



## Genetic Doping in Sports: A Biological and Legal Examination!

Prathyusha Samvedam<sup>1\*</sup>, Hiranmaya Nanda<sup>2</sup>

<sup>1</sup>Research Scholar, KIIT Law School, Bhubaneswar, Odisha

<sup>2</sup>Associate Professor, KIIT School of Law, Bhubaneswar, Odisha & KIIT, School of Law, Prasanti Vihar, Patia, Bhubaneswar, Odisha Email: [hiranmaya.nanda@kls.ac.in](mailto:hiranmaya.nanda@kls.ac.in)

\*Corresponding author's E-mail: [prathyushasamvedam@gmail.com](mailto:prathyushasamvedam@gmail.com)

Article History	Abstract
Received: 06 June 2023 Revised: 05 Sept 2023 Accepted: 13 Nov 2023	<p><i>Doping is commonly perceived as a moral and ethical violation. This matter is of global significance. Doping is the illicit use of certain substances and methods to enhance sports performance and stamina. This is accomplished by consuming these medications, which enhance the body's ability to supply a larger quantity of oxygenation to the muscles. However, the ingestion of these chemicals has a multitude of detrimental effects on an individual's well-being, encompassing but not restricted to infections, allergies, cardiovascular diseases, ischemic stroke, pulmonary embolism, hypertension, acne, male erectile dysfunction, and disturbances in women's menstrual cycles. Therefore, doping can directly impact sporting events. The ongoing development of novel drug delivery techniques presents a formidable obstacle to the battle against doping, rendering it progressively arduous for experts to detect these chemicals and medications. The government must remain updated on the latest advancements in chemicals and pharmaceuticals, and implement steps to regulate their usage to ensure fair competition. This article aims to comprehensively examine the practices of gene doping in athletics, with a specific emphasis on their biological and legal examination.</i></p>
CC License CC-BY-NC-SA 4.0	<b>Keywords:</b> Gene Doping, Biological, health, Sports

### 1. Introduction

Human nature demands that in the presence of intense competition, individuals are inclined to make efforts to obtain an advantage over their opponents. The extensive background of doping in sports serves as a prominent illustration of this occurrence<sup>1</sup>. The practice that originated over 2000 years ago in the Ancient Greek Olympics gradually evolved into more recent times when the utilization of chemicals like alcohol, cocaine, and amphetamines into the world of sports in the first part of the twentieth century.<sup>2</sup> Subsequently, athletes have resorted to employing more advanced methods of doping, such as blood doping, to illicitly enhance their performance. Globally, individuals have been introduced to the concept of human augmentation in sports, as certain players strive for an advantage in achieving triumph, fame, and monetary gain. Historically, progress in pharmacology and physiology has facilitated the use of doping and cheating in sports. The recent advancement in gene therapy has enabled the manipulation of genetic functions that impact typical human attributes, such as athletic ability. This progress has offered the necessary concepts, methods, and opportunities for genetic alteration, which some individuals may view as justified. The convergence of science and sport gives rise to essential ethical and policy concerns that cannot be resolved by either field without a more comprehensive social discussion. With the advancement of science and growing worries from sports and antidoping authorities, it is now opportune to examine the impact of genetic advancements on sports, which have unfolded in unforeseen ways over the past decade.<sup>3</sup>

### Background of doping

The use of performance-enhancing pharmaceuticals to gain a competitive advantage is commonly regarded as a modern problem. Greek Olympic athletes, who were skilled individuals participating in the games for both prestige and significant monetary rewards, were motivated to explore different performance-enhancing substances to surpass their competitors.<sup>1</sup> The chemicals utilized encompassed herbal mixtures like wine, brandy, psychedelic mushrooms, and even bovine testicles since they held the belief that it would augment their velocity and power. It is important to mention that fraud in the

ancient Olympic Games was severely forbidden and resulted in harsh penalties, such as servitude. To enhance the speed of their horses, chariot racers would administer a beverage known as mead, which is produced by the fermentation of honey, due to the substantial financial stakes involved. In addition, they would ingest herbal stimulants before competitions to counteract weariness and surmount the discomfort caused by injuries, thus augmenting their performance.

In the 19th and early 20th centuries, the advancement of modern medicine encouraged elite sportsmen in swimming, cycling, and long-distance sprinting to use particular doping mixtures to gain an advantage over their competitors<sup>5</sup>. These custom formulations comprised a specific combination of ingredients such as brandy, caffeine, cocaine, and heroin. The objective of these concoctions was to diminish exhaustion, augment cognitive focus, curb hunger, and lessen the uneasiness linked to physical effort. The use of these doping formulations was deemed acceptable by the Sports Federation until the mid-1920s. After events in which numerous notable athletes were on the verge of losing their lives during contests, the Government interfered and enforced restrictions to restrict the usage of drugs.<sup>6</sup>

The creation of methamphetamine was first accomplished by a Japanese scientist in 1919 to develop a more powerful and easier-to-manufacture version of prior methamphetamine medications obtained from the Chinese herb Mao hang. Moderate dosages of methamphetamine have been found to elevate mood, enhance cognitive concentration, reduce appetite, increase energy levels, and facilitate weight loss. Nevertheless, when used in larger quantities, the medication can induce schizophrenia, seizures, muscle weakness, and aggressive behaviour.

The International Olympics Committee implemented its first drug-testing program throughout the 1968 Winter Olympics in Grenoble, France, and the Summer Olympics in Mexico. Nevertheless, the lack of a dependable technique for identifying anabolic steroids resulted in their exclusion from the roster of banned compounds. As a result, athletes continued to use anabolic steroids without any obstacles. Despite the legal prohibition of narcotics in competitions by the International Olympic Committee in 1975, the 1970s and 1980s saw an ongoing conflict between IOC laboratory testers and athletes who turned to performance-enhancing chemicals, as reliable testing for anabolic steroids was being developed.

In 2008, the World Anti-Doping Agency (WADA) established the definition of Gene Doping as the manipulation of cells to alter genetic components or control gene expression to improve athletic performance. Gene doping is presently in the experimental stage, and its scientific components are linked to unpredictable results. Nevertheless, if gene doping becomes a feasible therapy, athletes are expected to be in the vanguard of individuals who aspire to alter their DNA to attain enhanced size, speed, and strength.<sup>7</sup>

## **Biological analysis of gene doping**

### ***Genetic doping***

Gene therapy is a medical approach that addresses disorders by substituting, altering, or adding functional genes to the body. The origins of this research can be traced back to scientists' quest for therapeutic interventions for ailments such as muscular dystrophy, diabetes, & and similar hereditary disorders.<sup>4</sup> Research on gene therapy has been conducted for several decades, however, recent advancements have significantly enhanced the efficacy of gene transfer. Athletes are intrigued by the promise of gene therapy approaches to enhance performance, as demonstrated by the notable achievements in the medical profession.<sup>3</sup>

Gene therapy is a scientific process that entails the injection of artificial genes into muscle cells, which then integrate seamlessly with the recipient's DNA. This integration leads to various beneficial effects such as slowing down muscle atrophy, accelerating metabolism, and enhancing muscle mass. In experiments conducted on mice, gene therapy resulted in the development of "marathon mice" that exhibited increased running distance and endurance compared to mice that did not receive the therapy. Furthermore, the genetic modification in mice not only improved their endurance but also prevented idle mice that were fed a high-fat diet from becoming obese. The genes are fundamentally vital<sup>4</sup>.

Both blood doping and the usage of EPO aim to elevate the concentration of oxygen-carrying haemoglobin in the bloodstream, hence enhancing endurance. Dr. Lee Sweeney has conducted experiments using genes that encode insulin-like growth factor one (IGF-1), a substance that facilitates muscle growth and regeneration.<sup>5</sup> The genes enhance muscle growth by augmenting the production of IGF-1 beyond normal levels and are delivered into the body through a harmless virus. Such advancements hold promise for metabolic disorders like obesity and heart disease but also present a strong allure for athletes seeking rapid muscle gain and improved endurance. Despite significant

progress in recent years, gene therapy is still in its nascent stage of application to humans. It remains highly experimental, with potential adverse effects yet to be determined. There is concern that long-term cancer risks may arise, although many athletes may be willing to accept this risk for the immediate benefits the technology offers.

The risks of gene therapy were illustrated in clinical trials conducted in France. Eleven boys underwent successful gene therapy to restore the missing proteins necessary for proper immune system functioning. Unfortunately, three of the boys developed leukaemia, and one of them passed away. Most studies on gene therapy have been carried out on mice, which have a lifespan of approximately two years. Consequently, the mice died before the long-term effects of the therapy could be observed. However, a twenty-year-old athlete who utilizes gene therapy to enhance athletic performance has a significantly longer life expectancy, allowing for the potential manifestation of long-term effects.

### ***Doping detection tools***

The traditional methods for detecting doping in sports have generally relied on either the chemical or molecular characterization of the doping agent or the observation of indicators that reflect the physiological or metabolic impacts generated by the substance. Both of these approaches have their advantages and disadvantages.<sup>4</sup> The chemical assays for corticosteroids and stimulant drugs, the molecular characterization of exogenous erythropoietin, and the identification of abnormally high erythropoietin-induced red blood cell formation due to outside exposure are some examples of illustrative cases.<sup>2</sup> Even if this method is straightforward and uncomplicated, there is a continuing demand for additional tests to address molecular changes. These changes make specificity more difficult to detect, increasing the potential for doping abuse. The concept that pharmaceutical formulations are chemical, biological, or genetic and can cause significant changes in metabolism, genetics, and proteomics led to the development of another detection method that can be more effective than before. Currently, advanced methods such as chromatographic and metabolomic analysis, as well as microarray technology and sequence-based transcriptome profiling can determine whether or not these mutations occurred these methods can be used by a person's history of drug exposure of internal doping, chemical classification or to provide a precise determination of the molecular "signature" associated with the method Even in the absence of knowledge or testing for specific doping substances, these fingerprints can be used to identify disrupted physiological systems. This is possible because these fingerprints are like biological fingerprints. This methodology is quite similar to the approach that is typically employed in the search for molecular indicators of the development of cancer, developmental abnormalities, and associated illnesses.<sup>3</sup>

### ***Doping Control Administration***

Testing is undertaken both during and outside of competitive events. In the context of competitive events, the selection process for testing can occur in various ways, such as randomized selection depending on the finishing place or targeted selection for specific reasons.<sup>4</sup> Out-of-competition testing allows for the testing of athletes at any location without prior notification. An athlete may undergo doping tests at any given moment, regardless of whether they are participating in a competition or not.

### ***Types of Testing***

Two categories of testing are conducted to detect doping.<sup>3</sup>

1. Urinalysis
2. Haematological analysis

The specimen should be gathered in the presence of a trainer or doctor, escorted by an authority of the respective gender. The specimen is bisected and safeguarded by the athlete. After adhering to the prescribed program, the athlete will subsequently fulfil the medical declaration. The samples are sent to a licensed laboratory facility, where they undergo thorough scrutiny. Upon obtaining positive results from the samples, the athlete is promptly notified. The subject or their authorized representative is allowed to be onsite during the procedure of unsealing the item and conducting the testing.

### ***Haematological analysis***

Blood analysis is employed to identify the existence of a protein called Erythropoietin (EPO) or synthetic oxygen carriers. Two specimens are collected under the supervision of an approved individual and are securely secured in the presence of the sportsman. The technique for both tests is the same. The testing period begins 12 hrs before the competition for the athlete who is participating. Assessments are conducted in competitive settings on both a global and domestic level. Moreover, before the Olympics, the International Committee of the Olympics conducts certain tests, while the International Federation

is responsible for testing in the Vault championship. National anti-doping organizations are in charge of testing at the national level.

### ***Testing conducted outside of competitive events***

It refers to the evaluation of an athlete's performance outside of official competitions, specifically focusing on their immediate involvement in the event. This process is conducted by doping control agencies at both the international and national levels.<sup>5</sup> WADA has the authority to conduct unannounced random tests at any location or during working hours.

### ***Negative consequences of gene doping***

Gene doping poses significant risks and can have negative consequences for maintaining good physical condition and well-being. The primary problems arise from recurrent usage of gene doping. However, the long-term outcome is currently uncertain due to the impacts of gene use. Furthermore, there is a potential danger associated with altering the physical form of the body. The utilization of gene therapy may also exert an influence on the upcoming generations. One significant issue arises from the genetic transfer carrier used for doping, which can be synthesized in unregulated laboratories. The DNA which can be easily and affordably synthesized using components acquired from authorized vendors, may become contaminated with chemicals and contaminants throughout the manufacturing and purifying processes<sup>4</sup>.

Moreover, the introduction of contaminated DNA into the runner's body can result in the proliferation of infectious viruses. People who intentionally boost the overall Erythropoietin (EPO) stages, boosting the density of red blood cells, heighten their susceptibility to strokes and heart attack as a result of the subsequent clotting of the blood. As the viscosity of blood increases, the body faces greater difficulty in efficiently circulating it to all tissues. This leads to the development of clots in regions where blood arteries are unable to adjust to the heightened density. Although modern athletes who use synthetic EPO face similar risks, these concerns decrease after a few weeks when the body expels EPO protein & and synthesis returns to normal levels. Administering erythropoietin (EPO) using gene therapy presents challenges in regulating the synthesis of EPO in respect of both volume and duration. Controlling the haematocrit would provide a challenge and might continue forever, resulting in abnormal levels of erythropoietin (EPO).

### **Legal implications of gene doping**

Organizations are responsible for preventing and detecting the use of performance-enhancing drugs in sports.

***The World Anti-Doping Agency (WADA)*** is a foundation headquartered in Canada that was created under the International Olympic Council. The main goal is to promote, coordinate, and supervise initiatives aimed at combating the utilization of performance-enhancing substances in sports. The main duties of WADA encompass research, education provision, advancement of anti-doping methodology, and supervision of conformity with the anti-doping rule.<sup>6</sup>

- Peptide hormones, growth factors, substances with similar properties, and compounds that imitate their effects.
- Beta-2 agonists.
- Pharmaceutical substances that affect hormone levels and metabolic processes.
- Diuretics along with concealing substances.

### ***WADA's Policies for Doping***

Annually, Wada releases a catalogue of prohibited substances. Additional testing is necessary to guarantee that no competitor is free from drug inquiries. Furthermore, nocturnal testing was used to deter the utilization of substances that enhance performance. WADA classifies any substance or procedure as doping and therefore prohibits it if it can enhance or improve sports performance. It presents a concrete or potential danger to the athlete. It violates the fundamental nature of athletics. Genetic or other types of enhancements are strictly forbidden as they would infringe upon the ideals of fair competition, compromise the character of the athlete, and weaken the fundamental nature of sports.

### ***The National Anti-Doping Agency (NADA)***

The National Anti-Doping Agency is responsible for overseeing and managing the doping control program in the sports sector of the country. The aim is to advocate for the promotion of sports in India

that are free from the use of drugs. NADA's main responsibilities encompass the enforcement of anti-doping rules, the development and execution of anti-doping policies, the improvement of testing endeavours, and the promotion of research and education in the anti-doping domain. NADA is responsible for conducting examinations at events.

Athletes are subject to stringent accountability under Anti-Doping standards, which require them to stay informed about the chemicals they consume. However, certain athletes in India may lack education and awareness regarding substances that constitute doping.

Furthermore, during training camps, athletes are obliged to consume the food provided to them. Consequently, even if their coaches or trainers provide such chemicals, the athletes willingly ingest them.

### ***NADA policies on Gene Doping***

The NADA plays the leading role in protecting India against sports doping. It makes use of an all-encompassing approach which entails multi-faceted factors. The present research note focuses on the policies of the NADA and its drive to impart awareness among the athletes and other support staff concerning the dangers associated with illegal drugs and how best to steer clear from their use and, therefore, curb doping. For instance, NADA is the leading authority that controls doping procedures within all the national contests in India, as well as for foreign events. WADA doping tests confirm that standards have been met. They use both targeted and random testing methods. NADA has the power to penalize athletes who are convicted of doping, including suspensions from competing, losing eligibility to participate in future sporting events, as well as, losing their medals and records won. However, NADA widens its authority to embrace all coaches who aid in administering performance-enhancing substances to athletes, a move that further supports this broad approach. There are various explanations as to why athletes may take banned substances including in order to better their performance, win medals, unawareness over prohibited substances and being subjected to such demands by coaches or peers. Anti-doping policies must be made stringent. At the same time, the hidden motivations should be acknowledged and addressed as well. NADA is actively involved in outreach initiatives and educational programmes that aim to raise awareness about the dangers of doping and emphasise the importance of equitable competition. By increasing support staff and athlete awareness, NADA seeks to eradicate the underlying factors that motivate individuals to engage in doping. In conclusion, the NADA employs a comprehensive strategy that encompasses education, vigilance, strong enforcement of anti-doping regulations, and stringent enforcement to tackle the intricate problem of doping in Indian sports. Amidst the pervasive presence of gene doping and the continuous development of doping techniques, the NADA continues to prioritise its steadfast dedication to a sporting environment that is both pure and ethical.

### **4. Conclusion**

Gene therapy is a groundbreaking medical method, however, there is a possibility of its misuse through gene doping. The gene therapy employed by the injured athletes would continue to significantly impact the game. The identification of gene doping would need a meticulous procedure, necessitating the expansion of the current system of both in and out-of-competition testing. Identifying gene doping will impose greater scrutiny on sports governance compared to existing doping methods. The detection technique must be based on solid principles to minimize any potential legal complications that may occur as a result. Existing doping detection technologies are insufficient in identifying gene doping, thus necessitating continuous progress in research and technology.

Research in sociology, behaviour, and ethics is necessary to address the specific implications of gene doping. Since gene therapy is an innovative medical procedure, there is a possibility of its misuse through gene doping. The gene therapy employed by the wounded athletes would continue to significantly impact the game. The identification of gene doping would necessitate a meticulous procedure, requiring the expansion of the current system of both in and out-of-competition testing. The identification of gene doping would impose greater scrutiny on sports governance in comparison to existing doping methods. The detection technique must be based on solid grounds to minimize potential legal complications. The existing techniques for detecting doping are insufficient in identifying gene doping, thus necessitating continuous progress in research and technology. Research into gene doping necessitates the exploration of sociological, behavioural, and ethical aspects.

**Conflict of Interest:** Being a conflict-free author free from other influences and prejudices is a freeing experience that lets me concentrate only on the search of information and the truth. It's a pledge to write with absolute neutrality. Hence there is no conflict of interest.

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