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Health-Related Issues: Use of Drugs and Exercise

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1. INTRODUCTION

This symposium focuses on the clinical pharmacology of sports and exercise, and there are some interesting similarities as to why individuals may engage in exercise and sports or use drugs. Individuals exercise for a variety of reasons. Some individuals may exercise to improve their health, some may train in attempts to enhance sport performance, while others may exercise and play sports for recreational or social purposes. Individuals may also use drugs with similar intentions. Some individuals use therapeutic drugs to improve their acute or chronic health status, some may use ergogenic drugs for their purported potential to enhance sport performance, while still others may take recreational drugs for mind-altering purposes.

As related to these purposes, there are various possible interactions between exercise or sports performance and the use of drugs. Drugs that are used for therapeutic or social purposes may elicit either an ergogenic or ergolytic effect on sport performance, depending on the drug and the sport. For example, beta blockers are normally used for therapeutic purposes, but their use could enhance performance in some sport events such as pistol shooting (by decreasing anxiety and hand tremor) and impair performance in aerobic endurance sports (by adversely affecting cardiovascular and metabolic responses to exercise)[1].

Additionally, many drugs used for ergogenic purposes may exert adverse effects on health. Most of the papers presented at this symposium focus on the potential performance-enhancing effect of selected pharmaceutical agents, such as anabolic-androgenic steroids (AASs) and erythropoietin (EPO). When used primarily as ergogenic aids, AASs and EPO may impact on health as well. Although the incidence of serious health effects associated with use of AASs thus far reported has been extremely low, some clinical studies indicate AASs use is associated with several adverse and even fatal effects [2]. The long term effects of using AASs are generally unknown, but some experimental studies suggest prolonged use of AASs may exacerbate risk factors associated with the development of coronary heart disease, such as decreased HDL-cholesterol levels and increased platelet aggregation [3,4]. Excessive use of EPO may lead to polycythaemia and possible cardiovascular complications during exercise, factors possibly underlying the proposed link between EPO use and the sudden deaths of young athletes[5].

Athletes view ergogenic drugs as an essential component for success [6]. Ergogenic drugs are banned for the unfair advantage they may give to athletes who use them to enhance performance, but they are also banned because of the possible harmful side effects which some drugs may induce. Where appropriate throughout this symposium, the adverse health effects of specific pharmacological ergogenics will be detailed.

2. RECREATIONAL DRUGS AND HEALTH

The World Health Organization defines health as a state of complete physical, mental, or social well-being and not merely the absence of disease or infirmity. In order to help develop optimal health status in their populace, most industrialized nations have initiated wellness programmes designed to favour life-style behaviours most conducive to health promotion and disease prevention. Wellness programmes include such components as healthful nutrition, smoking cessation, and stress management, but two of the key elements of any health promotion programme are appropriate exercise regimens and prevention of drug abuse.

The use of therapeutic and ergogenic drugs may be and has been abused by athletes, but this review focuses on the potential for abuse of recreational or social drugs, particularly as related to physically active individuals. Recreational drugs are used to alter mind states, to achieve a state of relaxation or sensation-seeking exhilaration. Commonly used recreational drugs include stimulants, cocaine and crack cocaine, marijuana/hashish, inhalants, hallucinogens, LSD, heroin, tranquillizers, alcohol, cigarettes, and smokeless tobacco. Although the use of recreational drugs declined throughout the 1980s, there has been a steady rise throughout the 1990s. For example, the National Institute of Drug Abuse reported that in almost all categories of recreational drugs, use is increasing among American teenagers [7].

Given the health environment associated with individuals who exercise or engage in sport, one would think that they would be less likely to use recreational drugs. However, that may not be the case. For example, some studies indicate that athletes are no more likely to use drugs than their nonathlete peers, with the exceptions of smokeless tobacco and anabolic steroids [8]. Athletes who use steroids are more likely to practice polypharmacy and use other drugs as well, such as tobacco, marijuana, cocaine, amphetamines, sedatives, opiates, inhalants, and designer drugs [9].

Heyman indicated that although there has not been a systematic study of athletes by sport and sensation seeking, several studies have shown that high risk sports such as American football, basketball, hockey, and boxing may contain a greater number of high sensation seekers. These are individuals who neurobiologically are programmed to want, tolerate, and enjoy higher levels of sensory stimulation, and thus it may not be a coincidence that cocaine appears to have become so prominent in athletic circles such as these [10].

In the United States alone, illicit drug use accounts for almost 20,000 deaths and much morbidity [11]. The drug problem in sports sees no age, gender, racial, or ethnic discrimination. It affects all athletes across the spectrum [10]. Some athletes develop significant health problems related to drug addiction and a number of reported deaths have been associated with drug use and abuse in athletes [12,13].

This paper will focus briefly on several drugs that may be used by athletes for recreational, and in some cases ergogenic, purposes, i. e., amphetamine, cocaine, and marijuana. Other

recreational drugs (alcohol, caffeine, tobacco, and tranquillizers) are covered elsewhere in this volume.

2.1 Amphetamine

Amphetamine acts directly on the central nervous system, stimulating the pleasure pathway of the brain. Although its mode of action is not clear, amphetamines may stimulate the release of noradrenaline and dopamine, and may also inhibit the reuptake of the catecholamines, but the behavioural effects of amphetamine cannot be explained completely by its effect on catecholamines [14].

Amphetamine is used therapeutically, primarily for the treatment of Attention Deficit/Hyperactive Disorder (ADHD) and Attention Deficit Disorder (ADD). However, amphetamine is used illicitly for its psychoactive effects, leading to euphoria, mood enhancement and a decreased sensation of fatigue. Although amphetamine was a popular stimulant in the 1950s and 1960s, more potent forms have been developed for recreational use, such as methamphetamine, or speed. Methamphetamine hydrochloride is available in a powder form, but in recent years has been free-based to a crystal form known as ice. The popularity of smoked crystal ice is due to the immediate clinical effects resulting from its rapid absorption from the lungs. Ice elicits effects similar to, but lasting longer than, cocaine, including euphoria, increased alertness and an enhanced sense of well-being [15].

Another form of amphetamine is methylenedioxymethamphetamine (MDMA), which was developed in 1914 by the Merck company for use as an appetite suppressant. Its use fell into disfavour until its reemergence as the recreational drug Ecstasy in recent years. Although there is a lack of research regarding the ways Ecstasy is used and the nature of its effects, it appears to share the properties of both amphetamines and hallucinogens. Ecstasy is gaining popularity worldwide, and users report sensations of energy and activation, feelings of intimacy and closeness to others, as well as psychedelic effects of perceptual and sensual enhancement [16].

Amphetamine is theorized to improve sport performance via psychological effects, increasing motivation and self-confidence that may raise the subjective limits of performance and possibly remove normal inhibitions which may restrict athletic capacity. In some studies, increased lactic acid levels at exhaustion provide some evidence of the ability of amphetamine to induce analgesic effects and deter the sensation of pain associated with intense exercise. Additionally, amphetamine may enhance metabolic processes, most notably an increased level of serum free fatty acids, which could benefit aerobic endurance performance. Several reviews have indicated that although research findings are equivocal, amphetamine treatment may improve a number of indices of physical performance, including reaction time, strength, acceleration, and aerobic endurance, particularly when subjects are fatigued. Rarely has amphetamine use impaired physical performance [14,17].

Use of amphetamine and its derivatives is not without health risk. Side effects of amphetamine use include insomnia, nervousness, dizziness, appetite loss, hyperthermia, drug dependence, and depression upon withdrawal. High doses may cause tremors, muscle twitching, irregular heartbeat, hallucinations, and death. The death of a Danish cyclist in the 1960 Rome Olympic Games was attributed to amphetamine use [13].

Clinical reports also indicate the use of ice and Ecstasy may be very toxic as well. Hong and co-workers reported the deaths of two patients associated with the smoking of crystal methamphetamine. One developed pulmonary oedema and a dilated cardiomyopathy, and the other most likely experienced a diffuse vasospasm that resulted in acute myocardial infarction

and cardiogenic shock [18]. Ecstasy use also causes severe health problems. One of the major side effects is hepatitis and possible liver failure, which may necessitate liver transplantation or result in death [19,20].

2.2 Cocaine

Cocaine is an alkaloid derivative of the leaves of the coca plant, erythroxylon coca, which grows extensively in the northern mountains of South America. Cocaine may be obtained by chewing the plant leaves, but is more commonly consumed as a white, crystalline powder derived from the leaves or in its more potent free-based form known as crack. Although cocaine has some therapeutic applications, its illicit use is attributed to its psychoactive effects. Cocaine stimulates both the central and sympathetic nervous systems, leading to euphoria, mood enhancement and a decreased sensation of fatigue [17].

Cocaine, as a stimulant, may be theorized to possess ergogenic potential. However, research with animals has indicated that cocaine has no beneficial effect on prolonged exercise and may be detrimental [17]. Research with humans is sparse, but one review noted that cocaine had no effect on heart rate, ventilation, oxygen consumption during maximal exercise, or exercise time to exhaustion on a cycle ergometer in native Indian chewers who obtained cocaine through leaf chewing. Although cocaine is a potent stimulant, its effects are short lived so that its use as a ergogenic aid in sport might not be very practical [14].

Cocaine has been designated as a drug of significant health concern [21]. Cocaine is strongly addictive and can lead to a variety of psychological and physiological health problems, including death. Cocaine abuse may cause several psychological and behavioural changes including depression, irritability, and paranoid ideation. An acute dose of cocaine may be toxic to the cardiovascular system, eliciting potentially life-threatening cardiovascular responses, primarily dysrhythmias and myocardial ischaemia via coronary vasospasm and increased myocardial oxygen demand. Sudden death has been noted in numerous case reports, including elite athletes. Additionally, use of cocaine is significantly associated with other forms of drug abuse, and if used intravenously, is significantly related to human immunodeficiency virus (HIV) seropositivity [22].

2.3 Marijuana

Marijuana contains the shredded, dried leaves, flowers, and stems from the cannabis sativa plant. The most active ingredient in marijuana is delta-9-tetrahydrocannabinol (THC), a cannabinoid possessing psychoactive properties. Marijuana is most commonly smoked and within minutes THC appears in the blood. The amount of THC in marijuana varies with the ratio of flowers to the leaves. A typical marijuana cigarette with 1.5 percent THC contains enough THC to elicit a psychoactive effect. Hashish, the resin from the female flowers, is approximately 10 percent THC [1].

Although the mechanisms underlying its psychoactive activity are poorly understood, THC is thought to influence the activity of numerous brain neurotransmitters, including noradrenaline, dopamine, serotonin and the endorphins. The manner of the psychoactive effect may be influenced by various factors, such as expectancy, preexisting mood, and the environment in which it is used, and may involve a relatively nonselective complex mixture of excitatory and depressant effects. The excitatory effects involve euphoria and enhancement of the senses, while the depressant effects are characterized by feelings of calmness and relaxation [1].

Marijuana may be theorized to be a sport ergogenic for either its stimulant or depressant effect. In some cases, marijuana may function as a sympathomimetic drug, increasing plasma noradrenaline levels. A psychological stimulant effect could enhance performance in a variety of sport endeavours. Psychological responses of calmness and relaxation could reduce anxiety and hand tremor, enhancing performance in sports involving fine motor control, such as pistol shooting. Conversely, some of the adverse side effects of marijuana, noted below, could be ergolytic. For example, the amotivational syndrome could impair the intensity of training, while increased plasma carboxyhaemoglobin could impair aerobic endurance. Indeed, research has shown that marijuana use decreased aerobic performance capacity. Although marijuana may be theorized to be a sport ergogenic, there are no data indicating athletes have used it in this regard [1].

Although experts note that occasional use of marijuana does not appear to be harmful to physical health, they do note that it exerts some alteration in almost every biological system in the body, and that the state of knowledge is too limited to rule out the possibility that THC may produce adverse health effects on various body organs. Marijuana use has been associated with adverse behavioural manifestations, including panic attacks, paranoia, anxiety, lethargy, distortion of visual perception, and a decrease in attention span, concentration, and memory, often referred to as the amotivational syndrome. Some of these psychological effects may adversely affect complex reaction time and a wide variety of psychomotor tasks, including driving ability. Reported adverse physiological effects include bronchitis and bronchospasm, increased plasma carboxyhaemoglobin levels, decreased testosterone levels, and unilateral gynecomastia [1,23].

3. SUMMARY

One of the fundamental laws of biology and the science of toxicology is that every substance that may influence cellular functions may be toxic if consumed in excess. This is particularly so for drugs, including therapeutic, ergogenic and recreational drugs. Therapeutic drugs may permit athletes to continue to train and compete, ergogenic drugs may help improve performance in specific sports, and recreational drugs may help the athlete socialize and relax, but all drugs produce side effects that may impair both sport performance and health. Most drug-related adverse health effects in society, including the world of the athlete, are associated with misuse or abuse of the recreational drugs, but the athlete is also very susceptible to abusing both therapeutic and ergogenic drugs.

Aside from possible adverse effects on sport performance and health, use of ergogenic or recreational drugs may cause other problems. Most, but not all, effective ergogenic drugs are banned from use in sport training or competition, and a positive drug test is grounds for disqualification and suspension from future competition. Use of illicit recreational drugs is also banned by several sports governing bodies as well as governmental agencies and, if detected, may result in a substantial financial penalty and/or prison term.

REFERENCES

1. M.H. Williams. In D.R. Lamb and M.H. Williams (eds.), Ergogenics: Enhancement of Performance in Exercise and Sport, Dubuque, Brown & Benchmark, (1991) 331-372.
2. C.E. Yesalsis and M.S. Bahrke. Sports Med., 19 (1995) 326-340.
3. L.I. Cohen, C.G. Hartford, and G.G. Rogers. Med. Sci. Sports Exerc., 28 (1996) 176-179.
4. G.S. Ferenchick. Med. Hypotheses, 35 (1991) 27-31.
5. J. Ramotar. Physician and Sportsmed., 18 (1990) 48-49.
6. D.A. Smith and P.J. Perry. Ann. Pharmacother., (1992) 653-659.
7. National Institute of Drug Abuse. Monitoring the Future, (1995), December, 1995.
8. L. Schnirring. Physician Sportsmed., 23 (1995) 25-26.
9. P.W. Meilman, R.K. Crace, C.A. Presley, and R. Lyerla. J. Am. Coll. Health., 44 (1995) 98-104.
10. S.R. Heyman. Prevention Researcher, 3 (1996) 3-5.
11. H.W. Haverkos and M.D. Stein. Am. Fam. Phys., 52 (1995) 2029-2035.
12. T. Verducci. Sports Illust., 84, May 27, (1996) 32-39.
13. R. Voy. Drugs, Sports, and Politics, Champaign, IL, Human Kinetics, 1991.
14. M.H. Williams. In A. Ryan and F. Allman (eds). Sports Medicine, New York, Academic Press, (1989) 183-210.
15. R.W. Derlet. West. J. Med., 153 (1990) 625-628.
16. N. Solowij, W. Hall, and N. Lee. Br. J. Addict., 87 (1992) 1161-1172.
17. R.K. Conlee. In D.R. Lamb and M.H. Williams (eds). Ergogenics: Enhancement of Performance in Exercise and Sport, Dubuque, Brown & Benchmark, (1991) 285-330.
18. R. Hong, E. Matsuyama, and K. Nur. JAMA, 265(1991) 1152-1154.
19. R.A. de Man, J.H. Wilson and H.S. Tjen. Ned. Tijdschr. Geneeskd., 137 (1993) 727-729.
20. N.T.A. Campkin and U.M. Davies. J. R. Soc. Med., 85 (1992) 61.
21. A.A. Welder and R.B. Melchert. J. Pharmacol. Toxicol. Methods, 29(1993)61-68.
22. M.H. Williams. In C. Bouchard, R. Shephard, and T. Stevens (eds.), Physical Activity, Fitness, and Health. Champaign, IL, Human Kinetics, (1994)898-915.
23. G. Wadler and B. Hainline. Drugs and the Athlete, Philadelphia, F. A. Davis, 1989.

Discussion: Health-Related Issues: Use of Drugs and Exercise

F. Brouns:

Some athletes use this type of drugs to improve their exercise and some also to have less pain and an improved mental feeling of recovery after exercise. As you know, severe exercise or severe competition may lead to a substantial feeling of pain in the legs or in the muscles, which may also disturb sleep. For instance, if an athlete undergoes severe training and smokes marijuana, he may not have a benefit during exercise but he may have a better mental feeling about his recovery after exercise, which will influence both the sensitivity to pain and the next day's performance when repeated. Over time this may possibly affect training capabilities. Is there any data on such effects?

M.H. Williams:

That may be why various athletes may possibly turn to various forms of social drugs. Alcohol is probably the number one abused drug by athletes as well as (in the United States) by the average population. Many athletes might possibly use that as a stress reliever or something like that after exercise. There are some studies dealing with social consumption of alcohol (like one or two drinks) in which no impact was detected on a wide variety of physical parameters the next day. In one study in which they got to the point where subjects were intoxicated, there certainly was an impact on performance the next day. In the case of marijuana, the effect may last for 4-5 hours and there may possibly be a delayed response the next day, including adverse effects on such performance parameters as complex reaction time tasks.

T. Reilly:

In an alcohol recovery study conducted on Irish rugby players, it was found that intake of high amounts of alcohol impaired performance in a fairly severe aerobic test the following morning.

N.T. Cable:

One of the problems with the social use of ectasy is that it seems to be taken in combination with "raves", that is dancing for many hours. One of the major problems seems to be temperature regulation with very high body temperatures reported. I was wondering if you knew of any research that had looked at the thermal response in conjunction with ecstasy?

M.H. Williams:

It may be there, but I have not seen it. When I did a Medline search on ecstasy, I uncovered a number of articles, but very few related to physical activity and exercise. Most of the information I uncovered dealt with the social implications, but it may seem that being a derivative of amphetamine it may possibly contribute to body temperature problems.

M. Orme:

Are there any data in the literature that point to fundamentally different effects in healthy athletes compared to patients? For example, Prof. Clarkson mentioned the case of a fit, healthy

athlete who suffered hyperkalaemia when given a diuretic. There are some differences between diuretics but the usual response to diuretics such as frusemide would be hypokalaemia and this is the effect we would worry about.

M.H. Williams:

I would imagine we should start talking about responders and non-responders. There may be interindividual differences in response among different athletes, but this is the case of non-athletes as well.