Not all athletes play by the rulebook. Many resort to drugs to enhance their performances. Apart from ethical implications of these substances there are serious potential negative health effects too.

In January this year, an Indian woman weightlifter was banned for life and five others suspended for four years for doping offences. But this was just the most recent incident in a series of shocking doping related acts that have become part and parcel of today’s highly competitive sporting arena.

One of the most sensational cases was that of Ben Johnson who was stripped of his 100 m gold medal from the Seoul Olympic Games in 1988 after he admitted to having taken a cocktail of drugs containing Recombinant Growth Hormone (rhGH).

Taking drugs to enhance performances has always been considered a short cut to sporting glory. This is the reason these drugs are also called Performance Enhancing Drugs (PEDs). The “win at all costs” mentality fuels athletes to seek performance-enhancing drugs to gain an advantage over their opponents.

PEDs have been a part of sports activities since as early as 776 B.C. when Olympians used substances such as mushrooms, dried figs and strychnine. Later heroin, cocaine & morphine were also used.

The word “doping” was used in the 1860s for horse racing that consisted of opium and narcotics.

Ancient Greek athletes used a variety of alleged performance enhancing drugs, such as plant extracts and testicular extracts.

Austrian physiologist Oskar Zoth was the first person to propose injecting athletes with a hormonal substance. In 1896 he described how the use of an “extract” could improve muscular strength.

Bodybuilders and athletes began using testosterone to increase muscle mass in the 1940s and 1950s.

In 1974 the International Olympic Committee banned the use of testosterone and its derivatives.

The exceptional athletic performance of the East German female swimmers in 1976 Montreal Olympics brought further public attention to anabolic steroid use.

The potential performance enhancing benefits of testosterone precursors were brought to attention in 1998 when major league baseball player Mark McGwire openly admitted to using androsteredione.

Ben Johnson was stripped of his 100 m gold medal from the Seoul Olympic Games in 1988, he admitted to having taken a cocktail of drugs containing Recombinant Growth Hormone (rhGH).

rGh was so popular with athletes that the 1996 Atlanta Olympics was known informally as rhGH games.

A Chinese swimmer, Yuan Yuan was forced to withdraw from 1998 world championship in Perth, Australia after 13 vials of rhGH were discovered in her suitcase at Sydney airport.

Jesse Gelsinger died in 1999 as a victim of an immune response to the virus used in a well-publicized gene therapy.

At the 2000 Olympic games in Sydney a coach from Uzbekistan was caught with a supply of rhGH.

The sprinter Tim Montgomery (former 100 m world record holder) admitted using rhGH in 2001.

A physician prescribed rhGH to several players on the Carolina Panthers football team during the team’s 2003 championship season.

More recently, actor Sylvester Stallone was formally convicted of importing 48 vials of rhGH to Australia.
What are PEDs?

"Any substance taken in non-pharmacological doses specially for the purpose of improving sports performance" could be classified as a PED. This may include prescription medicines, nutritional supplements or illicit substances that individuals use to increase their strength, speed or to control weight or alter body composition.

Anabolic Steroids

Anabolic steroids at supra physiological (greater than normally present in the body) doses increase strength and lean muscle mass when combined with increased calorie intake and exercise. Some athletes “stack” multiple formulations for presumed enhanced efficiency.

Steroid “pro-hormones” such as dehydroepiandrosterone (DHEA) and androstenedione are converted to estradiol more than testosterone and may have many side effects.

Short-term side effects of anabolic steroid use include liver toxicity, endocrine abnormality (gynecomastia, prostatic hypertrophy, hirsutism, impotence, decreased sperm count, testicular atrophy), blood changes (hyper coagulability, increase in low-density lipo proteins and decreased high density lipo protein cholesterol), musculoskeletal problems (primitive epiphyseal closure, muscle and tendon rupture), oncological disorders (prostatic and breast cancer progression), acne and psychiatric disorders.

Anabolic steroid use is suspected in an athlete who shows a rapid increase in lean mass and strength beyond that expected in normal development. Physical finding includes gynecomastia, testicular shrinkage, jaundice, acne and marked striae.

Erythropoetin (Blood Doping)

Blood doping is a process whereby athletes increase their oxygen carrying capacity by receiving blood transfusion from previously donated blood to increase their haematocrit a few days before the competition and to get more, richer blood than can normally be produced. Since blood carries oxygen to the muscles, more blood means more oxygen and potentially better performances.

There are two known types of blood doping. One uses ordinary transfusions, but that is easy to catch today by looking for foreign proteins on their surfaces. But a more sophisticated method is for an athlete to withdraw some of his or her own blood during training and store it.

The body then builds up replacement blood and, shortly before an event, the extra blood is injected back into the body. This method can sometimes be caught by tests that can tell if a person’s haemoglobin is suspiciously high. But athletes using this version of blood doping have been known to inject blood in the morning, race, then have the blood withdrawn later, thereby reducing their chances of being caught by random tests.

<table>
<thead>
<tr>
<th>PED</th>
<th>Potential Benefits</th>
<th>Adverse Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anabolic androgenic steroids</td>
<td>Increases strength &amp; lean body mass, decreases muscle breakdown</td>
<td>Acne, hair on body, breast enlargement in males (gynecomastia), baldness, liver tumors, agitation, psychosis, infertility, ligament injury, precocious puberty in younger adolescents</td>
</tr>
<tr>
<td>Steroid hormone precursors</td>
<td>None proven</td>
<td>Increases estrogen levels in boys</td>
</tr>
<tr>
<td>Creatine</td>
<td>Increases strength, weight gain, improves performance in sports and anaerobic activities</td>
<td>Kidney toxic, muscle cramps, dehydration</td>
</tr>
<tr>
<td>Human growth hormone</td>
<td>Decrease in subcutaneous fat</td>
<td>Heart disease, increased blood pressure, coarse facial features</td>
</tr>
<tr>
<td>Diuretics</td>
<td>Weight loss</td>
<td>Dehydration, electrolyte imbalance</td>
</tr>
<tr>
<td>Nutritional supplement</td>
<td>No proven effects</td>
<td>Hypertension, syndrome related to high viscosity of blood, especially when combined with dehydration</td>
</tr>
<tr>
<td>Erythropoetin</td>
<td>Overall improved athletic performance</td>
<td></td>
</tr>
<tr>
<td>Gene doping</td>
<td>Enhances performance</td>
<td>Gene over expression leading to excessive erythropoiesis, hypertension and sudden death</td>
</tr>
</tbody>
</table>
List of banned substances and methods

I. List of banned substances
A. Stimulants; B. Narcotics, both natural and synthetic; C. Anabolic agents; D. Diuretics; E. Peptide and glycoprotein hormones and analogs

II. Banned methods
A. Blood doping; B. Pharmacological, chemical or physical manipulation

III. List of substances under restriction
A. Alcohol; B. Marijuana; C. Local anesthetics; D. Corticosteroids; E. Beta-blockers

Another method of increasing oxygen carrying capacity in athletes is by the use of recombinant human erythropoetin (rhuEPO). The ability of rhuEPO to enhance endurance is impressive. Athletes can improve their overall performance by as much as 10% to 15%. Erythropoetin (EPO) is a naturally occurring glycoprotein hormone that regulates red blood cells (RBC) production.

Apart from being illegal, blood doping is dangerous too. Transfusions done at home, for example, can incur the risks of contracting blood-borne diseases and getting sick from bacteria growing in poorly stored blood. Blood doping can also make the blood dangerously thick. Some athletes have even died from efforts to overly enrich their blood. Athletes become particularly prone to myocardial infarction, seizures, stroke and sudden death. When combined with dehydration, athletes are especially at risk for this potentially lethal scenario.

Growth Hormone

Many athletes and bodybuilders believe that the growth hormone (GH) improves athletic performance. However, scientific evidence suggests that, in healthy individuals, GH supplementation does not offer any advantage.

The first purified preparation of hGH dates to 1956 and it was extracted from human cadaver pituitaries. The first clinical use of hGH was reported in 1958 as a treatment for children who have Growth Hormone Deficiency (GHD) to promote linear growth. The clinical use of hGH lasted until 1985, when its use was halted worldwide because of its association with Creutzfeldt-Jakob disease. Since 1985, all GH in clinical use has been obtained by recombinant DNA technology through genetic engineering.

GH also is widely used illegally as an anti-ageing agent and as a performance enhancing substance in athletes. Studies have demonstrated an increase in hemoglobin concentration and improvements in wound healing and ligamentous strength, bone mineral density, strength, cardiac function and quality of life in adult patients who have GHD and are treated with GH.

Despite the lack of evidence supporting significant positive effects of GH as an ergogenic aid, there are reports of the abuse of GH by athletes and bodybuilders for its anabolic properties. Such abuse rests on the belief that GH augments performance in endurance and power sports, is hard to detect and is without major side effects. In addition, it is believed that GH strengthens tendons and ligaments, prevents stress fractures, and speeds the healing process. Among bodybuilders striving to achieve the “ripped look” GH misuse is believed to decrease the subcutaneous fat through a repartitioning effect and to promote hypertrophy of their muscle fibers.

Nutrition Supplements

Protein supplements are often used by athletes with the hope of adding muscle or repairing muscle damage from workouts. They are sold in powders to be used in shakes and taken directly before or after a workout.

Although protein supplementation seems to be safe, if taken at the dose recommended, a significant protein load is placed on the kidneys. If this occurs during a period of dehydration, such as in a particularly intense workout in hot or humid conditions, the kidneys are at risk of acute failure.

Creatine

Creatine is used most commonly by athletes for increasing strength. About 1 to 2 gm of creatine is synthesized in the kidney, liver and pancreas from the essential amino acids arginine, glycine and methionine. An additional 1 to 2 gm/day is obtained from meat-containing diets. The remaining creatine is concentrated to creatinine and cleared by the kidneys. Creatine is sold in powder form or liquid form in recommended dosages sometimes greater than 10 gm/day. Taking doses greater than 2 gm/day is unnecessary and potentially harmful to the kidneys. Other reported side effects include weight gain, nausea and muscle cramping.

Narcotics & Analgesics

Narcotics and analgesics include morphine, codeine and pentidine. These are powerful painkillers producing a sense of euphoria and help players perform beyond their normal threshold of pain. As a result the player could seriously injure himself since he fails to recognize small injuries because of reduced pain. An overdose may even lead to stupor or coma. Beta blockers are drugs that reduce the heart rate. Archers and sharpshooters resort to these drugs to steady their hands. But it may lead to sleep disturbances and in extreme circumstances could also lead to a cardiac arrest.

Stimulants

Stimulants are even being used by high school and college athletes today. Common stimulants include caffeine, ephedrine, pseudoephedrine, neosynephrine, amphetamines and metamphetamines.

Stimulants can be found in coffee, colas, energy drinks, cough and cold medications, muscle building or weight loss supplements, attention deficit hyperactivity disorder medications and diet pills. Stimulants act on the central nervous system (CNS) producing a three-fold effect. First, as they indirectly suppress hunger, they are used to lower the weight of boxers and wrestlers. Second, as a metabolic stimulant they speed up the respiratory and circulatory systems and thus delay the onset of fatigue. Third, these act directly on the brain infusing a sense of excitement and euphoria, which is at times dangerously misleading.

The adverse effects include dizziness, insomnia, agitation and restlessness, anxiety, confusion, hallucinations, gastrointestinal disturbances, heat intolerance, stroke, myocardial infarction, arrythmias and death. Severe rebound of fatigue...
and depression occurs after discontinuation.

**Glycerol**
Glycerol is an osmotically active molecule that is used to optimize hydration status for the purpose of improving performance in warm conditions. It may be useful for athletes who undertake multiple exercise sessions daily (e.g., football players, all day tournaments in other team and individual sports).

Glycerol has been shown to be safe in doses up to 5 gm/kg body weight. But when used for hyper-hydration before exercise it has had adverse effects of gastro upset, headache and blurred vision.

**Vitamin, Mineral & Iron Supplements**
As a general rule, there is no benefit from supplementation of vitamins and minerals above the recommended daily amounts. With an adequately balanced diet athletes without any medical condition that predisposes to vitamin deficiency will not enhance performance by supplemental intake. However, athletes who follow restrictive diets may benefit from supplementation if their diet does not provide recommended amounts.

Chromium is an essential trace element that is used by athletes for modifying body composition (e.g., muscle building, decreasing body fat). It is most commonly ingested as chromium picolinate in quantities that provide approximately 100 times the recommended amount.

Iron supplement is used commonly by athletes for enhancement, a practice that can be helpful or harmful. In the presence of iron deficiency anaemia, iron supplementation is clearly beneficial for performance. However, the diagnosis can be difficult to establish in athletes. In response to training, haemoglobin concentration decreases transiently as the plasma volume expands to a greater degree than does red cell mass, the so-called ‘sports anaemia’. Ferritin levels also decrease, but this usually does not indicate true iron deficiency.

---

**Gene doping**
The World Anti-Doping Agency (WADA) defines gene doping as “the non-therapeutic use of genes, genetic elements and/or cells that have the capacity to enhance athletic performance”.

With the advent of gene therapy, a more direct way to deliver proteins and hormones to an athlete’s tissues and organs became reality. A substance that can alter the basic genetic expression of DNA such that muscles grow larger, contract more forcefully, and recover more quickly than non-doped muscles and cannot be detected by anti-doping laboratories would be ideal to gain a competition advantage. It can be of two types.

- **In vivo gene doping:** The delivery of the new gene into an athlete can be through biologic, physical or chemical methods. Viruses can be modified to biologically insert the artificial gene into cells in a specific organ or target
tissue or into cells throughout the competitor’s body.

Ex vivo doping: The technique of exogenous gene doping includes gene transfer to cells in culture first, then implantation of the tissue into the recipient. Once implanted into the athlete’s cell, the new genes express hormones or biochemicals that enhance performance of the athlete during competitions.

Catching the Culprit
The lure of glory makes sportspersons and their medicos resort to all sorts of tricks. For instance, a sportsperson would take a substance naturally occurring in the body such as human growth hormone, and if it is detected claim that the sportsperson happens to have a higher hormone level. However, testing rules now specify the highest permissible levels of such molecules as well.

Another method is by reducing the excretion of the tested substances in urine. Earlier weightlifters would take probenecid, used in gout, to reduce the excretion of anabolic steroids in urine. Suddenly muscle men increasingly started claiming to be gout suffers until the testers got wise and banned probenecid as well. Catching athletes indulging in doping, therefore, has always been a cops and robbers game.

The first step in a doping control test is getting an authentic urine sample from the correct person and getting it sealed. Athletes selected for a test identify themselves before they urinate in a cup, under direct observation of an official of the same gender. Next the urine is poured into a pair of bottles, A & B, labelled only with numbers (eg. 23652A and 23652B) and the bottles are sealed. Only the sport organization – not even the laboratory – knows which number corresponds to which athlete.

Testing urine is better than testing blood for most prohibited substances (small molecule, molecular weight less than 800 atomic mass units). Urine collection is non invasive and yields a large volume of sample, with higher drug concentration than in blood and with far fewer cells and proteins to complicate extraction.

There are several detection techniques performed in laboratories to test for banned drugs. These are based on immunological or radioimmunological methods, separative methods such as gas chromatography and liquid chromatography and methods associating two techniques, such as chromatography/mass spectrometry, or chromatography/atomic emission detection.

Undoubtedly, athletes always have striven, and will continue to strive, to improve their performance through means such as physical training, improved nutrition, and skills training. But there are some among them that resort to short cuts and take recourse to performance-enhancing substances. Apart from ethical implications of these substances there are serious potential negative health effects too. This has to be realized by sportspersons at all levels—right from international levels down to the school level too.

Dr Vivek Sharma is Consultant Paediatrician at Rungta Hospital, Jaipur. Address: 1/1291, Malviya Nagar, Jaipur (Raj)-302017; Email: drvivek_sharma@rediffmail.com.