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Catching a cheat

How do we determine if an athlete has been using drugs to boost their performance? Analytical science has the answer.

The use of banned substances to enhance athletic performance is known as 'doping'. Historical evidence suggests that doping goes back as far as 776 BC, where ancient Greeks devised a range of different methods to beat their competitors and combat pain. These included drinking herbal teas, mixing concoctions of hallucinogenic mushrooms and even consuming the alkaloid strychnine, a poison that causes muscle spasms in small doses. From the first Olympic games, cheating due to dopant use resulted in athletes receiving lifetime bans from public sport.

In the last century with the advances of modern medicine the range of substances that are used for doping have increased dramatically. These include, but are not limited to: hormones to promote muscle growth; stimulants to improve endurance; and blood transfusions to increase performance. For this reason, the world anti-doping association (WADA) exists to fight against doping of all kinds in sport.

During the London 2012 Olympics, teams of analytical scientists tested over 6000 samples of blood and urine in the Harlow Olympic testing laboratory for the presence of banned sport enhancing drugs. Analytical techniques can be used to detect these drug molecules directly, or look for traces of other by-products that could only be present due to doping.

Professional athletes in all sports are tested regularly to ensure they are not taking performance enhancing drugs.

Athletes have to provide blood and urine samples when requested. These are tested to ensure they contain no evidence of doping.

It's in the blood

One of the main illegal doping techniques is blood doping. This works by having blood transfusions or taking specific drugs to increase the haemoglobin in a person's blood. This results in an increase in the blood's ability to carry oxygen, which increases aerobic capacity and in turn increases physical endurance. When blood is transfused from a donor, specific antigen patterns can be used to identify doping. This is because each person's red blood cells exhibit specific genetic markers.

Identifying if an athlete has re-infused their own blood is more complex. Innovative methods such as searching for metabolites of blood bag plasticisers (broken down by-products of the plastic containers the blood is stored in) and analysing fingernail clippings to assess long term doping have emerged in the last few years. The key analytical technique used is liquid chromatography-mass spectrometry (LC-MS). Recently it has been announced that Olympian Jessica Ennis-Hill is set to be awarded her third World Championship heptathlon gold as the original winner tested positive for blood doping.

A liquid chromatography-mass spectrometry machine being used to test samples.

How much is too much?

For some drugs, a simple positive/negative screening can be enough, with the sheer presence of the substance indicating foul play, as the drug could not have been introduced into the body from natural sources. However, for some drugs, determining the amount of the substance present is extremely important. For example, a contaminant plasticiser from blood bags diethylhexyl phthalate, or DEHP, can be indicative of blood doping. However, the main source of DEHP stems from our diet due to plastic wrappers and storage containers and is thus naturally present in our bodies. An average 'baseline' of how much of the substance is in an athlete's body must therefore be established. Significant spikes in the concentration of DEHP above the baseline are therefore taken to indicate doping, induced by a blood infusion.

Designer Drugs

Historically, techniques have been developed for the detection of specific dopants that are known threats to the integrity of the sporting community. These methods involve the analysis of a 'standard' sample of the drug substance on the selected analytical instrument such as LC-MS, along with the samples provided by the athletes. This means that the signal response or 'spectrum' obtained from the standard can be correlated directly with the athletes' samples, to determine if the restricted substance is present.

Many analytical scientists are involved in on-going research to develop new analytical techniques.

More recently however, the development of 'designer drugs' has emerged. This is where the structure of an illegal drug is altered slightly to evade detection, but still maintains its physiological effects, giving an athlete the edge over their competitors. If the drug is new, with no standard available for confirmation, failure to identify doping may occur. For this reason, the analytical science community must to be ahead of the game, considering the structure of current drugs used for doping, and how they may be altered in an attempt to avoid detection. This highlights the importance of the continuing development of new analytical techniques, in addition to routine targeted screening and laboratory analysis, to stay one step ahead of the cheats.

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