A group of college students is staying up late together to study for exams. Several of them have been drinking coffee all day and are wide awake, although feeling jittery. One of the students, Lisa, mentions that she has recently started taking a prescription medication that helps her stay awake because of a medical condition. Lisa had previously been a heavy coffee drinker, consuming four or more cups of coffee a day in her struggle to stay awake. Since starting on the new medication, she is able to stay awake easily for a day or longer and is not experiencing any negative side effects. “It’s better than coffee,” she tells her friends, “but it is a lot more expensive.”

Should Lisa give her friends her medication? Should her friends take the medicine?

Background

The central nervous system (CNS—the spinal cord and brain) directs the functions of the body. The peripheral nervous system (PNS) takes sensory inputs and relays them to the brain, which evaluates them. The CNS then transmits messages to the appropriate organ or tissue. Drugs that act on the CNS usually do so by interacting with this messaging system, often by stimulating or inhibiting the release of neurotransmitters (the chemical messengers that travel between nerve cells).

Caffeine

Many drugs act on the CNS to enhance alertness. The most popular behavior-altering drug is the stimulant caffeine. An estimated 9 out of 10 Americans consume some type of caffeine regularly. Caffeine is well known for its ability to briefly relieve fatigue and drowsiness.

Caffeine is found naturally in more than 60 plants. It is in coffee, tea, soft drinks, and, to a lesser extent, chocolate, and it’s sometimes added to medicines. Caffeine is absorbed quickly and travels to the brain. Excreted several hours after it’s been consumed, it does not build up in the blood and is not stored in the body.

Although some people are highly sensitive to the effects of caffeine, most are not harmed by the amount of caffeine in two to three cups of coffee per day (200–300 milligrams total). More than 500–600 milligrams per day of caffeine (as much as in four to seven cups of coffee) can result in sleeplessness, headaches, irritability, anxiousness, and changes in heart rhythm. Caffeine is addictive, and individuals who consume large quantities of it exhibit withdrawal symptoms if they suddenly stop using it.
Modafinil

The chemical compound modafinil (moe-DAH-fih-nill) is another CNS stimulant. It is used to treat sleepiness, especially sleepiness from disorders such as narcolepsy (which causes people to fall asleep during the day, especially when excited), shift-work sleep disorder (which can occur as a result of working nights or on rotating shifts), and sleep apnea (when someone’s breathing is disrupted during sleep).

Modafinil helps people stay awake during the day and does not interfere with their ability to sleep at night or have many of the side effects of other CNS stimulants. Although the exact way modafinil works is unknown, it probably changes the amounts of neurotransmitters in the part of the brain involved in controlling sleep and wakefulness. Although it may be habit forming, its potential for abuse is considered lower than that of other CNS-stimulant drugs, such as amphetamines. It is frequently prescribed for off-label use (that is, for conditions other than those originally approved by the U.S. Food and Drug Administration). The estimated cost is over $200/month.

Sources


Enhancement Cases and Background Information

Myostatin (based on an actual case)

Doctors in Germany noted the birth of an extraordinary boy. While not heavy at birth (his weight was in the 75th percentile), he was unusually muscular. Muscles in his thighs and upper arms were very pronounced. Except for the fact that he had strong reflexes, his physical examination was normal. His levels of testosterone and growth factors were also normal. By age four, the boy could hold two 3-kg (6.6-lb.) dumbbells out at his side with arms extended.

His mother had been a professional athlete. She was healthy and had a normal pregnancy. Several other family members were also reputed to be very strong. Researchers analyzed the DNA of both mother and son and found a mutation in the myostatin gene, resulting in an abnormal myostatin protein. Myostatin normally inhibits muscle growth. When the protein is not functioning, that inhibition is lifted and muscles grow as a result. Myostatin inactivators might help people with muscular dystrophy and other muscle-wasting diseases or with sports injuries. However, the possibility also exists that healthy athletes would use such inactivators for enhancement purposes.

Imagine that a top athlete has that myostatin-gene mutation. A competitor is taking myostatin inactivators. Is there a difference in how these two athletes should be treated? Should they both be allowed to compete? Why or why not?

Background

Myostatin (my-oh-stat-in) is a protein that puts the brakes on muscle growth. When myostatin is somehow inhibited, muscles grow—although the precise mechanism by which they do so is not yet understood. A mutated form of the gene for myostatin has been found in types of cattle that are also abnormally muscular (Belgian Blue and Piedmontese) and have very little fat. Mice that have been genetically engineered to lack myostatin grow into “mighty mice”—from the increase in size and number of muscle fibers.

Scientists have come up with several approaches to blocking myostatin. One uses antibodies against myostatin to bind and block it. Another uses a smaller, incomplete version of myostatin. The incomplete version binds to many of the places in the cells surrounding the muscles that normal myostatin would otherwise bind to (competitive inhibition), thus blocking and preventing some of the normal myostatin from carrying out its normal function.

Sources


Enhancement Cases and Background Information

Erythropoietin (EPO) (based on an actual case)

The Tour de France is considered by many people the ultimate bicycle race. It’s between 3,000 and 4,000 km (1,800 and 2,500 miles) long, on a grueling course across France and over many mountain passes. Various techniques and drugs to enhance performance have become widespread among the racers. Particularly common has been the use of “blood doping.” This is when athletes increase the number of red blood cells in circulation, either through blood transfusions or by stimulating the production of more blood cells. An increase in red blood cells allows more oxygen to be carried to the tissues, which enhances aerobic performance.

One of the most frequently used blood-doping substances is erythropoietin (EPO). In 1998, an entire team was banned from the race when their use of EPO was discovered. Bjarne Riis of Denmark, who won the Tour in 1996, also publicly admitted his use of EPO. Erik Zabel, a German cyclist, noted in his public admission of EPO use, “My generation will probably be remembered as generation EPO.”

Some people have argued that allowing athletes to use EPO and other enhancements violates the spirit of sport. Others, such as Julian Savulescu and his colleagues, disagree: “Far from being against the spirit of sport, biological manipulation embodies the human spirit—the capacity to improve ourselves on the basis of reason and judgment. . . . The result will be that the winner is not the person who was born with the best genetic potential to be strongest. Sport would be less of a genetic lottery. The winner will be the person with a combination of the genetic potential, training, psychology, and judgment. . . . We should not think that allowing cyclists to take EPO would turn the Tour de France into some kind of ‘drug race,’ any more than the various training methods available turn it into a ‘training race’ or a ‘money race.’ Athletes train in different, creative ways, but ultimately they still ride similar bikes, on the same course. The skill of negotiating the steep winding descent will always be there” (Savulescu, Foddy, and Clayton, 2004).

Do you agree or disagree with Savulescu, Foddy, and Clayton? Should athletes be allowed to use EPO? Why or why not?

Should there be separate sports events for people who are taking drugs for enhancement and those who are not?
Background

Erythropoietin (e-rith-roh-POY-e-tin) (EPO) is a hormone naturally made by the kidneys. It is produced in response to a variety of conditions, such as living at a high altitude, pregnancy, or a lower-than-normal number of blood cells (anemia) or loss of large quantities of blood. EPO travels through the blood stream to the bone marrow, where it stimulates production of red blood cells. Human EPO was isolated and purified in the 1970s. Because of a strong interest in developing EPO for clinical uses, by the mid 1980s, several biotechnology companies had developed techniques to produce genetically engineered (recombinant) EPO.

Recombinant EPO is used to treat anemia (low levels of red blood cells) resulting from a host of conditions, primarily kidney failure and cancer chemotherapy. However, EPO has also been used in sports to enhance performance. One side effect of overuse of EPO is that the athlete’s blood can thicken and clog in the heart or brain, causing heart attacks and strokes. EPO was officially banned in 1985. Until recently, accurate testing was not possible because of the similarities between laboratory-made and natural EPO.

In the future, it may be possible to manipulate the genes that manufacture EPO naturally. Experiments involving the transfer of genes to increase EPO production have been conducted in monkeys. Although the animals’ red blood cell counts increased dramatically, their blood also thickened to such an extent that it had to be diluted regularly to prevent heart failure. If such gene-transfer or gene-manipulation techniques are developed, detection of EPO enhancement will become even more challenging.

Sources


Enhancement Cases and Background Information

Growth Hormone

Ryan knew he was shorter than other boys, and he was beginning to feel uncomfortable about it. His father had taken him to the doctor, who assured them that Ryan was within the normal range for height, even though he was on the lower end of that range. His sisters were small for their age, too, although they weren't getting teased like Ryan was. His doctor had Ryan’s blood tested, and all the results came back normal—he had adequate amounts of growth hormone.

One night, Ryan’s parents asked him if he wanted to try to increase his height with additional growth hormone. They had read about the treatment for individuals with short stature and wanted to bring it up at his next doctor’s appointment. Even though his hormone levels were normal, they reasoned that additional growth hormone would make him taller. Ryan’s parents had heard on TV that taller men were more likely to have successful careers. Even though they weren’t sure whether they could trust the TV report, they were concerned that Ryan might have fewer opportunities later in life if he was shorter than average as an adult.

Should Ryan take the growth hormone? Why or why not? What if Ryan doesn’t want to but his parents want him to?

Background

When people have normal body proportions but are unusually short, they may be deficient in growth hormone. This condition, which can either be present at birth or develop later in life, is often noticed when a child’s growth curve (a graph of change in height over time) indicates little or no growth. Short stature is associated with a height that is below the fifth percentile on a standardized chart. The condition can continue throughout childhood and is often associated with reduced levels of other hormones.

Growth hormone is involved in the metabolism of glucose and fat, as well as in the production of protein in growing cells. It also causes bones to grow from the growth plates at the ends of bones. The pituitary gland, which is about the size of a pea and is located at the base of the brain, ordinarily produces growth hormone. Mutations in genes that code for growth hormone can lead to a decrease in the amount of the hormone in the body. Injury to the brain and lack of a pituitary gland can also decrease the amount of growth hormone being produced. In most cases, however, the cause of the growth hormone deficiency is unclear.
Diagnosis of growth hormone deficiency is made using blood tests. Treatment involves giving people recombinant growth hormone that has been created by genetic engineering. The treatment is generally safe and has few side effects, although it has been associated with tumors. If someone gets the hormone treatment before puberty, additional growth can occur before the growth plates fuse.

The U.S. Food and Drug Administration first approved growth hormone treatment for idiopathic short stature (short stature with unknown cause) in 2003. An NIH study had followed 68 children who had the treatments because they were simply short (and not because of any growth hormone deficiency). The children, who were given injections three times a week over an average of 4.4 years, gained an average of 1.5 inches as adults.

Sources


Enhancement Cases And Background Information

Beta-Blockers

Juanita is an excellent violin player. Music is her passion in life, and she can’t see herself doing anything professionally other than playing the violin. The biggest problem she has is that when it comes time for an important performance, her hands start to shake and she starts to feel anxious and panicky. She is embarrassed to admit that she has this problem. Recently, though, the situation has gotten so bad that she told the conductor of her orchestra about it. He recommended she see the doctor to get a medication to “calm her down” so that she can continue to perform. Juanita feels uncomfortable about taking a drug for her tremors, but she also knows that she can’t continue to feel the way she does when she is on stage and the audience is looking at her.

Beta-blockers are sometimes used by musicians to minimize the outward effects of nervousness, but they are banned from some competitive sports such as archery. Is taking beta-blockers for performance anxiety fundamentally different from taking substances to enhance sports performance? Explain your position.

Background

Drugs called beta-blockers (such as propranolol) affect the response of the body to particular nerve signals. They are commonly used to treat heart conditions and high blood pressure. Because they relax blood vessels and lower blood pressure, the heart does not have to work as hard. Beta-blockers can also be used to prevent symptoms associated with anxiety.

Beta receptors, which bind the nerve-stimulating hormones such as epinephrine and norepinephrine, occur in the heart, blood vessels, kidneys, and lungs. Beta-blockers compete with the nerve-stimulating hormones to bind to the beta receptors, thereby blocking the physical basis of the flight-or-fight response.

Beta-blockers may be prescribed for social phobias or other situations when an individual has physical anxiety, such as stage fright. They are also used to treat tremors. The most common type of tremor, essential benign tremor, is often treated with beta-blockers. Beta-blockers are on the list of the World Anti-Doping Agency’s prohibited substances for certain sports (such as archery) because of their ability to reduce anxiety and muscle tremors.

Sources


