IB DIPLOMA PROGRAMME

Sports, Exercise, and Health Science

COURSE COMPANION

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Stimulants

Stimulants are psychoactive drugs. Psychoactive drugs are substances that enter the brain and exert their effects on the central nervous system (the brain and the spinal nerves). These effects lead to various alterations in the way a person feels. This can include greater levels of alertness, a sharper perception of what is occurring in the immediate environment, a more positive mood state, greater levels of motivation, greater vigilance and feelings of greater physical and mental "power".

Stimulants come in various guises. For example, many substances we consume in our daily lives, such as caffeine, sugar and vitamin supplements can be classed as stimulants. There are also chemical stimulants, including substances such as amphetamines and cocaine. In a clinical setting, amphetamines can be used to treat a variety of mental disorders, particularly depressive disorders, narcolepsy (a condition where the sufferer is unable to prevent themselves from falling asleep), Parkinson's disease and attention deficit disorder in children. However, amphetamines can become addictive, likely due to the positive and pleasant feelings and sensations they generate. Medically, cocaine can be used as a local anaesthetic and vasoconstrictor during surgery in areas such as the nose, throat and mouth. In many countries, both amphetamines and cocaine are classed as illegal substances for non-clinical (i.e. recreational) use.

TO THINK ABOUT

Why do you think beta blockers are banned in sports such as archery, snooker, and shooting, but not in sports such as sprinting or swimming?

Potential benefits of non-nutritional ergogenic aids

THEORY OF KNOWLEDGE

Our understanding of the benefits and dangers of many banned substances, for example, anabolic steroids, has been hindered by the ethical concerns about conducting experimental studies on these substances in healthy individuals.

1. Why is there an ethical concern here? Surely if individuals are informed of the potential risks of the research and still wish to continue, then the researcher should go ahead with the experiment? Discuss your point of view regarding this statement. Do some research of your own into the ethics of research experiments in order to support your discussion.
2. Imagine that you work for the World Anti-Doping Agency, and are in charge of compiling the list of banned substances in sport. A group of Olympic-level athletes present you with a signed petition asking for a response to the following: "There is a lack of specific evidence to show that 'Steroid X', a new form of anabolic steroid, can significantly improve sports performance, yet it has still been banned. We believe that it is inappropriate to ban a substance with no conclusive prove of its performance-enhancing effects or its health risks, and ask the World Anti-Doping Agency to review its decision to ban Steroid X". What would be your response to these athletes? What arguments would you employ to support your decision, and justify why you believe it is the right decision?

Anabolic steroids

Findings regarding the effects of anabolic steroid administration in humans are inconsistent for many reasons (Table 9.2). The available evidence suggests that the potential benefits of anabolic steroid use would be more applicable to athletes involved in strength or power events (sprinting, shot-put, powerlifting

etc) or those engaged in sports such as bodybuilding. The following is a summary of the main proposed benefits of anabolic steroid use.

Weight gain

Regular anabolic steroid use is reported to induce rapid weight gain in athletes, healthy non-athletes, and individuals with chronic health conditions (Casner et al 1971; Loughton et al 1977; Schols et al 1995; Yeh et al 2002). This weight gain can range from 2–5 kg as a result of short-term (less than 10 weeks) anabolic steroid use (Hartgens, Kuipers 2004). Weight gain could be of benefit to particular athletes, for example, a full back in American football or a forward in rugby.

However, some research has shown that the increase in weight gain with anabolic steroid use is not always accompanied by increased muscle strength or power (Casner et al 1971; Loughton et al 1977). Indeed, it is not fully clear what causes the increased weight gain with anabolic steroid use, particularly when increased muscle size is not reported. Increased weight gain without concomitant increases in muscle strength/power would be undesirable for any athlete, as it would negatively affect factors that would influence performance, such as power to weight ratio.

Able to train more frequently and more intensely

Anabolic steroid use has been associated with a faster recovery/healing time of damaged muscle tissue (Beiner et al 1999). This probably relates to their anabolic, i.e. tissue-building, abilities, which would facilitate development of new tissue to replace that which was damaged. However, anabolic steroids also have a potent "anti-catabolic" property. Essentially, this means that they prevent tissue such as muscle from being broken down or damaged as much as it normally would be during exercise. They achieve this by improving the way in which the body utilizes dietary protein and by improving the synthesis (making) of protein within the body (Haupt et al 1984; Kadi et al 1999).

As catabolism of muscle tissue is one of the potential causes of injury, this suggests that anabolic steroid use may reduce the risk of injury to muscle tissue during exercise, or increase the stress that the muscles can be placed under before they become injured. Put together, these effects of anabolic steroids may enable an athlete to train longer and harder, and therefore improve their performance to a greater extent than they could without using steroids. Clearly, this would be of great benefit to all athletes, regardless of their sport.

Catabolism the breaking down of molecules.

Increased muscle mass, strength and power

Perhaps the most common perceived benefit of anabolic steroid use is an increase in muscle mass and/or strength and power. Indeed, evidence in humans does show a significant increase in muscle mass and muscle strength with anabolic steroid administration (Bhasin et al 1996; Bhasin et al 2001). It appears that this effect may demonstrate a dose-response relationship, i.e. the more anabolic steroid used, the greater the effect on muscle mass and strength (Bhasin et al 2001). However, this dose-response relationship may only exist for certain muscles (Kutscher et al 2002).

It also appears that steroid use without exercise can increase muscle mass and strength, but that steroid use combined with exercise produces the greatest increases in these variables, more than either one individually (Bhasin et al 1996).

However, it is important to note that not everyone would gain the same increases in muscle mass and strength with anabolic steroid use. It has been

shown that individuals who are experienced in weight training increase muscle mass and strength with anabolic steroid use above that which would be expected with training alone. But for individuals who are not experienced weight trainers using anabolic steroids will not result in them gaining any more strength or muscle mass than would be expected from just exercise alone (Bahrke, Yesalis 2002). The main way in which anabolic steroids increase muscle mass and strength is by increasing the rate of protein synthesis (Kutscher et al 2002).

The majority of research into anabolic steroids has focused on changes in muscle size and strength (how much resistance the muscle can overcome). Comparatively little work has focused on the influence of anabolic steroids on muscle power (the speed at which a muscle can generate force). It appears that anabolic steroids do not induce increases in muscle power in the same way that they do muscle size and strength. However, the comparative lack of research makes a consensus regarding anabolic steroids and muscle power difficult.

Lower body fat

It is important to note that anabolic steroid use does not reduce fat mass, that is, the absolute amount of fat that your body contains (Hartgens, Kuiper 2004). However, as has already been discussed, anabolic steroids can significantly increase muscle mass. It is this increase in muscle mass (or fat-free mass) that causes an apparent visual decrease in fat mass (the athlete looks more muscular and less fat), and causes a reduction in the percentage of the athlete's total body mass that is attributed to fat. This is highlighted in the following example:

Before steroid use	Total body mass: 95 kg	Muscle mass: 76 kg (80% of total body mass) Fat mass: 19 kg (20% of total body mass)
After steroid use	Total body mass: 102 kg	Muscle mass: 82 kg (80% of total body mass) Fat mass: 19 kg (18% of total body mass)

Here, you can see that before steroid use, the athlete had 19 kilograms of fat, which meant that 20% of his total body mass was fat. After steroid use, the athlete gained 7 kilograms, all of which was muscle mass, but his fat mass stayed the same (19 kg). Therefore, as a percentage of his new body mass, his fat content appears to be lower. However, in absolute terms, the amount of body fat is the same (19 kg).

Endurance performance

Long-term use of anabolic steroids can increase concentrations of haemoglobin (Hinterberger, Vierhapper 1993), the protein in red blood cells that oxygen binds with in order to be transported around the body. Increasing haemoglobin concentration can increase the oxygen-carrying capacity of the blood, and has been shown to improve endurance exercise performance. As a result, anabolic steroids have been used by endurance athletes as a means of improving exercise performance (Hartgens, Kuipers 2003).

However, the vast majority of research demonstrates that anabolic steroids do not increase endurance exercise performance (Bowers, Reardon 1972; Johnson et al 1972; Johnson et al 1975). Anabolic steroids have now largely been abandoned by endurance athletes as a means of improving exercise performance due to more stringent anti-doping controls, a greater ability to detect steroid use and the development of rEPO (Hartgens, Kuipers 2003).

VARIABLE	REASON
Dosage	Studies use varied dosages. Only a few studies have used dosages approximating those used by competing strength athletes .
Testing methods	Strength is often not measured in the training mode. Body composition is often assessed from skinfold estimates, reducing the accuracy of the data.
Training methods	Volumes and intensities of training vary between studies.
Drugs	Studies used a variety of different anabolic steroid(s). Few studies have reported the self-administration of anabolic steroids by athletes.
Study participants	The number of participants, their experience in weight training, and their physical condition at the start of the studies varies.
Diet	Mostly diet was not controlled or recorded.
Study design	Some studies are crossover, some single-blind, some double-blind, some not blind; some had no controls.
Mechanisms of action	There are unknown and varying degrees of anabolic and anti-catabolic action and of interaction with motivational effects.
Length of study	Studies vary in length and are generally short; reports on prolonged training and self-administration of steroids is lacking.
Placebo effect	It is difficult to assess placebo effect due to easy detection of steroid administration by athletes; consequently blind studies are lacking.
Data interpretation	Interpreters had different backgrounds (scientific, clinical, athletic, administrative), perspectives, and goals
Legal and ethical factors	These considerations preclude design and execution of well-controlled studies using doses and patterns of administration of drugs with unknown long-term effects in healthy volunteers in a manner comparable to that of many steroid users.

↑ Table 9.2: Reasons for the lack of consensus on the effects of anabolic steroid use on performance variables in humans.

KEY POINT

The potential benefits of using anabolic steroids are weight gain, being able to train more, increased muscle mass, strength and power, lower body fat and an improvement in endurance performance.

Erythropoietin

The following discussion of the proposed benefits of EPO use refers to the administration of rEPO in healthy people.

Increased oxygen carrying capacity of blood

The primary mechanism by which EPO exerts its effects on exercise is via an increase in the maximal oxygen transport capacity of the blood. Regular injections of rEPO for 4–14 weeks have shown significant increases in the haemoglobin concentration of healthy individuals (Lundby, Olsen 2011).

It has long been thought that the increase in haemoglobin concentration with rEPO use was due to significant increases in red blood cell number, as this is a primary function of naturally produced EPO. Indeed, increased red blood cell count is a crucial function of EPO use. However, EPO also decreases plasma volume, the liquid portion of blood (Lundby et al 2007). This would also have the effect of increasing the volume of red blood cells, as the volume of red cells as a percentage of total blood volume would be greater in much the same way as the relationship between fat mass and total body mass in the anabolic steroid example above. Therefore, physical increases in the number of red blood cells and a decrease in the plasma volume both serve to increase red cell number and therefore the oxygen carrying capacity of the blood.

As a result of this increased blood oxygen carrying capacity, significant increases

Caffeine

Caffeine is one of the most widely used ergogenic aids (Astorino, Roberson 2010) and has been researched in a variety of different exercise situations.

Improved endurance capacity

Below is a summary of current knowledge regarding the potential benefits caffeine could afford an athlete in exercise of different durations and intensities.

Type of exercise	Duration	Effects of caffeine
Endurance exercise	Longer than 40 minutes	Many research studies have consistently shown that ingestion of caffeine before and during endurance exercise can improve both endurance capacity and endurance performance (Tarnopolsky 2010). Endurance capacity is defined as how long a person can continue to exercise before they become exhausted, and endurance performance is how much distance/work can be completed in a given time, or how quickly a given distance/amount of work can be completed. Therefore, athletes involved in endurance running, cycling, cross-country skiing, and other sports could benefit from caffeine ingestion.
Short exercise	20 to 40 minutes	It was originally thought that caffeine only exerted an ergogenic effect during prolonged endurance exercise. However, there are a number of research studies that now demonstrate that caffeine is able to improve both endurance capacity and performance during exercise lasting approximately 20 to 40 minutes (Graham et al 1998; MacIntosh, Wright 1995). This means that many more athletes across a wider range of sports may be able to access the ergogenic benefits of caffeine. The exact reasons for how caffeine exerts its benefits during exercise of this duration are not fully known, but it is likely that the reasons relate less to metabolic causes and more to the potential influence of caffeine on the central nervous system.
Very short exercise	4 to 8 minutes	Again, research now indicates that caffeine intake can improve endurance capacity and performance during high intensity exercise lasting only approximately four to eight minutes (Anderson et al 2000; Bruce et al 2000; Jackman et al 1996). As above, these findings suggest that caffeine could be used as an ergogenic aid in an even wider range of athletes and sports. The exact mechanisms behind caffeine's effect during exercise of this nature is not known, but may be a combination of effects on metabolism, muscle contraction and the central nervous system.
Sprint exercise	30 to 90 seconds	In a recent review of the topic, it was found that of 12 studies investigating the effect of caffeine intake during high intensity exercise lasting approximately 30–90 seconds, 6 found a benefit of caffeine and 6 did not (Astorino, Roberson 2010). Therefore, current knowledge makes it difficult to answer the question of whether caffeine intake would be beneficial for athletes involved in sports lasting 30–90 seconds. Also, the mechanisms for caffeine's possible benefit during this form of exercise have not been confirmed. The differing findings in the research may be due to the inherent difficulties associated with researching caffeine during exercise (see "Health issues associated with use of non-nutritional ergogenic aids" below).

Resistance exercise	Any	Current knowledge regarding the ergogenic effect of caffeine intake on the parameters of resistance exercise such as the number of repetitions that can be performed before fatigue, the maximum load that can be lifted for one repetition, peak power and peak torque is similar to that for sprint exercise. Approximately half the research supports that caffeine improves aspects of resistance exercise performance and approximately half fails to show a benefit of caffeine intake on these parameters (Astorino, Roberson 2010). Once again, specific mechanisms of caffeine's enhancement of resistance exercise performance have not been fully confirmed.

↑ Table 9.3: Effects of caffeine on performance

How caffeine enables improvements in endurance capacity and performance is still not fully known. However, there are three overriding theories.

1. Caffeine exerts a "metabolic effect" whereby it promotes a greater use of fat by the body during exercise, and enables "sparing" of the finite stores of carbohydrate, therefore allowing the athlete to exercise for longer (Essig et al 1980; Spriet et al 1992). However, more recent research has shown very little evidence for a sparing of carbohydrate stores during exercise with caffeine ingestion (Graham 2008).
2. Caffeine enables the muscles to contract with more force due to a greater release of calcium within the muscle fibres (calcium plays an important role in allowing the muscle fibres to contract). This hypothesis does have some supportive research (Tarnopolsky, Cupido 2000).
3. Caffeine may be able to increase performance by its actions on the central nervous system. It is well known that caffeine is a central nervous system stimulant, and elicits increased feelings of alertness, vigilance and wakefulness. However, many research studies have shown that caffeine can also reduce the perceived exertion an individual feels during exercise, i.e. caffeine makes the exercise feel easier (Tarnopolsky 2010). Also, a reduction in pain has been reported when caffeine is consumed during exercise (Tarnopolsky 2008). This could certainly contribute to improved endurance capacity and performance.

TO DO

Can you think of other sports that could benefit from caffeine ingestion?

TO THINK ABOUT

It is likely that you ingest caffeine in your food and drink. Have you ever noticed an effect on your performance in any sport?

Difficulties when studying caffeine intake and exercise

The overall body of research investigating caffeine ingestion before and during exercise shows a wide variability in the response to caffeine. This means that there are factors present that can alter a person's response to caffeine ingestion, so that giving different people the same amount of caffeine, at the same time, during the same exercise protocol will not necessarily generate the comparable results. Some of these potential factors have been identified.

- Firstly, the amount of caffeine that a person habitually consumes in their diet can influence the relative effect of a caffeine supplement before and during exercise. People who generally consume less caffeine in their diet may receive a greater ergogenic effect from a caffeine supplement then someone who habitually consumes large amounts of caffeine (Kalmar, Cafarelli 1999).
- Secondly, people may fall into "responder" or "non-responder" groups regarding caffeine intake during exercise, particularly of short duration (Astorino, Roberson 2010). This means that some people simply do not respond to caffeine intake during exercise for as yet unknown reasons. These first two points are important, as they suggest that caffeine is not a "universal" ergogenic aid, i.e. it will not necessarily work for all athletes, or even different athletes within the same sport or team.

- Thirdly, the training status of an individual may affect caffeine study data. Well-trained athletes are likely to be more motivated to perform maximal or fatiguing exercise (Astorino, Roberson 2010). As most research studies into caffeine require maximal and/or fatiguing exercise to be performed, it could be that those studies using well-trained athletes produced more reliable data than those using less well trained or untrained individuals. This difference in study samples could contribute to the variability in research findings.

Is caffeine a suitable ergogenic aid for all sports?

It is unlikely that caffeine would be an appropriate ergogenic aid for athletes engaged in sports that require high levels of accuracy, precision and fine muscle control. The reason for this is that one of the side effects of caffeine supplementation is the "jitters", an uncontrollable shaking or tremor, particularly in the hands. Obviously, this would place the performance of athletes such as archers, shooters, golfers etc at risk. The side effects of caffeine are discussed further later in the chapter.

Diuretics

Weight control

Many sports structure levels of competition according to weight categories or classes. Examples of these sports include boxing, wrestling, and powerlifting. Often, athletes will desire to be as close to the upper weight limit of their class as possible, in order to gain a potential weight advantage over their rival(s). This will often require the athlete to rapidly lose weight just prior to competition, to ensure that they qualify for the correct category. Athletes can do this by using starvation diets and/or drugs to induce diarrhoea or vomiting. However, they can also lose weight by losing body water, as the loss of 1 litre of body water is equivalent to about 1 kilogram of body weight. This can be accomplished by using dehydration techniques such as exercising in hot conditions, wearing suits that do not permit the body to evaporate sweat, therefore leading to greater sweat production, and the use of saunas. They can also invoke dehydration by using diuretic agents. Often, an athlete will use a diuretic in combination with some of the above techniques in order to achieve the desired outcome.

TO DO

Can you find examples of other sports where weight is a key factor?

There are also sporting situations where being as light as possible may confer a competitive advantage. Jockeys may attempt to be as light as possible prior to a race to reduce the load that the horse must carry and therefore enable the horse to run faster for longer. Indeed, the use of diuretics by jockeys is commonplace (Bahrke, Yesalis 2002).

Physical appearance

Success in some sports is, at least partly, dependent on the physical appearance of the competitor. For example, female gymnasts have emphasis placed on a slender, lean physical appearance. Conversely, bodybuilders require excellent muscle definition in order to be successful. Diuretics can, and have, been used in order to help gymnasts to get a slender, lean appearance, and to help bodybuilders to get a "cut" look and maximize muscular appearance and definition before competition (Bahrke, Yesalis 2002).

TO RESEARCH

Find three other examples of high profile sportspeople being disqualified from world class competition for using banned substances.

Hiding illicit substance use

As was briefly mentioned earlier, diuretics can be used by athletes in an attempt to hide, or mask, the use of other illegal substances that can be detected via urine analysis. This is primarily achieved by increasing the volume of urine output, thereby diluting the illicit substance so that it appears that less is present in the athlete's body, or by making detection of the substance altogether impossible.

The first athlete to be disqualified at an Olympic Games for the illicit use of diuretics was a Bulgarian powerlifter in Sydney in 2000 (Bahrke, Yesalis 2002). It was reported in the media that the athlete was using diuretics in order to mask the use of anabolic steroids, however this was not conclusively proven.

Health issues associated with use of non-nutritional ergogenic aids

Most, if not all, non-nutritional ergogenic aids will cause changes in the physiological and/or mental function of the individuals who use them. That is how many exert their beneficial effect. However, prolonged and/or excessive use of some can cause potentially serious, even fatal, conditions.

Anabolic steroids

Prolonged use of anabolic steroids can potentially affect the body in many ways. The common adverse effects of prolonged anabolic steroid administration are summarized in Table 9.3.

Heart problems

Prolonged anabolic steroid use can cause disease of the heart muscle (termed cardiomyopathy). Additionally, anabolic steroid use can significantly reduce the concentrations of a particular form of cholesterol called high density lipoprotein (HDL) cholesterol. This form of cholesterol helps to protect the arteries of the heart from clogging up, and therefore lowers the risk of developing coronary artery disease or of suffering a heart attack. Low levels of this form of cholesterol significantly increase the risk of encountering these conditions.

Liver problems

The liver is closely involved in the metabolism of the chemicals that compose anabolic steroids. Long-term use of steroids can cause liver toxicity and can also cause liver disease (hepatitis). Prolonged steroid use can lead to the development of liver tumours which can be cancerous.

Hormone problems

Prolonged use of anabolic steroids reduces the production of gonadotropic hormones, a group of hormones that control the function of the testes in males and the ovaries in females. Reduced production of these hormones in males can cause testicular atrophy (a reduction in size, or shrinkage, of the testicles), a reduction in testosterone concentration and a reduced sperm count, therefore affecting fertility. It can also lead to an enlargement of male breast tissue.

Reductions in gonadotropic hormone production in females can significantly disturb the menstrual process, again affecting fertility, and can reduce the production of estrogen. This can lead to "masculinization" effects in females (i.e. the development of male characteristics). These include a reduction in breast size, enlargement of the clitoris, deepening of the voice and the development of facial and body hair.

Skin problems

Anabolic steroids increase the amount of free fatty acids and cholesterol that is present in the skin. This can cause oily hair and skin, increased acne, alopecia (hair loss) and hypertrophy of the sebaceous glands.

Mental problems

The potentially damaging effects of anabolic steroids are not limited to physical issues. Prolonged steroid use can significantly alter an individual's mental state.

It is commonly reported that individuals using steroids demonstrate a marked increase in aggressive and/or violent behaviour. Increased feelings of depression are also reported. There is also evidence to show that anabolic steroid use can become addictive. However, it should be noted that, mainly for ethical reasons, well-controlled studies into the psychiatric effects of steroid use in humans are lacking. Furthermore, the effects of steroids on psychiatric variables can be individual and overall conclusions are difficult to make (Kutscher et al 2002).

KEY POINT

Using anabolic steroids can affect both physical and mental health, with problems ranging from greasy skin and hair to heart disease.

It is very important to note that the potential long-term (i.e. lifelong) effects of anabolic steroid use in humans is unknown. It is known, however, that long-term intake of anabolic steroids can significantly reduce the lifespan of mice (Bronson et al 1997).

Liver	**Reproductive and hormonal**
Liver toxicity	Males:
Liver cancer	Decreased sperm count
	Abnormal sperm structure
Cardiovascular	Increased breast size
Decreased HDL cholesterol	Shrinkage of testicles
Increased LDL cholesterol	Females
Decreased triglycerides	Voice deepening
Fluid retention (increased blood pressure)	Enlargement of clitoris
Cardiac hypertrophy	Decreased breast size
Increased risk of coronary heart disease	Disruption to menstrual cycle
Increased risk of heart attack	Male pattern baldness
	Increased facial and body hair
Psychiatric	**Dermatologic**
Mood changes	Oily hair
Increased aggression	Oily skin
Increased hostility	Alopecia
Depression	Increased occurrence of acne
Dependence/addiction	Increased size of sebaceous glands

↑ Table 9.4: Possible physical and mental adverse effects associated with anabolic steroid use.

Erythropoietin

It is impossible to predict how many new red blood cells will be produced with rEPO use. Therefore, there is always a risk of increasing blood viscosity due to the production of a large number of new red blood cells. This increased blood viscosity can increase the risk of blood clots, which could lead to a number of health problems including stroke, heart failure and heart attack. The risk of blood clots is also increased as EPO initiates activities associated with platelets and the inner lining of blood vessels that increase the likelihood of developing blood clots.

Athletes who use rEPO may also combine this with injections of iron in an attempt to further boost the oxygen carrying capacity of the blood (Bahrke, Yesalis 2002). Excess iron in the body can cause a number of serious problems in many organs, most notably the liver.

Blood pressure during submaximal exercise after rEPO administration is higher than before its use. This is not solely due to increased blood viscosity, and the exact cause is currently unknown. This elevation in blood pressure infers a greater stress on the heart during exercise, despite the lower exercising heart rate, and may contribute to the unexpected deaths of some athletes that have

used rEPO (Bahrke, Yesalis 2002). In cycling alone, the use of rEPO is strongly thought to have caused the deaths of more than 20 athletes (Szygula 2010).

Beta blockers

The main health concerns result from prolonged use of beta blockers. Beta blockers can cause bronchospasms in people suffering from asthma. They can also cause cardiac failure in people with underlying cardiovascular issues. Beta blockers increase the secretion of insulin in the blood and can therefore cause hypoglycaemia, especially in people with type II (insulin-dependent) diabetes. Some of the most common side effects with beta blockers are brachycardia (abnormally low heart rate), orthostatic hypotension (a drop in blood pressure), a feeling of dizziness or light-headedness due to reduced blood pressure, and potentially life-threatening heart arrhythmias. Beta blockers can also cause feelings of fatigue, obviously not beneficial for optimal sports performance.

Caffeine

Many people are familiar with some of the common side effects of caffeine ingestion. They include nervousness, restlessness, insomnia, and tremors. These side effects are exacerbated in people who are not familiar with caffeine ingestion, who are sensitive to caffeine or who consume high doses. Disturbed sleep caused by caffeine ingestion can lead to fatigue. Some people also suffer gastrointestinal upset. Caffeine acts as a diuretic and can lead to dehydration, particularly during exercise in hot and/or humid conditions. Clearly, all of these issues could negatively influence sports performance, but are not of serious danger to health.

Caffeine is an addictive substance, and people who rapidly stop taking it can suffer withdrawal symptoms including headaches, irritability, fatigue and gastrointestinal upset. High doses of caffeine can also be associated with more serious health risks, such as heart arrhythmias and mild hallucinations. There is also a possible link between continued ingestion of caffeine and problems in pregnancy, risks of cancer, problems with calcium levels and with bone health (Bahrke, Yesalis 2002).

Diuretics

The use of diuretics can hinder the ability of the body to thermoregulate. During exercise, a greater skin blood flow is required so that heat can be lost from the body to the environment. However, diuretics reduce plasma volume (the liquid portion of the blood). In this situation, more blood is required in the central/core areas of the body in order to maintain an adequate blood pressure. Therefore, less blood would be available to travel to the skin, reducing the potential for body heat loss.

Diuretic use is associated with a number of potentially performance-affecting issues such as fatigue, drowsiness, muscle cramps and soreness, a feeling of numbness/tingling in limbs/extremities, nausea and vomiting, diarrhoea, mood changes and blurred vision.

Increased sensitivity of the skin to light is also a possible side effect, likely due to an allergic reaction or sensitivity to a specific type of diuretic. Use of diuretics can increase electrolyte loss, particularly sodium and potassium, and it is thought that many of the above issues are caused by this loss of electrolytes, especially potassium. Excess less of potassium can also contribute to life-threatening conditions such as heart arrhythmias and cardiac arrest. Loss of potassium can also cause changes to metabolism such as a reduced ability to synthesize glycogen. Clearly, this would be an issue affecting sporting performance.