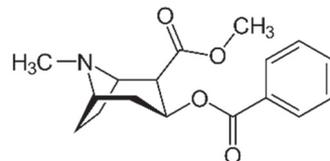


Figure 9. Chemical structure of cocaine. Formula: C₁₇H₂₁NO₄.

- Fighters involved in doping with cocaine.
 1. Bradley Scott tested positive for cocaine following an out-of-competition test conducted on 27 May 2018. Sanction time: 2 years.
 2. Dequan Townsend tested positive for cocaine following an in-competition test conducted on 28 June 2019. Sanction time: 6 months.
 3. Juancamilo Ronderos Alvis tested positive for cocaine following an in-competition test conducted on 22 May 2022. Sanction time: 1 month.

3.1.10. Dehydroepiandrosterone (DHEA) (Figure 10)

Physiological effect: Androgen [18]. Provides a significant, continuous, cumulative and lasting physical advantage in sports competitions by creating larger and stronger bones, greater muscle mass and strength, and increased circulating hemoglobin.

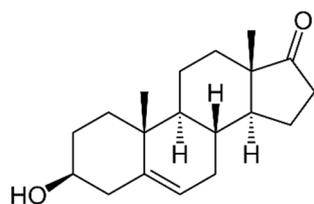


Figure 10. Chemical structure of DHEA. Formula: $C_{19}H_{28}O_2$.

- Fighters involved in doping with dehydroepiandrosterone (DHEA)
 1. Jessica Penne tested positive for the presence of DHEA following an out-of-competition test conducted on 20 March 2017.
Sanction time: 18 months.
 2. Lyoto Machida tested positive for 7-keto-DHEA following an out-of-competition test conducted on 8 April 2016.
Sanction time: 18 months.
 3. Raquel Pennington tested positive for 7-keto-DHEA following an out-of-competition test conducted on 17 November 2020.
Sanction time: 6 months.
 4. Ashlee Evans-Smith* tested positive for 7-keto-DHEA following an out-of-competition test conducted on 3 and 27 January 2022.
Sanction time: 14 months.

* During an investigation into the circumstances of the case, Evans-Smith provided evidence, including medical records, indicating that a physician incorrectly prescribed her DHEA.

3.1.11. Dehydrochlormethyltestosterone (DHCMT) (Figure 11)

Physiological effect: Anabolic–androgenic steroid [19]. Provides a significant, continuous, cumulative and lasting physical advantage in sports competitions by creating larger and stronger bones, greater muscle mass and strength and increased circulating hemoglobin.

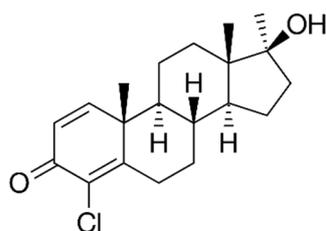


Figure 11. Chemical structure of DHCMT. Formula: $C_{20}H_{27}ClO_2$.

- Fighters involved in doping with dehydrochlormethyltestosterone.
 1. Frank Mir tested positive for dehydrochlormethyltestosterone following an in-competition test conducted on 20 March 2016.
Sanction time: 2 years.
 2. Alex Gorgees tested positive for dehydrochlormethyltestosterone following an in-competition test conducted on 2 December 2018.
Sanction time: 16 months.
 3. Jon Jones tested positive for dehydrochlormethyltestosterone following an in-competition test conducted on 28 July 2017. This was the second time Jones failed a test for doping. The first one was caused by clomiphene and letrozole.
Sanction time: 15 months.
 4. Chi Lewis-Parry tested positive for dehydrochlormethyltestosterone following an out-of-competition test conducted on 12 September 2019 and 19 September 2019. Drostanolone and Stanozolol were also detected.
Sanction time: 4 years.

3.1.12. Diuretics: Furosemide (Figure 12), Hydrochlorothiazide (Figure 13) and its metabolite 4-amino-6-chloro-1,3-benzenedisulfonamide (ACB) (Figure 14)

Formula: Furosemide ($C_{12}H_{11}ClN_2O_5S$), hydrochlorothiazide ($C_7H_8ClN_3O_4S_2$), chlorothiazide ($C_7H_6ClN_3O_4S_2$) and 4-amino-6-chloro-1,3-benzenedisulfonamide (ACB) ($C_6H_8ClN_3O_4S_2$).

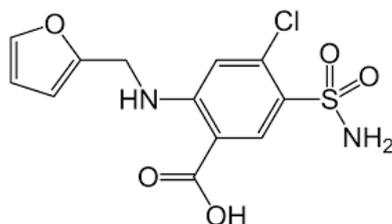


Figure 12. Chemical structure of Furosemide.

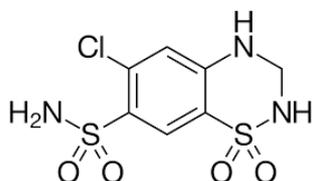


Figure 13. Chemical structure of Hydrochlorothiazide.

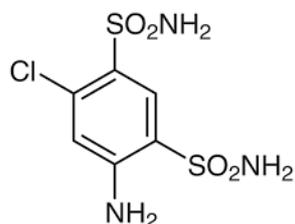


Figure 14. Chemical structure of 4-amino-6-chloro-1,3-benzenedisulfonamide (ACB).

Physiological effect: Diuretic [20,21]. It can change the body's natural balance of fluids and salts (electrolytes), which can lead to dehydration. This loss of water can decrease the athlete's weight. Additionally, can be used to mask the use of other substances.

- Fighters involved in doping with diuretics.
 1. Carls John de Tomas tested positive for furosemide, stemming from a sample he provided during the in-competition period on 29 December 2017.
Sanction time: 1 year.
 2. Azunna Anyanwu tested positive for furosemide, stemming from a sample he provided during the in-competition period on 18 October 2017.
Sanction time: 1 year.
 3. Jennifer Maia tested positive for the presence of furosemide/hydrochlorothiazide/chlorothiazide/4-amino-6-chloro-1,3-benzenedisulfonamide (ACB) in 16 August 2018. This was proven to be caused by a contaminated supplement.
Sanction time: 6 months (reduced due to contamination).
 4. Melissa Gatto Regonha tested positive for furosemide, stemming from a sample she provided during the in-competition period on 5 June 2019.
Sanction time: 1 year.
 5. Khalid Taha tested positive for furosemide, stemming from a sample he provided during the in-competition period on 6 October 2019.
Sanction time: 1 year.

6. Priscila Cachoeira Gomes da Silva tested positive for furosemide, stemming from a sample he provided during the in-competition period on 12 October 2019. Cachoeira provided evidence that the prohibited substance detected in her sample was from a blood-pressure medication given to her by her parent in response to symptoms she was experiencing; also, she did not have or apply for a Therapeutic Use Exemption, which is required to authorize the use of a prohibited substance in sport. Finally, based on the specific circumstances, USADA determined that a reduced sanction was appropriate. Sanction time: 4 months.
7. Raphael Pessoa Nunes tested positive for hydrochlorothiazide from a sample he provided during the out-of-competition period on 4 March 2020. Sanction time: 1 year.
8. Raphael Pessoa Nunes tested positive for hydrochlorothiazide from a sample he provided during the out-of-competition period on 9 February 2021, 15 February 2021, 16 February 2021 and 4 March 2021. Additionally, he evaded sample collection on 25 January 2021 and 28 January 2021. Evading sample collection, or refusing or failing to submit to sample collection, without compelling justification is a doping violation under the UFC Anti-Doping Policy. Sanction time: 2 years.
9. Rogerio Bontorin tested positive for hydrochlorothiazide from a sample he provided during the out-of-competition period on 1 May 2021. Sanction time: 3 months.
10. Erin Blanchfield had a violation that resulted from her use of topical spironolactone, a prescription medication, which she used under the care of a dermatologist for a diagnosed medical condition. The report was released 13 May 2022. Sanction time: Public Warning.

3.1.13. Drostanolone (Figure 15)

Physiological effect: Agonist of the androgen receptor [22]. Provides a significant, continuous, cumulative and lasting physical advantage in sports competitions by creating larger and stronger bones, greater muscle mass and strength, and increased circulating hemoglobin.

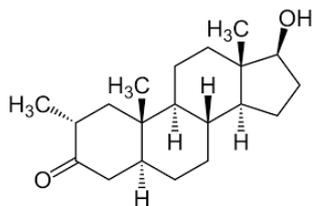


Figure 15. Chemical structure of drostanolone. Formula: $C_{20}H_{32}O_2$.

- Fighters involved in doping with drostanolone.
 1. Khalid Murtazaliev tested positive for drostanolone following an out-of-competition test conducted on 3 October 2018 and 6 December 2018. Sanction time: 2 years.
 2. Giacomo Y Frederico Salvador de Lemos tested positive for drostanolone following an out-of-competition test conducted on 9 July 2019. Sanction time: 2 years.
 3. Stefan Sekulic tested positive for drostanolone following an out-of-competition test conducted on 15 September 2018. Sanction time: 2 years.

3.1.14. Erythropoietin (EPO) (Figure 16)

Physiological effect: Stimulation of erythroid progenitors [23]. It stimulates the production of red blood cells in the bone marrow and regulates the concentration of red blood cells and hemoglobin in the blood. Red blood cells carry oxygen to cells, including muscle cells, enabling them to function more efficiently.

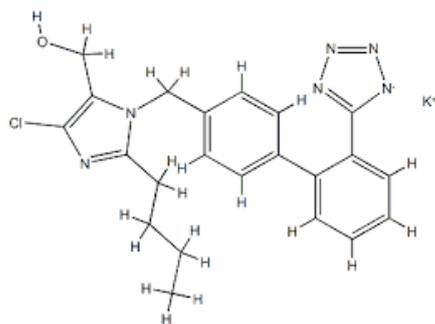


Figure 16. Chemical structure of EPO. Formula: $C_{815}H_{1317}N_{233}O_{241}S_5$.

- Fighters involved in doping with erythropoietin.

1. Gleison Tibau tested positive for erythropoietin following an out-of-competition test conducted on 23 October 2015 and an in-competition test conducted on 7 November 2015. Sanction time: 2 years.

3.1.15. GHRP-6 (Growth Hormone-Releasing Hexapeptide) (Figure 17)

Physiological effect: Stimulate secretion of growth hormone [24]. It has a number of beneficial effects associated with increased growth hormone levels, such as decreased body fat, increased muscle, and increased strength and endurance.

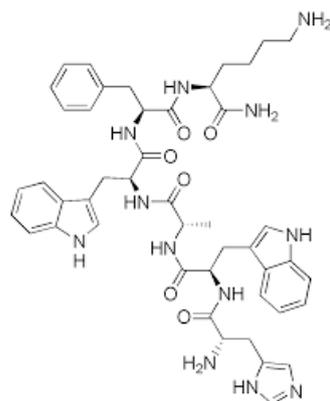


Figure 17. Chemical structure of GHRP-6. Formula: $C_{46}H_{56}N_{12}O_6$.

- Fighters involved in doping with GHRP-6.

1. Chad Mendes tested positive for GHRP-6 following an out-of-competition test conducted on 17 May 2016. Sanction time: 2 years.
2. Gilbert Melendez tested positive for GHRP-6 following an out-of-competition test conducted on 16 October 2019. Sanction time: 2 years.

3.1.16. GHRP-2 (Growth Hormone-Releasing Peptide 2) (Figure 18)

Physiological effect: Stimulate secretion of growth hormone [25]. It has a number of beneficial effects associated with increased growth hormone levels, such as decreased body fat, increased muscle, and increased strength and endurance.

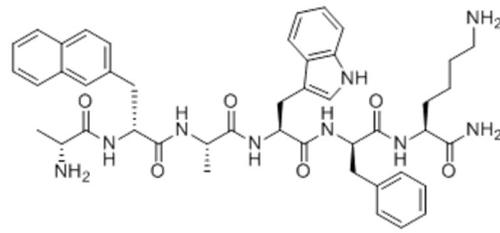


Figure 18. Chemical structure of GHRP-2. Formula: $C_{45}H_{55}N_9O_6$.

- Fighters involved in doping with GHRP-6.
1. Oskar Piechota tested positive for GHRP-2 following an out-of-competition test conducted on 25 September 2020.
Sanction time: 22 months.

3.1.17. Higenamine (Figure 19)

Physiological effect: β_2 adrenoreceptor agonist [26]. It seems to increase heart contractions and speed up the heart rate.

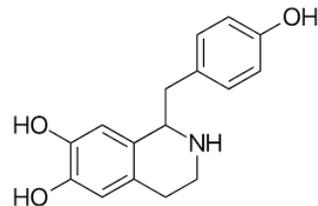


Figure 19. Chemical structure of higenamine. Formula: $C_{16}H_{17}NO_3$.

Sanction time: 10 months.

- Fighters involved in doping with higenamine.
1. Jake Collier tested positive for higenamine following an out-of-competition test conducted on 27 December 2018. Due his cooperation throughout the results management process, USADA determined that Collier was eligible for a reduction in the otherwise standard one-year period of ineligibility to 10 months.
Sanction time: 10 months.

3.1.18. Human Growth Hormone (“hGH”) (Figure 20)

Physiological effect: Anabolic effects [27]. It has a number of beneficial effects associated with increased growth hormone levels, such as decreased body fat, increased muscle, and increased strength and endurance.

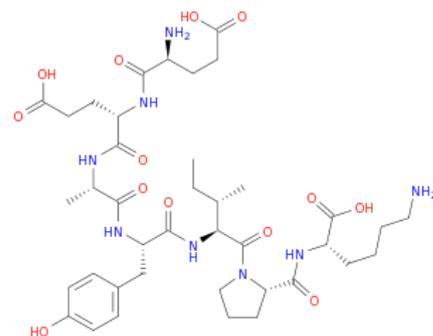


Figure 20. Chemical structure of hGH. Formula: $C_{19}H_{26}O_3$.

- Fighters involved in doping with hGH.

Mirko Filipovic. tested positive for hGH following an out-of-competition test conducted on 4 November 2015.

Sanction time: 2 years.

3.1.19. Ibutamoren (Figure 21)

Physiological effect: Long-acting, selective, and non-peptide agonist of the ghrelin receptor and a growth hormone secretagogue [28]. It has a number of beneficial effects associated with increased growth hormone levels, such as decreased body fat, increased muscle and increased strength and endurance.

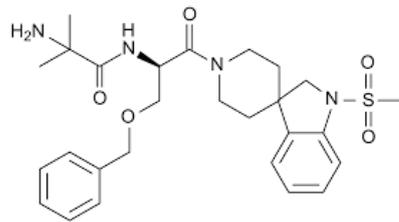


Figure 21. Chemical structure of ibutamoren. Formula: $C_{27}H_{36}N_4O_5S$.

- Fighters involved in doping with ibutamoren.

1. Yoel Romero tested positive for ibutamoren following an out-of-competition test conducted on 15 December 2015. After a thorough investigation, USADA concluded that the result was caused by a contaminated supplement. Finally, Romero sued the laboratory responsible for the supplement, winning the claim for USD 27 million. Sanction time: 6 months (reduced due to contamination).

3.1.20. Insulin-like Growth Factor-1 (IGF-1) Protein (Figure 22)

Physiological effect: Anabolic effects [29]. It has a number of beneficial effects associated with increased growth hormone levels, such as decreased body fat, increased muscle and increased strength and endurance.

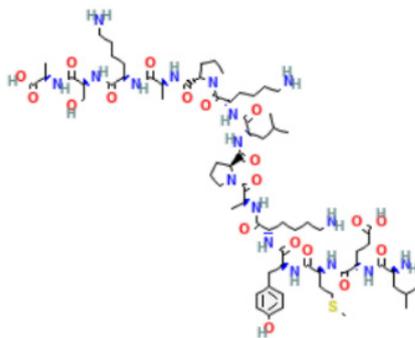


Figure 22. Chemical structure of IGF-1. Formula: $C_{71}H_{119}N_{17}O_{19}S$.

- Fighters involved in doping with IGF-1.

1. George Sullivan. Although Sullivan did not test positive for any prohibited substances, under the UFC Anti-Doping Policy, the admission of use of a prohibited substance or product containing a prohibited substance (13 July 2016) is regarded as an anti-doping policy violation. Sanction time: 1 year.

3.1.21. Ipamorelin (Figure 23)

Physiological effect: Peptide selective agonist of the ghrelin/growth hormone secretagogue receptor (GHS) and a growth hormone secretagogue [30]. It has a number of beneficial effects associated with increased growth hormone levels, such as decreased body fat, increased muscle, and increased strength and endurance.

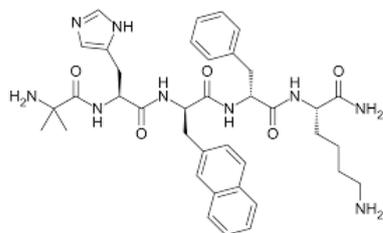


Figure 23. Chemical structure of ipamorelin. Formula: $C_{38}H_{49}N_9O_5$.

- Fighters involved in doping with ipamorelin.
 1. David Branch tested positive for ipamorelin following an out-of-competition test conducted on 24 May 2019.
Sanction time: 2 years.

3.1.22. Ligandrol (LGD-4033) (Figure 24)

Physiological effect: Selective androgen receptor modulator [31]. Like anabolic steroids, it can stimulate muscle growth, which will give the fighter an advantage in competition.

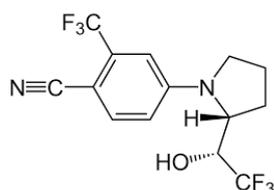


Figure 24. Chemical structure of ligandrol. Formula: $C_{14}H_{12}F_6N_2O$.

- Fighters involved in doping with ligandrol.
 1. Walt Harris tested positive for ligandrol following an in-competition test conducted on 29 December 2018; however, after Harris delivered the information to USADA about the dietary supplement product he was using at the time of the sample collection, it was established that this was a result of contamination.
Sanction time: 4 months (reduced due to contamination).
 2. Eduarda Neves Satananna tested positive for ligandrol following an out-of-competition test conducted on 10 January 2020.
Sanction time: 1 year.

3.1.23. Meldonium (Figure 25)

Physiological effect: Anti-ischemic [32]. Increases and improves blood flow. By reducing oxygen consumption within cellular structures, it significantly increases the athlete's endurance and tolerance of higher physical workloads.

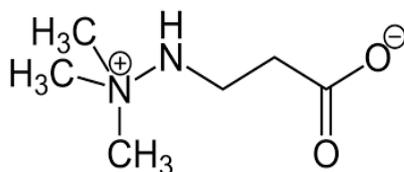


Figure 25. Chemical structure of meldonium. Formula: C₆H₁₄N₂O₂.

- Fighters involved in doping with meldonium.
 1. Daniel Omielanczuk tested positive for meldonium following an out-of-competition sample conducted on 21 January 2016. During USADA's investigation of the case, Omielanczuk presented evidence establishing that his use of meldonium was limited to a three-week span, from mid-August to early September 2015. Finally, it was concluded that the quantities were minimal and that considering that the substance was only banned on the first of January 2016, there was no penalty.
Sanction time: None
 2. Islam Makhachev tested positive for meldonium following an out-of-competition sample conducted on 4 April 2016. During USADA's investigation of the case, Makhachev presented evidence establishing that his use of meldonium was limited to four weeks for medical proposals from late November to late December 2015. Finally, it was concluded that the quantities were minimal and that considering that the substance was only banned on the first of January 2016, there was no penalty.
Sanction time: None.
 3. Abdul-Kerim Edilov tested positive for meldonium following an out-of-competition sample conducted on 7 January 2016. USADA accepted Edilov's explanation that meldonium was a prescription drug he was taking in a therapeutic dose without the intention of improving his athletic performance, but since Edilov continued using meldonium after the substance was officially banned on 1 January 2016, he should have requested a valid Therapeutic Use Exemption (TUE) to avoid violating the Anti-Doping Policy.
Sanction time: 15 months.
 4. Liliya Shakirova tested positive for meldonium following an out-of-competition sample conducted on 5 December 2020.
Sanction time: 2 years.

3.1.24. Methyltestosterone (Figure 26)

Physiological effect: Androgen. Antineoplastic [33]. Provides a significant, continuous, cumulative and lasting physical advantage in sports competitions by creating larger and stronger bones, greater muscle mass and strength, and increased circulating hemoglobin.

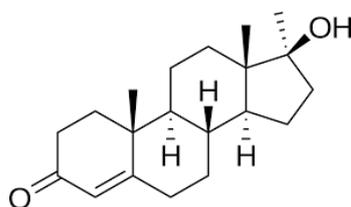


Figure 26. Chemical structure of methyltestosterone. Formula: C₂₀H₃₀O₂.

- Fighters involved in doping with methyltestosterone.
 1. Felipe Olivieri tested positive for methyltestosterone following an out-of-competition test conducted on 11 January 2016.
Sanction time: 2 years.
 2. Anderson Silva tested positive for methyltestosterone following an out-of-competition test conducted on 26 October 2017. In addition, the sample contained hydrochloroth-

iazide. After the USADA investigations, it was determined that the supplement had been sold in a compounding pharmacy in Brazil from which USADA took other subsequent samples and it was verified that they were indeed contaminated with methyltestosterone and hydrochlorothiazide, thus confirming the unintentional use of the contaminated product.

Sanction time: 1 year (reduced due to contamination).

3.1.25. Mesterolone (Figure 27)

Physiological effect: Androgen and anabolic steroid [34]. Provides a significant, continuous, cumulative and lasting physical advantage in sports competitions by creating larger and stronger bones, greater muscle mass and strength and increased circulating hemoglobin.

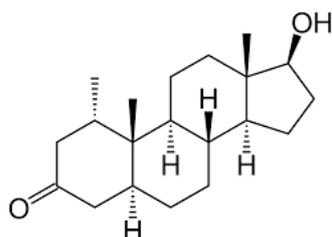


Figure 27. Chemical structure of mesterolone. Formula: $C_{20}H_{32}O_2$.

- Fighters involved in doping with mesterolone
- 1. Oleksandr Doshkalchuk tested positive for mesterolone following an out-of-competition test conducted on 6 June 2020.
Sanction time: 14 months.

3.1.26. Methandienone (Figure 28)

Physiological effect: Androgen and anabolic steroid [35]. Provides a significant, continuous, cumulative and lasting physical advantage in sports competitions by creating larger and stronger bones, greater muscle mass and strength, and increased circulating hemoglobin.

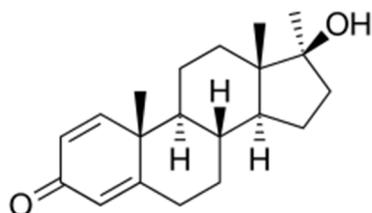


Figure 28. Chemical structure of methandienone. Formula: $C_{20}H_{28}O_2$.

- Fighters involved in doping with methandienone
- 1. Jesse Ronson tested positive for methandienone following an out-of-competition test conducted on 22 July 2020.
Sanction time: 20 months.

3.1.27. Modafinil (Figure 29)

Physiological effect: Neuro stimulant [36]. Its effect on performance has been little researched but based on its effects it is believed to improve endurance and explosiveness.

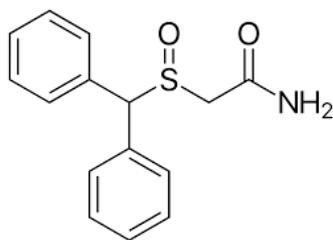


Figure 29. Chemical structure of modafinil. Formula: $C_{15}H_{15}NO_2S$.

- Fighters involved in doping with modafinil.
1. Ryan Benoit tested positive for modafinil following an out-of-competition test conducted on 14 October 2020.
Sanction time: 2 years.

3.1.28. Nandrolone (Figure 30)

Physiological effect: Muscle growth, appetite stimulation and increased red blood cell production [37]. Provides a significant, continuous, cumulative and lasting physical advantage in sports competitions by creating larger and stronger bones, greater muscle mass and strength, and increased circulating hemoglobin.

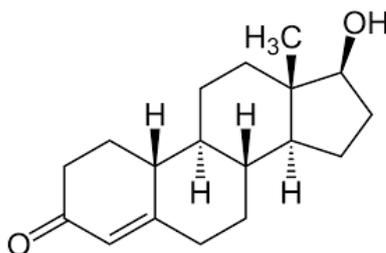


Figure 30. Chemical structure of nandrolone. Formula: $C_{18}H_{26}O_2$.

- Fighters involved in doping with Nandrolone.
1. Ricardo Abreu tested positive for nandrolone following an out-of-competition test conducted on 21 December 2016. It was the second time he failed to comply with anti-doping policies. The first time was during an out-of-competition test conducted on 3 June 2016; on this occasion, he received 2 years of sanction.
Sanction time: 4 years.

3.1.29. 19-Norandrosterone (19-NA) (Figure 31)

Physiological effect: Anabolic-androgenic steroid [38]. Provides a significant, continuous, cumulative and lasting physical advantage in sports competitions by creating larger and stronger bones, greater muscle mass and strength and increased circulating hemoglobin.

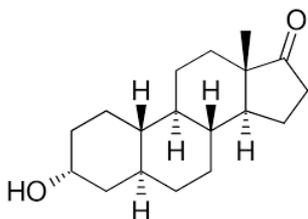


Figure 31. Chemical structure of 19-norandrosterone. Formula: $C_{18}H_{28}O_2$.

- Fighters involved in doping with 19-norandrosterone (19-NA).

1. Isabela de Padua tested positive for 19-norandrosterone (19-NA) following an out-of-competition test conducted on 19 November 2019 and 19 December 2019. Sanction time: 2 years.

3.1.30. Ostarine (Figure 32)

Physiological effect: Increase in mass muscle [31]. Provides a significant, continuous, cumulative and lasting physical advantage in sports competitions by creating larger and stronger bones, greater muscle mass and strength and increased circulating hemoglobin.

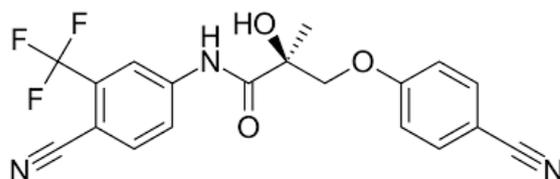


Figure 32. Chemical structure of ostarine. Formula: $C_{19}H_{14}F_3N_3O_3$.

- Fighters involved in doping with ostarine.
1. Carlos Diego Ferreira tested positive for ostarine following an out-of-competition test conducted on 29 April 2016. USADA demonstrated that this was due to contamination. Sanction time: 17 months (reduced due to contamination).
 2. Tim Means tested positive for ostarine following an out-of-competition test conducted on 21 January 2016. USADA demonstrated that this was due to contamination. Sanction time: 6 months (reduced due to contamination).
 3. Ruslan Magomedov tested positive for ostarine following an out-of-competition test conducted on 7 September 2016. Then, Magomedov tried to deceive USADA, claiming that this was caused by a sample of contaminated supplement, but he failed. Sanction time: 2 years.
 4. Zubaira Tukhugov tested positive for ostarine following an out-of-competition test conducted on 7 September 2016. Then, Tukhugov tried to deceive USADA, claiming that this was caused by a sample of contaminated supplement, but he failed. Sanction time: 2 years.
 5. Guido Cannetti tested positive for ostarine following an out-of-competition test conducted on 5 October 2016. USADA demonstrated that this was caused by contamination. Sanction time: 10 months (reduced due to contamination).
 6. Tom Lawlor tested positive for ostarine following an out-of-competition test conducted on 10 October 2016. Sanction time: 2 years.
 7. Josh Barnett tested positive for ostarine following an out-of-competition test conducted on 9 December 2016. USADA demonstrated that this was caused by contamination. Sanction time: None but received a public reprimand for his anti-doping policy violation.
 8. Amanda Ribas tested positive for ostarine following an out-of-competition test conducted on 7 June 2017. USADA demonstrated that this was caused by contamination. Sanction time: 2 years.
 9. Jim Wallhead tested positive for ostarine; however, after Wallhead delivered the information to USADA about the dietary supplement product he was using at the time of the sample collection on 7 October 2017, it was established that this was caused by contamination. Sanction time: 9 months (reduced due to contamination).
 10. Augusto Mendes tested positive for ostarine following an out-of-competition test conducted on 7 March 2018. USADA demonstrated that this was caused by contamination. Sanction time: 6 months (reduced due to contamination).
 11. Marvin Vettori tested positive for ostarine following an out-of-competition test conducted on 6 August 2018. USADA demonstrated that this was caused by contamination.

- Sanction time: 6 months (reduced due to contamination).
12. Sean O'Malley tested positive for ostarine following an out-of-competition test conducted on 5 September 2018. USADA demonstrated that this was caused by contamination. Sanction time: 6 months (reduced due to contamination).
 13. Nicco Montano tested positive for ostarine following an out-of-competition test conducted on 25 October 2018. USADA demonstrated that this was caused by contamination. Sanction time: 6 months (reduced due to contamination).
 14. Thibault Gouti tested positive for ostarine following an out-of-competition test conducted on 12 March 2019. USADA demonstrated that this was caused by contamination. Sanction time: 6 months (reduced due to contamination).
 15. Sean O'Malley tested positive for ostarine following an out-of-competition test conducted on 6 August 2019 and 12 August 2019. Sanction time: 6 months.
 16. Diego Sanchez tested positive for ostarine and S-23 following an out-of-competition test conducted on 12 December 2019. Then, it was proved that the cause was a contaminated supplement. Sanction time: 3 months.
 17. Ovince Saint Preux tested positive for ostarine, LGD-4033 and GW1516 following an out-of-competition test conducted on 1 November 2019. Then, it was proved that the cause was a contaminated supplement. Sanction time: 3 months.
 18. Rachael Ostovich-Berdon tested positive for ostarine and GW1516 following an out-of-competition test conducted on 3 January 2020. Sanction time: 1 year.
 19. Lara Fritzen Procopio tested positive for ostarine following an out-of-competition test conducted on 17 February 2020. Sanction time: 6 months.
 20. Marc-Andre Barriault tested positive for ostarine following an in-competition test conducted on 20 June 2020. Sanction time: 6 months.
 21. Andre Ewell tested positive for ostarine following an out-of-competition test conducted on 15 October 2020. Sanction time: Public warning.
 22. Elizeu Zaleski dos Santos tested positive for ostarine following an out-of-competition test conducted on 14 March 2022. Sanction time: Public warning.

3.1.31. Ozone (Figure 33) Therapy (Blood Transfusion)

Physiological effect: Disinfects and treats disease [39]. Ozone therapy consists of drawing blood, enriching it with a mixture of ozone and oxygen and then reintroducing it into the veins, which will give the fighter a greater reserve of oxygen during fights.

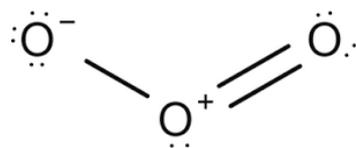


Figure 33. Chemical structure of ozone. Formula: O₃.

- Fighters involved in doping with ozone therapy.
1. Ion Cutelaba tested positive for ozone therapy following an out-of-competition test conducted on 18 October 2017. USADA determined that, for Cutelaba's violation, a reduction to six months from the standard two-year period of ineligibility was an appropriate sanction according to the rules. Sanction time: 6 months.

3.1.32. Recombinant Human Erythropoietin (rHuEPO)

Formula: $C_{815}H_{1317}N_{233}O_{241}S_5$.

Physiological effect: Stimulation of erythroid progenitors [40]. It stimulates the production of red blood cells in the bone marrow and regulates the concentration of red blood cells and hemoglobin in the blood. Red blood cells carry oxygen to cells, including muscle cells, enabling them to function more efficiently.

- Fighters involved in doping with Recombinant Human Erythropoietin.
 1. TJ Dillashaw tested positive for recombinant human erythropoietin following an in-competition test conducted on 18 January 2019. Sanction time: 2 years.
 2. Dmitrii Smoliakov tested positive for recombinant human erythropoietin following an out-of-competition test conducted on 22 April 2019 and an in-competition test on 27 April 2019. Sanction time: 2 years.

3.1.33. Stanozolol (Figure 34)

Physiological effect: Agonist of the androgen receptor [41]. It is used to increase muscle mass and strength.

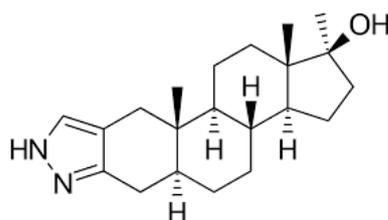


Figure 34. Chemical structure of stanozolol. Formula: $C_{21}H_{32}N_2O$.

- Fighters involved in doping with stanozolol.
 1. Viscardi Andrade tested positive for stanozolol following an out-of-competition test conducted on 17 March 2016. Sanction time: 2 years.
 2. Carlos Felipe Cabral de Almeida tested positive for stanozolol following an out-of-competition test conducted on 29 July 2017. Sanction time: 2 years.
 3. Amanda Lemos tested positive for stanozolol following an out-of-competition test conducted on 8 November 2017. Sanction time: 2 years.
 4. Mairbek Taisumov tested positive for stanozolol following an out-of-competition test conducted on 15 September 2018; however, after Taisumov delivered the information to USADA about the dietary supplement product he was using at the time of the sample collection, it was established that this was caused by contamination. Sanction time: 6 months (reduced due to contamination).
 5. Istela Iane Nunes Souza tested positive for stanozolol following an out-of-competition test conducted on 22 July 2019. Sanction time: 2 years.
 6. Sarah Frota Lima tested positive for stanozolol following an in-competition test conducted on 27 July 2019. Sanction time: 2 years.
 7. Sarah Jessica Penne tested positive for stanozolol following an out-of-competition test conducted on 8 April 2019. Sanction time: 20 months.
 8. Jorge Gonzalez Villa tested positive for stanozolol and drostanolone following an out-of-competition test conducted on 5 August 2020. Sanction time: 2 years.

9. Erik Koch tested positive for stanozolol following an out-of-competition test conducted on 3 October 2020.
Sanction time: 18 months.

3.1.34. Tamoxifen (Figure 35)

Physiological effect: Antineoplastic agent [42]. It is often claimed that estrogen blockers can help you build muscle faster by increasing your testosterone levels.

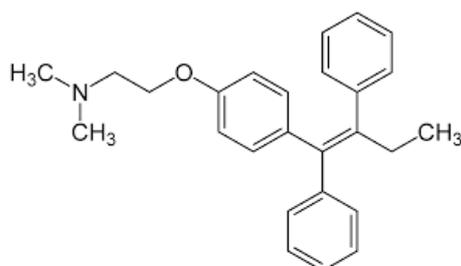


Figure 35. Chemical structure of tamoxifen. Formula: C₂₆H₂₉NO.

- Fighters involved in doping with tamoxifen.
 1. John Allan Arte tested positive for tamoxifen following an in-competition test conducted on 13 July 2019.
Sanction time: 1 year.
 2. Abu Azaitar tested positive for tamoxifen following an out-of-competition test conducted on 25 August 2020, 4 September 2020, 9 September 2020 and 17 September 2020.
Sanction time: 7 months.
- Fighters involved in doping with Tamaxifen, Boldenone, Methandione, drostanolone and clenbuterol.
 1. Mirko Filipovic tested positive for Tamaxifen, Boldenone, Methandione, drostanolone and clenbuterol following an out-of-competition test conducted on 11 August 2016.
Sanction time: 2 years.

3.1.35. Exogenous Testosterone (Figure 36)

Physiological effect: Long-acting, selective, and non-peptide agonist of the ghrelin receptor and a growth hormone secretagogue [43]. Provides a significant, continuous, cumulative and lasting physical advantage in sports competitions by creating larger and stronger bones, greater muscle mass and strength and increased circulating hemoglobin.

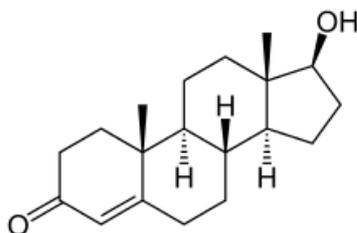


Figure 36. Chemical structure of testosterone. Formula: C₁₉H₂₈O₂.

- Fighters involved in doping with exogenous testosterone.
 1. Ben Rothwell tested positive for exogenous testosterone following an out-of-competition test conducted on 6 February 2017 and 15 February 2017.
Sanction time: 2 years.
 2. Geraldo Augusto de Freitas tested positive for exogenous testosterone following an out-of-competition test conducted on 14 October 2020.
Sanction time: 2 years.

3.1.36. Tetrahydrocannabinol (Figure 37)

Physiological effect: β 2 adrenoreceptor agonist [44]. It distorts the user's perception of reality; for example, an athlete may perceive an increase in performance and a decrease in fatigue versus a real decrease in performance in strength and endurance activities during the fight.

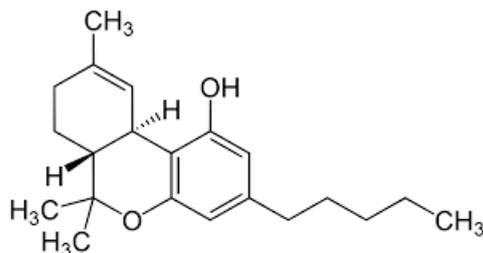


Figure 37. Chemical structure of tetrahydrocannabinol. Formula: $C_{21}H_{30}O_2$.

- Fighters involved in doping with tetrahydrocannabinol.
 1. Diego Brandao tested positive for tetrahydrocannabinol following an in-competition test conducted on 2 January 2016 at UFC 195. Sanction time: 9 months.
 2. Nate Diaz tested positive for tetrahydrocannabinol following an in-competition test conducted on 20 August 2016 at UFC 202.

Sanction time: None, but he received a public reprimand for his anti-doping policy violation.

3. Kelvin Gastelum tested positive for tetrahydrocannabinol following an in-competition test conducted on 11 March 2017. Sanction time: 6 months.
4. Cynthia Calvillo tested positive for tetrahydrocannabinol following an out-of-competition test conducted on 30 December 2017. Sanction time: 6 months.
5. Alen Amedovski tested positive for tetrahydrocannabinol following an in-competition test conducted on 20 April 2019 at Fight Night 149. Sanction time: 6 months.
6. Kelvin Gastelum tested positive for tetrahydrocannabinol following an in-competition test conducted on 3 November 2019. Sanction time: 6 months.

3.1.37. Trenbolone (Figure 38)

Physiological effect: Androgen and anabolic steroid [45]. Fighters use it to improve muscle strength and increase strength. The drug creates huge amounts of muscle tissue and increases the synthesis of proteins within the body.

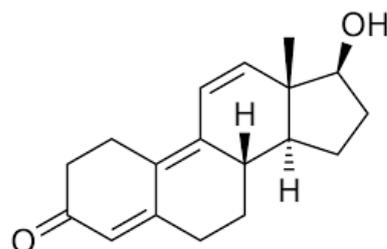


Figure 38. Chemical structure of trenbolone. Formula: $C_{18}H_{22}O_2$.

- Fighters involved in doping with Trenbolone.

1. Fabricio Werdum tested positive for trenbolone following an out-of-competition test conducted on 25 April 2018.
Sanction time: 2 years.

3.1.38. Use of Prohibited Method

- Fighters involved in doping via a prohibited method.
 1. USADA determined that on 2 June 2017 and 3 November 2017, Paulo Costa received an intravenous (IV) infusion of allowed substances, including saline and a stomach medicine, of more than 100 mL for a 12 h period after weighing for UFC 212 and UFC 217, respectively.
Sanction time: 6 months.
 2. USADA determined that, out of competition, BJ Penn on 25 March 2016 received an intravenous (IV) infusion of allowed substances of more than 50 mL for 6 h.
Sanction time: 6 months.

3.2. Ratio of Positive of Prohibited Substances by Year

It can be seen in Table 1 that the ratio of positive results to anti-doping tests performed by USADA on UFC competitors has varied over time, having its peak at the beginning of the program with a value of 1.223 in 2016, and reducing to 0.231 so far in 2022.

Table 1. Percentage of positive of prohibited substances by year.

	Quarter 1	Quarter 2	Quarter 3	Quarter 4	TOTAL
2015					
Tests carried out	-	-	81	272	353
Positive tests	-	-	0	3	3
Percentage of positive tests	-	-	0%	1.102%	0.849%
2016					
Tests carried out	450	535	683	621	2289
Positive tests	8	8	6	6	28
Percentage of positive tests	1.777%	1.495%	0.878%	0.966%	1.223%
2017					
Tests carried out	634	778	744	662	2818
Positive tests	6	2	7	8	23
Percentage of positive tests	0.946%	0.257%	0.940%	1.208%	0.816%
2018					
Tests carried out	721	674	703	790	2888
Positive tests	1	3	6	8	18
Percentage of positive tests	0.138%	0.445%	0.853%	1.012%	0.623%
2019					
Tests carried out	1094	1085	1058	1059	4296
Positive tests	6	9	9	8	32
Percentage of positive tests	0.548%	0.829%	0.850%	0.755%	0.744%
2020					
Tests carried out	1027	437	961	1132	3557
Positive tests	4	3	8	6	21
Percentage of positive tests	0.389%	0.686%	0.832%	0.530%	0.590%
2021					
Tests carried out	1140	1069	1076	1057	4342
Positive tests	4	1	2	4	11
Percentage of positive tests	0.350%	0.093%	0.185%	0.378%	0.253%
2022					
Tests carried out	1083	1075	-	-	2158
Positive tests	3	2	-	-	5
Percentage of positive tests	0.277%	0.186%	-	-	0.231%

3.3. Top Rank Fighters Tested without Anti-Doping Violations

The anti-doping program seeks to ensure clean competition among the fighters and to this end, during the year in competition or out of competition, different tests are performed. It is important to point out that there are some fighters who are tested more than others and, despite this, have not failed any doping test. Table 2 presents information on the most tested fighters, along with their current MMA fight record.

Table 2. Number of negative tests for anti-doping violations in top-rank fighters.

	2015	2016	2017	2018	2019	2020	2021	2022	TOTAL
Misha Cirkunov	0	10	9	7	9	8	27	12	82
Jose Aldo	8	6	8	11	19	9	13	4	78
Amanda Nunes	1	11	9	13	12	9	14	8	77
Kamaru Usman	2	6	9	6	13	6	17	14	73
Dustin Poirier	4	7	10	9	11	10	15	5	71
Rafael Dos Anjos	6	11	11	11	8	7	6	7	67
Holly Holm	7	10	15	6	12	7	5	5	67
Frank Edgar	3	7	11	9	10	4	9	11	64
Donald Cerrone	5	6	8	14	14	6	7	3	63
Stipe Miocic	2	11	12	11	9	5	8	5	63
Conor McGregor	8	11	6	11	7	8	11	0	62
Daniel Cormier	4	11	13	16	9	6	3	0	62
Derrick Lewis	0	9	7	10	8	9	13	5	61
Rose Namajunas	2	6	12	8	7	5	10	11	61
Francis Ngannou	1	3	11	8	13	7	9	9	61
Dominik Cruz	1	14	10	8	10	6	6	6	60
Israel Adesanya	0	0	0	9	13	13	13	11	59
Glover Teixeira	4	5	11	6	6	9	9	9	59
Robbie Lawler	4	10	11	8	9	5	8	4	59
Brian Ortega	1	8	9	9	6	6	10	10	59
Neil Magny	3	6	10	8	8	5	5	13	58
Tecia Torres	2	8	14	7	7	8	7	5	58
Max Holloway	1	6	9	10	12	5	7	8	58
Aljamain Sterling	1	9	12	6	8	5	7	9	57
Stephen Thompson	0	12	11	7	11	6	6	4	57
Cody Garbrandt	0	11	11	7	8	4	12	4	57
Edson Barboza	3	9	10	10	8	5	6	5	56
Michelle Waterson	1	7	10	9	8	7	7	6	55
Jessica Eye	5	7	6	6	6	10	10	5	55
Rob Font	0	5	9	4	5	7	16	9	55
Valentina Shevchenko	0	7	12	8	6	7	8	6	54
Jessica Andrade	0	4	11	7	11	7	7	6	53
Justin Gaethje	0	0	10	10	9	11	6	7	53
Chris Weidman	4	9	9	6	8	5	7	4	52
Jiri Prochazka	0	0	0	0	0	5	11	36	52
Henry Cejudo	2	6	10	11	10	2	0	10	51
Andrei Aslovski	3	7	8	8	6	4	8	7	51
Carla Esparza	0	7	11	8	8	6	5	6	51
Colby Covington	1	4	5	12	7	6	7	7	50
Khabib Nurmagomedov	0	9	11	10	9	9	2	0	50
Joanna Jedrzejczyk	3	9	9	8	6	5	6	4	50
Jorge Masvidal	1	3	8	4	8	6	7	12	49
Derek Brunson	0	5	11	8	6	8	7	4	49
Tyron Woodley	1	12	8	10	8	7	2	0	48
Martin Vettori	0	3	2	4	11	9	12	7	48
Deiveson Alcantara	0	0	4	7	8	9	10	6	44
Figueiredo	1	4	4	5	10	7	12	5	48
Gilbert Burns	0	1	9	8	9	6	8	7	48
Curtis Blaydes	1	5	8	6	6	4	10	6	46
Julianna Pena	1	7	12	8	5	8	5	0	46
Joseph Benavidez	1	2	7	4	8	7	12	5	46
Jan Blachowicz	0	2	4	3	9	7	12	8	45
Jared Cannonier	0	2	4	3	9	7	12	8	45

4. Discussion

Ostarine has been found in 22 cases as a contaminant of supplements; USADA has incorporated it into the high-risk list so that for future purchases, athletes know that this product with that brand has a history of contamination and that supplements are recommended which are certified by laboratories accredited by USADA. With this strategy, the products that generated contamination problems are no longer easily purchased. In the case of clomiphene, the circumstance is different, since it could be demonstrated in most cases that a positive result was caused by meat contaminated with clomiphene, both in China and in Mexico. This entails strict measures in the feeding of athletes during

events developed in those countries. Three other components of the USADA website include Therapeutic Use Exemptions (TUE), which explains step by step how to proceed to request a TUE due to medical treatment necessary for the athlete, in coordination with the attending physician. The Drug Reference Phone Line is a telephone line that provides information about prohibited substances and helps athletes make safe purchasing decisions. Finally, when it comes to an operation, a “surgery checklist” is also provided to check the medications that will be used. Although USADA provides detailed information on the website and develops specific training for athletes of various disciplines, in the case of MMA, there have been many cases of initial doping due to contamination; however, it is trusted that the amount will decrease as the system is implemented. A relevant aspect of this comprehensive strategy is that it must be analyzed and carried out by other MMA companies. From a regional perspective, there are several companies and MMA tournaments in which there is no doping control, which makes it urgent to start with concrete measures that reduce the use of substances that give athletes an advantage and can consequently generate the greatest damage to others. There are some reported cases that detail how, by using more modern methods of detection, certain substances can be detected, and that they had even come out negative and that when evaluated with modern methods, they were found to be positive. Future research will determine whether a martial artist’s performance decreases after positive doping has been detected.

It is important to see that the doping ratio has decreased from 2015 to 2022, which shows that the UFC USADA program has been effective. Regarding the top-ranked fighters tested with no anti-doping violations, it is important to note that the list includes several world champions such as Jose Aldo [46], Amanda Nunes [47], Kamaru Usman [48], Dustin Poirier [49], Rafael Dos Anjos [50], Holly Holm [51], Stipe Miocic [52], Conor McGregor [53], Daniel Cormier [54], Rose Namajunas [55], Francis Ngannou [56], Dominik Cruz [57], Israel Adesanya [58], Glover Teixeira [59], Robbie Lawler [60], Max Holloway [61], Aljamain Sterling [62], Cody Garbrandt [63], Valentina Shevchenko [64], Chris Weidman [65], Jiri Prochazka [66], Henry Cejudo [67], Andrei Aslovski [68], Carla Esparza [69], Khabib Nurmagomedov [70], Joanna Jedrzejczyk [71], Tyron Woodley [72], Deiveson Alcantara Figueiredo [73], Julianna Pena [74] and Jan Blachowicz [75].

Despite the various findings of positive doping results, there are new techniques used to evade testing, and one of these is gene doping. Gene therapies developed for the treatment of diseases such as anemia (the erythropoietin gene), muscular dystrophy (the insulin-like growth factor-1 gene) and peripheral vascular diseases (the vascular endothelial growth factor gene) are potential doping methods, and it is necessary to develop timely legal regulations and research the field of gene doping to develop detection methods [76,77]. However, gene doping has been more frequently described in sports based on horse movements [78,79]. Doping is not solely a sporting issue; it also has a social impact because it generates distrust among people who may end up seeing a sport as a space for cheating, which goes against the very meaning of sport. On the other hand, it has economic effects because the sponsors behind an athlete see their income and reputation damaged in the case of positive doping. It also generates institutional damage, as it affects the credibility and seriousness of sports federations [80]. There are very few reported cases of cannabinoid use, but there is always a debate that these substances do not really generate a competitive advantage for the fighter. However, it is pertinent to point out that the fact that these substances are on the prohibition list is explained by the disinhibitory effect that consumption generates; the level of danger perception decreases, so there is a much greater risk of the fighter suffering physical damage during a competition [44,81,82].

The main damage caused by doping is usually cardiovascular [83–85] and cerebral [86,87], which will put the athletes’ lives at risk during their professional careers and even when they retire. Athletes must be very careful when purchasing food and vitamin supplements [88,89], as they are often a source of contamination, leading to positive doping tests. For this reason, the USADA has created a program to endorse certain brands of multivitamins so that athletes can purchase with confidence. However, as ex-

plained above, these products have also been reported as a cause of positive doping due to contamination, although these cases are very limited.

Strategies That Are Being Developed to Reduce Cases of Positive Doping

Many dietary supplements may contain prohibited ingredients, even those not listed on the label. The only way to be 100% safe from supplements is to not use them. USADA has always recommended that athletes use only dietary supplements that have been certified by a third-party program that tests for the presence of banned substances in sport. If athletes choose to use supplements, despite the risks, it is important that they only use certified supplements, which are listed below and identified on the UFC Prohibited List. In this regard, as part of the collaborative strategy between USADA and UFC, a substance search facility is available at <http://ufc.globaldro.com/> (accessed on 1 October 2022) for fighters to find out whether the substance in question is banned. Among the most consulted substances are trenbolone, cannabis, paracetamol, testosterone and caffeine; information is also available at the link www.supplement411.org (accessed on 1 October 2022). In relation to the detection of banned substances, they are looking to implement testing hours before the fight to detect any substance used at the last minute by the fighters. Therefore, education programs for competitors are needed to improve their food consumption and dietary habits [90].

5. Conclusions

Not all cases in which martial artists leave a fight imply that they are guilty of positive doping. That is why there is a complementary investigation, and only after that process will you have a clear idea whether there has been a violation of the doping policy. The information presented in this article can serve as a basis for the implementation of regional and local measures in MMA events and organizations.

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