

# **Young Athletes, Sports, and Performance Enhancing Drugs**

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## **Overview**

In a frequently referenced 1997 Sports Illustrated article, aspiring Olympians were asked 2 questions; “If you were offered a banned performance-enhancing substance that guaranteed that you would win an Olympic medal and you could not be caught, would you take it?” Remarkably, 195 of 198 athletes said yes. The second question was: “Would you take banned performance-enhancing drug with a guarantee that you will not be caught, you will win every competition for the next 5 years, but then will die from adverse effects of the substance.” Over 50% of the athletes said yes to this question as well.

Driven by the popularity of sports and athletes’ drive to succeed, the use of ergogenic (performance enhancing) drugs is at all time high in the United States today. Fifty-seven percent of high school students play on formal sports teams, and 1-3 million US athletes nationally are taking some form of performance enhancing drugs. Many of these athletes are youths who use these substances without knowledge of their risks and potential benefits. This article summarizes the current literature regarding performance enhancing drugs including their use, effects, potential risks, and current legal standing.

## **History and Society**

A landmark date in performance-enhancing drugs involves the discovery in 1889 by Dr. Brown-Sequard in France that he could partially reverse the degenerative ailments in his 72 year-old body by injecting himself with the extracts of dog and guinea pig testicles. The discovery of hormones in 1905 and testosterone in 1935 soon followed. The Russian and United States’ weight lifting teams began using steroids in the 1950s, and the decades that followed have seen more widespread use of performance enhancing drugs. More recently, scandals have surfaced involving Olympic athletes in track and field (Ben Johnson 1988, Marion Jones 2000), professional cycling (Floyd Landis 2006), and professional baseball (Barry Bonds 2006, Andy Pettitte and Roger Clemens 2008), to cite just a few examples.

Many factors place pressure on young athletes to use performance enhancing drugs. The recent steroid investigations suggest to young athletes a more direct link between steroids or other drugs and record-breaking performances. In addition, the desire of the viewing public for sports has increased exponentially as evidenced by the ever increasing capacity of collegiate sport stadiums, the increase in televised high school and Little League all-star games, and internet discussions on talented sporting youth as young as junior high. Finally, the pressure to obtain coveted collegiate sport scholarships worth as much as \$200,000 in tuition costs has been a self-reported factor in the use of performance-enhancing drugs at the high school level. Thus, it comes as little surprise that multiple studies have shown the incidence of steroid use in high school to range from 4-11% in boys and up to 3% in girls.

## **Anabolic Steroids**

### **Physiology**

Anabolic steroids are synthetic derivatives of the hormone testosterone. They are modified to maximize their anabolic (muscle building) effects while minimizing their androgenic (male sexual characteristics) effects. Recently, there has been increasing attention paid to “designer steroids”, which are simple chemical modifications of known banned steroids that will not be detected in existing testing protocols. Referred to in the media as “the cream” and “the clear” in relation to the Bay Area Laboratory Co-Operative (BALCO) investigation surrounding major league baseball player Barry Bonds, these steroids are presumed to have similar effects to those of more commonly studied anabolic steroids.

Steroids can be taken orally, injected, or absorbed through the skin, and exert their effects by promoting a positive nitrogen balance in muscle (i.e. muscle building), while also preventing the breakdown (catabolic effect) of muscle that can occur with overtraining.

### **Dose and Performance Effects**

Steroids are generally taken in 4-12 week cycles, and are often combined or “stacked” with other steroids taken at the same time in a pyramid type dosing schedule. Typically this causes athletes to have 50-100 times the normal physiologic concentration of steroids in their body. Between cycles, users typically have a “drug holiday” or abstinence period of varying duration.

There is a research consensus that steroids, when combined with weight training, do result in objective gains in muscle size and strength as well as an increase in fat-free mass. However, while the muscle may be strengthened, the accompanying tendon does not increase in strength and may actually decrease in strength, leading to muscle strains and ligament tears. Aerobic gains (better conditioning) are generally not observed with steroid use.

### **Adverse Effects**

From a cardiovascular perspective, there is an association between steroid use and an increase in blood lipids; specifically a decrease in high density lipoprotein (HDL, the “good” cholesterol). Additionally, steroids cause a dysfunction in the lining of blood vessels that can predispose these vessels to constrict and/or clot, resulting in potential heart attacks or strokes. When taken in large doses, the additional steroid also is converted to estrogen, which can lead to male gynecomastia (breast enlargement), premature balding, and acne. Psychologically, steroid use may cause severe mood swings from depression to mania and aggression. Finally, there is a documented association between steroid use and other high-risk behaviors such as driving under the influence, carrying weapons, use of marijuana or alcohol, and engaging in unsafe sexual practices. Whether these adverse effects are reversible is unknown, and likely depends on the duration and amount of use.

## Legal Aspects

Anabolic steroids are available only with a prescription and are banned for use other than in the treatment of a disease. Most sporting organizations including the International Olympic Committee (IOC), the NCAA, the NFL and the NBA, have banned their use.

## **Human Growth Hormone**

### Physiology

Growth hormone (GH) is secreted by the pituitary gland in the brain. Its secretion peaks in adolescence, and then gradually decreases. Growth hormone is converted in the liver to insulin-like growth factor 1 which increases protein synthesis in muscle, increases fat breakdown, and leads to increased bone growth. Children deficient in GH are short in stature, while patients with conditions that are characterized by an over-abundance of GH have the clinical condition known as gigantism.

### Performance Effects

There is little research to suggest that GH has any performance-enhancing effect. In support of this, patients with gigantism (excess of GH) often have weaker muscles as a result of GH-induced myopathy. GH does increase lean body mass, but it does so by decreasing subcutaneous fat stores and not by any muscle-enhancing effect. For this reason, it has some appeal to individuals who desire a leaner, more toned appearance. However, due to ethical limitations in studying the effects of high dose GH on adults, there have been few quality research studies on its performance-enhancing effects.

### Adverse Effects

From experience in treating patients with gigantism, it is known that high levels of GH over long periods of time can lead to weak muscles (myopathy), water retention, insulin resistance, and hypertension.

## Legal Aspects

Growth hormone is banned by all major sporting leagues and is available only through a doctor's prescription. However, no reliable test is available to detect its use by athletes.

## **Amphetamines/Ephedra**

### Physiology

Amphetamines and other related stimulants are chemically related to the catecholamines, i.e. adrenaline. Ephedra has a similar chemical structure, and is derived from ephedra herbs known as ma huang. They stimulate the release of norepinephrine from sympathetic nerves giving the user a feeling of an "adrenaline" rush by increasing blood pressure, causing mood elevation, and increased alertness. They have been popular with baseball players, pilots, and truck drivers.

## Performance Effects and Dosing

Previously available ephedrine compounds included the brands Metabolife356 and Ripped Fuel. Pseudoephedrine, a closely related compound, is available in over-the-counter (OTC) cold remedies as a nasal decongestant. While some studies have shown that high doses of amphetamines or ephedra can aid in improving speed and strength while increasing fat loss, other studies have failed to support these findings. However, the doses needed to give performance-enhancement pose significant risks to athletes.

## Adverse Effects

The use of amphetamines and ephedra have been associated with numerous side-effects including anxiety, high blood pressure, cardiac arrhythmias, stroke, heart attacks, hallucinations, and even death. A 2000 study evaluated all 140 adverse events of the drug reported to the Food and Drug Administration (FDA) from 1997 to 1999. Included in these 140 events were 10 deaths and 13 cases of permanent disability. These events were followed by the high profile deaths of Minnesota Vikings offensive lineman Korey Stringer in 2001 and Baltimore Orioles pitcher Steve Bechler in 2003, both of which were linked to the use of ephedra.

## Legal Aspects

In 2004, the FDA removed ephedra from the market. Additionally, the IOC, NCAA, Major League Baseball, NBA, and NFL have also banned the use of ephedrine products.

## Erythropoietin and Blood Doping

### Physiology and Performance Enhancement

Endurance athletes are particularly sensitive to the oxygen-carrying capacity in their blood. The more blood cells available (called red blood cells) to carry oxygen, the more oxygen is available to the muscles. Better oxygenated muscles are able to work longer and more efficiently, thereby giving the endurance athlete a competitive advantage. This advantage has been exploited naturally by athletes in the past by training at high altitudes. At high altitudes, there is less oxygen in the air. The body compensates by increasing the amount of red blood cells available to carry oxygen, thereby offsetting the lower oxygen concentration in the air. When these athletes returned to lower altitudes, they retained the increased red blood cells, and thereby had more oxygen carrying capacity than they otherwise would have had if they trained at low altitude.

Erythropoietin is a hormone naturally produced in the kidney that causes bone marrow to produce more red blood cells. The drug EPO is an artificially produced drug nearly identical to the natural form, that when taken, causes an increase in red blood cell production.

## Adverse Effects

Artificially increasing the amount of red blood cells causes an increase in the viscosity or thickness of the blood. This increased viscosity can lead to an increased risk of blood clotting leading to pulmonary emboli (clots in the lungs), heart attacks, and stroke.

## Legal Aspects

The drug EPO is available only by a physician's prescription. It is not legal in any sport. However, because it is a naturally occurring body hormone and because its effect is an increase in blood counts (which can normally vary from athlete to athlete), its detection has been extremely difficult. Because of this, many sport governing bodies have issued an upper limit for red blood cell mass for athletes in competition.

## Creatine

### Physiology

Creatine was introduced in 1992, and since has become the most popular nutritional supplement, with US sales over \$300 million dollars. Creatine is made from 3 common amino acids and naturally occurs in the body with the highest concentration in skeletal muscle. When combined with phosphorus in muscle to form phosphocreatine, it provides muscle with its major energy source during short duration/high intensity exercise (<1 minute duration). It is phosphocreatine that is the limiting factor in short, high-intensity exercise (such as weight lifting or a short sprint). Studies on oral creatine show supplementation can cause a ~20% increase in muscle phosphocreatine stores. This can quicken the replenishment of phosphocreatine during recovery from exercise and lessen the acid buildup in muscle that often occurs during short duration/high intensity exercise. Both of these mechanisms delay the onset of muscle fatigue.

### Performance Effects and Dosing

Creatine is usually taken in a loading phase, with athletes consuming 5 grams 4 times per day for the first 4-6 days. The dose is then decreased to 2 grams/day for the next 3 months. A month of abstinence is typically practiced before starting another cycle.

Research on creatine has generally involved small numbers of athletes in well controlled studies in activities such as weight lifting and short sprints. In weight lifters, maximal weight lifts and number of repetitions at a specific weight both increased significantly, as did lean body mass. In sprinters, sprint times have generally decreased 1-2%. However, nearly 30% of athletes do not see benefits with creatine use, thereby falling into a category of "nonresponders" who are theorized to have already maximal phosphocreatine stores in the muscles.

## Adverse Effects

Athletes who take creatine commonly experience weight gain of 1.6-2.4 kg, which can be counter-productive in pure speed based athletic events. Dehydration may also occur if 6-8 glasses of water are not taken per day during supplementation. Other common side-effects include minor stomach discomfort and muscle cramps. There have

been two cases in the literature of kidney function compromise, both of which were transient with full recovery noted. Other questions remain unanswered, such as the effect on other tissues that store creatine including the heart and brain.

### Legal Aspects

Creatine is a legal nutritional supplement. However, some medical organizations including the American College of Sports Medicine has recommended that it not be used by any athlete under age 18.

## Androstenedione

### Physiology

Androstenedione is the immediate precursor to testosterone and estrone (an estrogen-like steroid) in the human body. It has been postulated that if the concentration of andro is increased, it will allow for the increased conversion to testosterone, a natural steroid. Thus, andro is marketed as a supplement that can raise testosterone levels in the blood and functions as a natural alternative to anabolic steroids. It gained popularity after Major League baseball player Mark McGuire admitted to using it during his historic 1998 chase of Roger Maris's single-season home run record.

### Performance Studies

No study has shown a significant performance-enhancing effect with andro supplementation. While studies have failed to show a significant change in testosterone levels, they have confirmed increased estrone/estrogen levels in male individuals. Increased estrogen levels in males have the opposite effect on performance.

### Adverse Effects

As andro shares a metabolic pathway with testosterone and anabolic steroids, they do share several common adverse effects. They tend to decrease HDL cholesterol levels and downregulate the natural production of testosterone in the body. Also, impurities during production can introduce illegal substances, thereby placing athletes at risk for testing positive for a banned substance.

### Legal Aspects

The 2004 Steroid Control Act designated andro a controlled substance available only with a prescription. Andro is now banned by all major sporting leagues, the Olympics, and collegiate sports.

## Nutritional Supplements

The list of nutritional supplements available is so large that even a partial listing of such products is beyond the scope of this article. However, a general understanding of the research behind such products is crucial to make informed health choices. The 1994 Dietary Supplement Health and Education Act has had many important implications in this regard. For any nutritional supplement, FDA approval is not necessary for a supplement to reach the marketplace (unlike a prescription drug). Additionally, manufacturer claims do not need to be proven before appearing on labels; such claims

require only a disclaimer that there is a “lack of proof.” The burden of proof in establishing that these claims are false falls solely on the FDA, not the manufacturer.

This lack of regulation in the supplement marketplace can place athletic consumers at significant risk. To illustrate this point, a 2001 study sampled capsules from every bottle of 12 supplement brands. Each capsule was then carefully analyzed for its composition. Eleven of the twelve brands contained less than the stated dose of their product, with 2 brands containing none of the stated ingredient. Remarkably, one brand contained testosterone which, as a steroid, would place the athlete at risk for failing a drug test. Thus, caution should be exercised when considering use of these legal, over-the-counter supplements, as the manufacturing and efficacy standards are not the same as those used in prescription pharmaceuticals.

## Summary

Multiple studies have proven that substances that improve performance, or even perceived to improve performance, are widely used by athletes. To combat the use of these drugs requires both changes to the rules/testing procedures as well as improved educational initiatives. A better understanding of these drugs and their side-effects by athletes, coaches, and staff is critical to counteract the potent marketing influence applied by drug manufacturers as well as the powerful drive of athletes seeking a competitive advantage.