

SPORT AND EXERCISE PHYSIOLOGY: PERFORMANCE-ENHANCING SUBSTANCES - ANABOLIC STEROIDS

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Summary

This article examines the effects of anabolic steroids on health and performance. The discussion includes the history of anabolic steroid use in sports, mechanism of action of the drugs, side effects, doping control, and legal and ethical considerations. Anabolic steroids are drugs that resemble the male hormone testosterone. Athletes use them to gain weight, strength, power, speed, endurance, and aggressiveness. Testosterone was synthesized in 1934 and its use has been controversial ever since. Steroids were used as a tool by the both sides during the Cold War to further national athletic agendas. Professional and amateur sports organizations have taken proactive steps to prevent drug use through comprehensive testing programs. In spite of these efforts, we continue to have a constant stream of drug scandals in sports. Steroids improve physical performance and body composition, provided the dose is high enough. Side effects increase with dose. Most side effects are minor, but steroid use might cause heart disease, cancer, and premature death in some people. While steroids are no more unnatural than weight machines or fiberglass poles, they are contrary to goals of sport in the society and should be discouraged.

1. Introduction

This section describes the scope of the article.

Dozens of “how to” books and websites on anabolic steroids are available on the Internet. The *Underground Steroid Handbook* by Dan Duchaine, originally published in 1981, was the first of many books on steroids that were based largely on personal experience and word of mouth from bodybuilders and weight trained athletes. This is understandable because there was little research on the performance enhancing effects or side effects of these drugs in athletes. The existing studies used low doses that did not improve performance.

That has changed. Thousands of studies and research reviews give us a clearer picture of the effects of these drugs and their side effects. Historical documents from the former Soviet Union and East Germany, the Mitchell report on drug use in Major League Baseball in the United States, and anecdotal reports from athletes and coaches from throughout the world provide a clearer picture of widespread anabolic steroid use in sport before the advent of comprehensive doping control. This article will help scientists, coaches, athletes, and health professionals understand the science and history behind this controversial subject.

Anabolic steroids are drugs that resemble the male hormone testosterone. Athletes use them to gain weight, strength, power, speed, endurance, and aggressiveness. They are widely used in athletics, bodybuilding, weightlifting, and American football. Increasingly, men and women who do not play sports use steroids to improve physical appearance. Even school-aged children use them. Studies of children around the world found that about four to eight percent of adolescents have tried the drugs; one quarter of these children are non-athletes.

Athletes take anabolic steroids because they increase strength, muscle size, and power. Although they can sometimes have serious side effects, the lure of making rapid gains in strength, power, and muscle size make these drugs irresistible to many athletes.

Almost all governing bodies of amateur and professional sports ban steroids. Athletes, active people, coaches, and scientists should know as much as possible about training, nutrition, and supplements to maximize performance without resorting to drugs.

2. Anabolic Steroids: Historical Perspective

2.1. Historical Perspective

Research on testosterone began more than 125 years ago. Specialization in sport has made these drugs a major issue.

Drug use to improve performance is almost as old as sport itself. Ancient Greek athletes used a variety of concoctions to improve performance. Inca warriors in South America chewed coca leaves before doing battle in the rarified air of the Andes. At the turn of the century, athletes often breathed supplemental oxygen to improve endurance. Athletes,

such as boxers and soccer players, got a boost by drinking a cocktail composed of strychnine, brandy, and cocaine.

The roots of testosterone research reach back to ancient times. Farmers learned that castrated animals had reduced sex drives and were more docile. Royalty in Persia employed castrated men called eunuchs to guard the harem because they had reduced sex drives. Modern scientific research on testosterone began in 1889 when 72-year old French scientist Brown-Sequard reported that testicular extracts of dogs and guinea pigs made him feel younger and more virile. His report triggered widespread use of testicular extracts in Europe and North America for more than 30 years. We have no report that athletes used the preparations but they were widely heralded as a health tonic, so it is possible that some athletes used them to improve performance.

Ernest Laqueur isolated testosterone from bull testes in 1934 and received the Nobel Prize for his discovery in 1935. This started a lively debate in the medical community regarding testosterone replacement therapy that continues to this day. The early interest in testosterone centered on its effect on libido and sexual performance.

During World War II, the German and American armies experimented with testosterone (testosterone propionate) to improve performance. In 1951, scientists discovered that testosterone could increase lean muscle mass, which made it a serious candidate as a performance-enhancing drug.

After World War II, international athletic competitions became the cold war surrogates to the battlefield. Eastern and Western bloc countries squared off on the playing fields, ice rinks, basketball courts, and running tracks. Countries poured money into athletics in the hope of promoting their political agendas. Victory was the only acceptable outcome for both sides. In this climate, widespread drug use to improve performance was almost inevitable.

Excesses in drug use in sport began to catch up with the athletes. Between 1960 and 1963, the public became disgusted with a series of drug related deaths in cycling, boxing, and track and field. Many people felt that athletic drug use threatened all sports, undermining the very foundations of the Olympic ideal.

The International Olympic Committee (IOC) began to formulate its anti-doping policies in the 1960s. Their basic philosophy was to 1) protect the athletes' health, 2) defend medical and sports ethics, and 3) provide an equal chance for all in a competition. In 1968, the IOC began the first large-scale drug-testing program at the Grenoble winter Olympics and the Mexico City summer Olympics.

The early history of athletic drug testing was controversial and inconsistent. During the early years, amphetamines and anabolic steroids were the most common banned drugs used by athletes. While amphetamines were easily measured, anabolic steroid assays were more difficult and expensive. Gradually, anabolic steroid detection became very sophisticated. Drug testing methods were limited by their sensitivity and specificity and the predictability of doping control schedules at major championships.

The obvious answer was random tests. Unfortunately, the Cold War limited equal access to athletes in Eastern and Western bloc countries. Doping officials had to rely on surprise tests at competitions, such as the Pan American Games held in Caracas in 1983.

That all ended with the close of the Cold War. Beginning in the late 1980s, the IOC instituted random drug testing of elite athletes. Athletes were expected to inform officials of their location and be prepared to submit a urine sample within 48 hours at any time. If they refused, they would be treated as though they tested positive for banned drugs and would receive sanctions. Sanctions ranged from reprimands to permanent exclusion from sport.

In the United States, professional baseball and the National Football League introduced drug-testing programs in 2004 to stem the tide of drug use in sports. In December of 2007, the Mitchell Report— commissioned by the Commissioner of Major League Baseball at the request of the U.S. Congress— concluded that drug use was widespread at all levels of the sport:

“For more than a decade there has been widespread illegal use of anabolic steroids and other performance enhancing substances by players in Major League Baseball, in violation of federal law and baseball policy. Club officials routinely have discussed the possibility of such substance use when evaluating players. Those who have illegally used these substances range from players whose major league careers were brief to potential members of the Baseball Hall of Fame. They include both pitchers and position players, and their backgrounds are as diverse as those of all major league players.”

2.2. State-Sponsored Doping Research Program in Former Soviet Union

The State Central Institute of Physical Culture in Soviet Union published a highly classified document that outlined the State-sponsored Soviet research on steroids and recommendations for use steroids in sports.

The former Soviet Union began participating in the Olympic Games after World War II, beginning with the Helsinki games in 1952, and soon achieved a dominant position in these sporting competitions. The success of Soviet athletic programs was astounding. It was one of the most successful sport programs of all time. One of the sports in the Helsinki games where Soviet athletes did exceptionally well was weight lifting, with the Soviets winning three gold, three silver, and one bronze -medals.

Following the Helsinki Olympic Games, the United States Olympic weightlifting coach, Bob Hoffman, accused the Soviet weight lifters of taking hormones to increase strength. This public charge was corroborated by one of the Russian team physicians to the United States weight-lifting physician, Dr. John Ziegler, during the 1954 World Weightlifting Championships in Vienna. Rumors abounded during the 1956 Olympic Games in Melbourne, Australia, that competitors in the weight lifting and throwing events used androgens.

One of the most damaging Soviet scandals occurred in 1984 at the International Athletics Meet of Paris when Tatiana Kazankina, one of the best track and field athletes ever produced in the Soviet Union, was suspended for life for refusing to submit to a drug test for anabolic-androgenic steroids. These long-standing suspicions of testosterone use by the Soviet athletes were abundant in the Western literature. Nevertheless, even in light of scandals involving Soviet athletes caught doping, no one was able to obtain documentation of State collusion.

Suspicion of anabolic-androgenic steroid use by athletes in the former USSR was rampant as early as the 1960s. Although anecdotal reports continued, steroid use by certain Soviet athletes cannot be considered proof of the existence of State sponsored research and conspiracy. Athletic success in Olympic games provided extensive privileges in the USSR for the elite athletes, coaches, scientists and sport officials. These privileges included prestige at the state level, expensive gifts, cars, apartments, state stipends, increased salaries, and extensive travel abroad.

The security measures that could be used routinely in totalitarian societies are difficult to appreciate in Western countries. During the 1940s through the 1980s, authorities in those totalitarian countries would have punished any scientist, journalist, athlete or coach who published revelations about steroid use in elite sport.

In 1972, the State Central Institute of Physical Culture published a classified document that outlined the Soviet research on steroids and recommendations for use steroids in sports. The document contains a series of scientific reports providing the times and dosages for the administration of androgenic-anabolic steroids to human subjects (athletes) and data from experiments conducted at the Research Laboratory of Training Programming and Physiology of Sport Performance of the State Central Institute of Physical Culture in Moscow. It contains the following subsections: “Introduction”, “Anabolics and Endurance”, “Anabolics and Strength”, “Anabolics and Sport Performance”, “Anabolics and Sport Results”, “Dosages of the Anabolics”, “Possible Adverse Effects”, “Control of Use”. There is no evidence in any of the research reports that treatments of the athletes with anabolic-androgenic steroids adhered to the guidelines of human treatment for research (use of informed consent, institutional review boards, etc.). It is obvious from the State Central Institute of Physical Culture’s report that experiments with anabolic-androgenic steroids using athletes as subjects had occurred in the former USSR by 1971 to 1972 or earlier.

All orders to organize and finance such research were given in a highly centralized system. Research into the medical and biological aspects of sport was an integral part of the athletic agenda in the former Soviet Union. It was conducted in more than 28 State Institutes of Physical Education and State Research Institutes of Physical Culture. It is unlikely that crucial decisions about financing and implementation of research programs on androgenic-anabolic steroids by the State Central Institute of Physical Culture in Moscow were made without the knowledge and consent of governmental officials.

Some may argue that androgenic-anabolic steroid use is widespread and that the current situation in the West is no different from what occurred in the former Soviet Union. There is, however, an important difference between East Germany, the former USSR,

and Western countries in this regard. In the West, governments do not finance human subject research on steroids to enhance athletic performance. Use of these substances is prohibited and not encouraged. Athletes who choose to use steroids are doing so on their own initiative, without the support or consent of government agencies.

The document from the State Central Institute of Physical Culture made clear that within the former USSR, there was a completely different situation - a government sponsored scientific effort, which apparently did not follow the accepted norms for treatment of human subjects. By governmental agencies circulating the research report among elite State Sport Institutions in the former Soviet Union, sport officials, coaches and athletes were being advised, recommended, and encouraged to use androgenic-anabolic steroids. In East Germany, for example, it was reported that it was mandatory for any athletes who wanted to participate in the 1988 Seoul Olympics to take anabolic-androgenic steroids.

The classified document described in this article proves the existence of state-sponsored studies on the effect of anabolic-androgenic steroids on athlete's morphological, biochemical, physiological variables and athletic performance conducted in the former Soviet Union. The studies were performed in the Research Laboratory of Training Programming and Physiology of the Sport Performance at the State Central Institute of Physical Culture in Moscow, and could not have been enacted and financed without government orders. Recommendations for steroid use for different sports were given, particularly for elite athletes specializing in endurance and strength-dependent sports. Ethical considerations do not appear to have been important, as informed consent does not appear to have been obtained and high doses were recommended for weightlifters.

The results and recommendations obtained from these studies on androgenic-anabolic steroids were secretly circulated among elite sport institutions in the former USSR. This information was classified and accessible only to selected professionals.

3. How Anabolic Steroids Work

Anabolic steroids have anabolic (tissue building) and androgenic (sex-linked) effects.

Male hormones, mainly testosterone, partly cause the tremendous increase in height, weight, and muscle mass that occur during puberty and adolescence. The hormones have androgenic and anabolic effects. Androgenic effects are changes in primary and secondary sexual characteristics. These include the enlargement of the penis and testes, voice changes, hair growth on the face, underarms, and genital areas, and increased aggressiveness. The aggressive behavior of teenage boys is at least partly due to increased testosterone levels. The anabolic effects of androgens include accelerated growth of muscle, bone, and red blood cells, and faster conduction of nerve impulses.

Pharmaceutical companies make anabolic steroids to boost their tissue building properties (anabolic effects) and reduce their effects on sexual tissues (androgenic effects). However, it is impossible to create a purely anabolic steroid—one with no sexual side effects. The androgenic effects are really anabolic effects in sex-linked

tissues. The effects of male hormones on accessory sex glands, genital hair growth, and oiliness of the skin are anabolic processes in those tissues. The steroids with the most powerful anabolic effects are also those with the greatest androgenic effects.

In women, side effects merely reflect the normal action of the hormone. Facial hair growth, increased sexual desire, deepening of the voice, and enhanced aggressiveness are natural and desirable effects of androgen hormones in men. However, they may be unacceptable in women. Women who take these drugs must balance the increased muscle mass and power they get with undesirable sexual side effects.

3.1. Steroid Receptors

Androgens bind to receptors in the cells, which triggers protein synthesis in the cell nuclei.

Steroid hormones work by binding to receptor molecules, which activate specific genes to synthesize proteins. This process works very much like a lock and key. The key—the anabolic steroid— binds with a testosterone receptor—the lock, which begins a process that makes new proteins. The result of this process depends on the target cell. In muscle, steroids stimulate hypertrophy. Oil production increases in oil-secreting glands in the face. Steroids stimulate hair follicles to grow hair, and so on. Steroids increase the production of muscle growth factors (IGF-1) that is very important for increasing muscle size.

Large doses of steroids promote muscle hypertrophy, even without weight training. Combining steroids and high intensity training magnifies the gains. Most research studies show that steroids work best in experienced weight lifters who use heavy weights and produce high muscle tension during exercise. The effectiveness of anabolic steroids is dependent upon unbound receptor sites in muscle. Intense strength training increases the number of unbound receptor sites. More receptor sites make anabolic steroids more effective. Diets high in protein and calories may also be important in increasing the effectiveness of anabolic steroids.

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Biographical Sketches

Thomas Fahey received B.A and M.A. degrees in physical education from San Francisco State University and an Ed.D. from the University of California, Berkeley. He is the author of 19 books and more than 600 refereed journal and magazine articles. Thomas Fahey is also a masters level discus thrower. He is a professor of Kinesiology at California State University, Chico.

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Michael Kalinski received B.S. degrees from Kyiv Institute of Physical Education and Schevchenko National University, M.S. degree from Uzhorod University and Ph.D. from Palladin Research Institute of Biochemistry all in Ukraine.

Dr. Kalinski has served as a Chair of the Department of Exercise Biochemistry, as Research Vice-President of Kyiv State Institute of Physical Culture, Coordinator of Physical Education and Exercise Science programs at the School of Exercise, Leisure & Sport at Kent State University, and Chair of the Department of Applied Health Science at Murray State University. Dr. Kalinski is an author of 12 research monographs and textbooks and 80 refereed journal articles. Dr. Kalinski served as a Chair of the Exercise Physiology Symposium at the 14th Commonwealth International Sports Sciences Congress in 2010, as a Chair of Exercise Biochemistry Symposium at International Convention on Science, Education and Medicine in Sport, ICSEMIS 2012, as a session Chair at the XVI International Scientific Congress "Olympic Sports and Sports for All" & VI International Scientific Congress "Sport, Stress, Adaptation", 2012. Dr. Kalinski is a member of Editorial Boards of six scientific journals in Europe and Asia. He is Fulbright Scholar, Honorary Professor and Honorary Doctor of Bukovinian State Medical University, Life member of National Association of Physical Education and Sport Science, India.