

**Pearson Edexcel** International Advanced Level

**Biology**

**Advanced**

**Unit 5: Energy, Exercise and Coordination**

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**Scientific Article for use with Question 7**

Paper Reference

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## Scientific article for use with Question 7

### Drugs and Sport

1. There are three reasons why athletes and sports people may take drugs:
2. As medication for disease: they are as entitled to treatment of a medical condition as anyone else but both the competitor and the doctor must be aware of the rules about banned substances. Failure to heed them can have serious consequences. An athlete could receive either a temporary or permanent ban from competing in that sport. If the doctor is at fault, there is potential for litigation irrespective of whether the individual is an amateur or professional competitor.
3. To enhance performance: in doing so this could give an unfair advantage. Doctors who prescribe or collude in the provision of drugs or treatment with the intention of improperly enhancing an individual's performance in sport would be contravening the GMC's guidance and such actions would usually raise a question of a doctor's continued registration. This does not preclude the provision of any care or treatment where the doctor's intention is to protect or improve the patient's health.
4. As recreational drugs: for example, cannabis is a banned substance even though it is not considered a performance-enhancing drug. The authorities say that it is necessary to take such steps, as athletes and sports people are role models for young people and hence should not take illicit drugs. However, they do not suggest how young people would know that their heroes take drugs if they were not tested and positive results made public.

### Drug testing

5. All elite athletes competing at international level and professional sportspeople are likely to be routinely tested. However, testing may go down to much lower levels and include young competitors. Sometimes testing may be anticipated. It is common practice to test all who have won medals in major events but random drug testing can also take place. Elite athletes may also be visited by representatives from their governing body for out-of-season testing.
6. Some drugs are permissible when not competing but not during competition. Others, such as anabolic steroids are banned at all times.
7. Some drugs are banned in some sports but not in others. Banned substances can include alcohol and caffeine above a certain level. Beta-blockers would impair performance of an endurance athlete but suppression of tremor gives unfair advantage in shooting events.
8. Drug testing does not apply simply to sports such as athletics and football but may include snooker, bridge and chess played at the highest levels.

### Therapeutic use exemption

9. If a doctor believes that there is a good reason why his patient needs a banned substance, it is possible to issue a Therapeutic Use Exemption (TUE) certificate – for example, the one used for football is found at the FIFA website. They may be temporary for a single spell of illness or of longer duration. They must be issued in good faith, stating that alternative medication is inappropriate – for example, if a snooker player has hypertension, does he really need a beta-blocker?
10. The problems faced by a doctor may be for relatively minor treatments such as decongestants, analgesics and medication for asthma. As mentioned above, some drugs are permissible in some sports and not in others. Some are permissible out of competition but not whilst competing.

11. The World Anti-Doping Agency (WADA) produces a full list of prohibited drugs every year. Doctors need to be aware of the possibility that patients may use an element of deceit to acquire prescriptions for substances that they know they should not have.
12. Athletes often suffer injuries and analgesics may be appropriate. Non-steroidal anti-inflammatory drugs (NSAIDs) are the group of choice and are always permissible, as is paracetamol.
13. Opiate-related analgesics are more problematic. Codeine is not on the WADA list of banned substances and combinations such as co-codamol appear acceptable. It is the stronger narcotic agents that are banned. However, screening does not always differentiate adequately between the various narcotic – or codeine-related compounds and they are best avoided.
14. Sometimes an athlete will ask the doctor to give an injection into an injured part to permit competition. Pain is an important warning that something is wrong and if a significant injury is pain-free this is a potentially dangerous situation. Steroid injections may also weaken ligaments and should not be given into tendons or ligaments.
15. The main reason for wishing to use diuretics is to produce more dilute urine so that illicit substances are not detected. For this reason they are banned. They may also be used in sports with weight categories, such as judo and weightlifting. The competitor can dehydrate, make the weight at the weigh-in and then rehydrate before the competition, as even mild dehydration can ebb fitness significantly. Jockeys have used diuretics for many years. Masking substances to hide the use of illicit drugs include probenecid and this is also banned.
16. The problem of stimulants in sport reached public attention in 1960 when the Danish cyclist Knut Jensen died in the Rome Olympics and it transpired that he had been taking amfetamines. The problem for doctors is not usually with amfetamines, as these now have few indications but with decongestants that may be requested or bought over the counter to clear the airways of an athlete with a cold.
17. Substances containing phenylephrine and pseudoephedrine should be avoided. Ephedrine is prohibited when its concentration in urine is >10 micrograms per millilitre. This probably means that 0.5% ephedrine nasal drops are safe. Saline nasal drops are certainly safe and allowed but less effective. If a pharmacological agent is required, an anticholinergic such as ipratropium spray may be used.
18. Beta-2 agonists are banned substances but they may be used if delivered by inhaler to a patient with asthma and a TUE is issued. Corticosteroids are also banned but if anyone needs them, whether they are otherwise fit to compete at top level needs to be questioned. A TUE may be issued. Topical steroids are permitted.
19. For endurance events, a high haematocrit enhances performance. There are three ways to achieve this:
  - Training at altitude in a low PO<sub>2</sub> stimulates endogenous erythropoietin.
  - Recombinant erythropoietin is effective, especially if combined with supplementary iron.
  - Blood doping means removal of a unit of blood, perhaps 4 to 6 weeks before competition, the body replaces the lost blood and shortly before competition the blood is transfused (autologous transfusion).
20. Of these three techniques, only altitude training is legal. Substances to enhance oxygen uptake and haemoglobin substitutes are also banned. Although it was hoped that techniques to detect blood doping by autologous transfusion would be ready by the 2012 Olympics, this did not transpire. Research on this and on other methods of detecting illicit methods of oxygen transfer enhancement are ongoing.

21. Anabolic steroids are a generic term for male hormones. The idea behind their abuse in sport is that they promote muscle growth and protein synthesis. However, abuse also has side-effects such as cardiomyopathy, atherosclerosis, hypercoagulopathy, hepatic dysfunction and psychiatric and behavioural disturbances. They may be used for hypogonadism or diseases such as aplastic anaemia but such people are unlikely to compete at an elite level.
22. In the 1970s, athletes would take synthetic androgens such as nandrolone and these are easy to detect without any controversy. A much more difficult problem is when an endogenous substance such as testosterone is taken. The ratio of testosterone to dehydroepiandrosterone (DHEA) is usually about 1:1 or 2:1. A similar ratio is expected in women. If it is over 4:1 then exogenous testosterone is likely. Some men appear to have naturally high ratios but a radiocarbon test can detect synthetic testosterone. New ways are being developed to detect metabolites of androstenedione, testosterone and dihydrotestosterone abuse.
23. Female hormones also have anabolic effects, although not as marked as male hormones. Athletes who return to training after pregnancy often find that they are stronger than they were before. Oral contraceptives are permitted substances and may well be desirable. They tend to reduce menstrual loss and hence any tendency to iron deficiency. As well as making menstruation more tolerable, they can be used to adjust its timing so that the competitor is not premenstrual or menstruating during an important event. Their value as a contraceptive is also appreciated.
24. Other banned substances include tibolone, which has some anabolic effect, and anti-oestrogens including the selective oestrogen receptor modulators (SERMs) and aromatase inhibitors. If there are genuine reasons to prescribe such drugs, a TUE can be issued.
25. New illicit performance-enhancing agents are being developed all the time. One of the most recent is peroxisome proliferator-activated receptor-delta agonists termed GW1516. It is a constant battle to develop analytical techniques which can detect these substances. In the case of GW1516, mass spectrometry is being used for this purpose.
26. The chemicals that we tend to think of as anabolic (the male hormones described above) are not the only ones with anabolic properties and hence other hormones may also be abused. In 1989 the Medical Commission of the International Olympic Committee (IOC) introduced the new doping class of peptide hormones and analogues. This includes:
- Human chorionic gonadotrophin (hCG) and related compounds.
  - Corticotropins, including adrenocorticotrophic hormone (ACTH).
  - Human growth hormone (hGH), insulin-like growth factors and mechano growth factors.
  - All the releasing factors of these listed hormones.
  - Erythropoietin.
  - Insulins.
27. Both hCG and luteinising hormone (LH) may also be used to enhance the endogenous production of testosterone by artificial means and are prohibited in males.
28. Over a period of 20 years, growth hormone (GH) has been considered as a performance-enhancing drug in the world of sport. A blood test for hGH was first introduced at the 2004 Summer Olympic Games in Athens, Greece. Further tests are being developed to enhance the detection window for hGH abuse.
29. Recombinant GH abuse remains a major challenge and isoform assays have been developed to detect this.

30. GH and insulin seem to work together to control blood glucose but the role of insulin is much more profound than just glucose homeostasis. Insulin may be used to counter the hyperglycaemic effects of GH but it is also abused by bodybuilders and there are reports of severe hypoglycaemia as a result. The legal classification of insulin has been changed from 'P' (for sale in pharmacies) to 'PoM' (prescription-only medicine).

### **Gene doping**

31. In the future, this could potentially become a new possibility for abuse as a performance enhancer in sport. The World Anti-Doping Agency describes gene doping as 'the non-therapeutic use of cells, genes, genetic elements, or of the modulation of gene expression, having the capacity to improve athletic performance'. The potential for gene doping would be to inject 'normal' genes into the body to increase the functioning of a 'normal' cell. For example, genes producing insulin growth factor 1 to help muscles grow and repair.

### **Denying the charges**

32. Sometimes when an athlete is found to have taken a banned substance, he or she admits to the fault but very often they deny ever knowingly having taken a banned substance. Cynics are unsurprised but often the athletes seem very genuine.

33. Elite athletes are not 'normal' people and so reference ranges for physiological substances need to be determined on their peers. A cyclist who may be burning 9,000 calories a day during competition is not a normal subject. Sprinters tend to be very muscular and have a low body fat content. Fat is important in the metabolism of steroid hormones. The people who set such standards are sufficiently well versed in sports medicine and exercise physiology that they set their standards by the normal for the group that they examine. Nevertheless, if they say that their reference range will include 99% of all those active athletes who are not taking banned substances, then 1 in 100 will fall outside that range.

34. Most top athletes use dietary supplements and the contents of these may not be as vigorously controlled as may be hoped. Contaminants that have been identified include a variety of anabolic androgenic steroids including testosterone and nandrolone as well as the pro-hormones of these compounds, ephedrine and caffeine. This contamination may be the result of poor manufacturing practice but there is some evidence of deliberate adulteration of products. The principle of strict liability that applies in sport means that innocent ingestion of prohibited substances is not an acceptable excuse and athletes testing positive are liable to penalties. Although it is undoubtedly the case that some athletes are guilty of deliberate cheating, some positive tests are likely to be the result of inadvertent ingestion of prohibited substances present in otherwise innocuous dietary supplements.

### **Ethical considerations**

35. The position of the GMC with regard to a doctor aiding and abetting drug abuse in sport is clear. However, a doctor may be faced with a patient who admits to using anabolic steroids. He or she does not enter competitions and so is not tested. The patient wants the doctor to monitor their liver function as an early warning of any damage. What is the position? The patient will continue to take the steroids whether the doctor co-operates or not. Would it be reasonable to warn the patient of the dangers and to check liver function and lipids? This would not be endorsing the patient's action any more than a needle exchange encourages intravenous drug abuse. He or she may also benefit from the needle exchange. Is it a damage limitation exercise that can be justified?

## Getting drugs out of sport

36. There is a constant battle between those seeking new techniques to detect illicit use of performance-enhancing substances and those who wish to circumvent the rules. Testing is vigorous and can be unannounced and the penalties for being discovered are severe. Nevertheless, there are and always will be those who attempt to use illicit ways of enhancing performance to get the necessary slight edge that is required to win. From time to time illegal substances are discovered. In British sport this should not be seen as evidence of widespread abuse of drugs but evidence that a vigorous and effective system of monitoring is in place.
37. Some would argue that the only way to get a 'level playing field' is to lift all bans on drugs and let us push human endurance to the limit. Records have tumbled with new technologies going back to spikes and starting blocks and including modern running shoes and fibreglass poles for vaulting. Should we encourage the same with pharmacological technology? This is a false argument, as the banned substances are not without significant risk. It cannot even be argued that the athlete is free to make his or her own choice because if the opposition use drugs to gain advantage, he or she will have to do the same to be able to compete.
38. The 2012 London Olympics acted as a stimulus for UKAD, the UK anti-doping organisation affiliated to WADA, to strengthen its anti-doping initiatives. These were brought together under the umbrella of its 'Win Clean: Say No To Doping' campaign.

## World Anti-Doping Agency

39. WADA was founded with the belief that 'athletes have a fundamental right to participate in doping-free sport and that doping endangers athlete health and the integrity of sport'. It serves as the independent international body responsible for co-ordinating and monitoring the global fight against doping in sport.

## A personal view on drugs prior to the Beijing Olympics by Michael Le Page

40. The Finnish cross-country skier Eero Mäntyranta won two gold medals in the 1964 Olympics and accumulated an impressive tally of medals during his career. Later it turned out that he has a mutation in a gene called *EPOR* that means he produces up to 50 per cent more red blood cells than normal.
41. The east African runners who dominate distance events have also been shown to have at least one genetic advantage: their lower legs are thinner and weigh on average 400 grams less than those of Danish athletes, which translates into a massive 8 per cent energy saving. Other people have distinct genetic disadvantages. For instance, 1 in 5 Europeans cannot produce the alpha-actinin-3 protein found in fast-twitch muscle fibres. Very few people with this genotype excel at power sports such as sprinting.
42. So much for fairness in sport. The World Anti-Doping Agency says its aim is "to protect the athletes' fundamental right to participate in doping-free sport and thus promote health, fairness, and equality for athletes worldwide". Such notions are a quaint hangover from the amateur age. Sports are inherently unfair. Genes alone do not make you a winner, of course, but some people's genes give them a massive advantage with which others struggle to compete no matter how young they start or how hard they train.

43. There is a way to level the playing field: allow athletes to make up for their natural disadvantages by taking performance-enhancing drugs. There is not yet a “foot growth potion” for the rivals of Australian swimmer Ian Thorpe, who has size-17 feet, but an estimated 1 million Americans have already taken human growth hormone, which in the US can now be prescribed for children with “idiopathic short stature” – effectively anyone who is very short. No one knows how many average-sized people have used growth hormone to help them make the national basketball team, but would it really be fair to exclude such people as cheats when, for example, players such as Pavel Podkolzin or Sun Ming Ming owe their great height to pituitary tumours that resulted in an excess of growth hormone?
44. Or take the mutation that boosted Mäntyranta’s red blood cell count. All athletes know that there are ways of equalling or surpassing his natural advantage: take the hormone EPO, indulge in blood doping (injecting extra red blood cells), train at high altitude or sleep in a low-oxygen tent. Only the last two are allowed, of course, but the effect is the same. So the consequence of the ban on EPO and blood doping is to give an unfair advantage to athletes who can afford to train at altitude or invest in an altitude chamber – or on cunning doctors who can help them beat drug tests.
45. If we were really serious about making sport fair, we would try to ensure some sort of equality in the resources athletes have access to. And when genetics becomes advanced enough, we would introduce different divisions or some kind of handicapping system based on people’s inherited advantages or disadvantages. After all, people who lack a Y chromosome already compete separately from those who have one. Will it happen? Unlikely.
46. There is one decent argument against performance-enhancing drugs: safety. Many drugs taken by cheating athletes are dangerous, and allowing their use would force all athletes to take them to have any chance of winning. But the rules as they stand are clearly not designed with the safety of athletes in mind. A good example of this is the lack of any safety limit on the concentration of red blood cells, which beyond a certain level considerably increases the risk of heart attacks and strokes. Dehydration resulting from exercise makes matters even worse. Yet doping authorities allow athletes to compete no matter how high their blood cell concentration, as long as it is not due to doping. So it is fine for athletes to risk death, just as long as it is a natural death.
47. If these arguments do not convince you that we need to rethink the ban on drugs in sport, there is a more pragmatic one: the existing regime is not working. Clearly, many top athletes still resort to drugs. And the situation is only going to get worse. In the not too distant future, gene therapy could be used to boost the strength of muscles. The only way to detect such modifications may be to remove and test a piece of muscle. Are we really going to inflict that on athletes?
48. There is another way: allow the use of drugs, and have sports authorities focus on testing the health of athletes rather than their use of drugs. This is the suggestion of ethicists Julian Savulescu at the University of Oxford and Bennett Foddy at the University of Melbourne, Australia. They argue that any drugs that are safe should be permitted, whatever their effect on performance. Authorities would set a safe level for, say, red blood cell concentration, and anyone exceeding it would not be allowed to compete, whether their result was due to doping, altitude training or genetics.
49. Savulescu says he would prefer it if there were no drugs in sport. But the drugs are out there and they are not going to go away. So let’s adopt the policy that is best for athletes and best for sport. We cannot live in fantasy land. Savulescu thinks doping authorities will have to adopt his idea sooner or later. Sooner would be better.

50. Consider the list of banned substances at the heart of the new world rules. It includes some 50 stimulants, nearly 40 anabolic steroids, 20 beta-blockers, 14 diuretics and eight narcotics. Some, especially the steroids, certainly are performance enhancers, but many substances on the list are there purely on suspicion of offering unfair athletic benefits. Others, including methadone and heroin, would do just the opposite, while some substances that almost certainly can enhance performance, such as creatine monohydrate, are not listed at all. To get on the list a substance has to satisfy two out of the following three criteria: taking it is harmful; it enhances performance; or it is "against the spirit of sport". Tobacco escapes the banned list because, though harmful, it is deemed to be neither a performance enhancer nor against the spirit of sport – it gets just a single strike. Methadone, by contrast, is deemed to be both harmful and, unlike nicotine, against the spirit of sport.
51. You can see the problem. "Spirit of sport" is not something that can be objectively measured. It is a slippery set of moral presumptions and values. There is only one reason athletes consume lots of creatine or, if they are rich enough, train at high altitude: to enhance performance. But are these activities against the spirit of sport? Apparently not. Moreover, while supplements of the banned substance erythropoietin (EPO) are deemed a no-no, sleeping in a decompression chamber to boost levels of the body's own EPO is apparently fair and sporting.
52. Such arbitrariness would be more forgivable if it were clear this style of prohibition worked. But to date it may simply have conditioned athletes and their coaches to use drugs in more sophisticated ways. While urine tests can pick up traces of common minor stimulants, many comparatively potent and risky substances on the WADA banned list cannot yet be tested for. Insulin, growth hormone, and insulin-like growth factor would all escape detection. Until this changes, anti-doping measures will remain better at catching athletes who have inadvertently taken the wrong sort of decongestant than at catching the serious cheats.

### References and Acknowledgements

<http://www.patient.co.uk/doctor/drugs-and-sport>

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