Basic Athletic Training
Course Pack B

FACTORS CONTRIBUTING TO THE THERAPEUTIC EFFECT OF A DRUG

? What factors contribute to the therapeutic effect of a drug during the pharmacokinetic process? Does taking more medication increase its effectiveness?

Subsequent to absorption and distribution in the body, various factors contribute to the therapeutic effects of a drug. These include blood plasma levels, therapeutic range, half-life, dose response, and potency.

Blood Plasma Levels

In most cases, a direct correlation exists between the therapeutic and toxic response of a drug and the concentration level of a drug in the blood plasma. As a result, drug dosing objectives (i.e., frequency and quantity of the drug to be taken) often are referred to in terms of achieving specific blood plasma levels. There are two basic drug plasma levels:

1. **Minimum effective concentration** (MEC) refers to the minimum concentration that must be present for the drug to be effective.
2. **Toxic concentrations** reflect drug levels in blood plasma that are too high and, therefore, increase the risk of toxic effects.

Therapeutic Range

The range between the MEC and the toxic concentration is referred to as the **therapeutic range** of a drug. The objective of drug dosing is to maintain plasma levels within the therapeutic range. The wider this range, the safer the drug. For example, because acetaminophen has a toxic concentration range that is 30-fold greater than the MEC, it is considered to be a safe drug. In comparison, lithium has a much narrower toxic concentration range of only threefold greater than the MEC and, therefore, is not considered to be as safe a drug.[2,3]

Medications with a very narrow therapeutic range often require monitoring of blood levels. The asthmatic medication theophylline, for example, is a drug with a narrow therapeutic range. If the dose is too low, the patient runs the risk of an asthma attack; if the dose is too high, the extreme result can be arrhythmias or convulsions. A slight alteration in the dose or a change in absorption, distribution, metabolism, or excretion can easily result in the blood level falling below, or rising above, the therapeutic range of the drug.

Dosing Intervals and Plasma Concentrations

Drug concentrations in the blood rise during metabolism and decline during excretion. Because an adequate response to a drug cannot occur until plasma levels meet the MEC, a latency period occurs between the time of drug administration and the onset of effects. The extent of this delay is determined by the absorption rate. Because injected drugs are absorbed and enter the blood rapidly, they produce more rapid effects. In contrast, drugs that are taken orally usually require approximately 30 minutes before the onset of effects is noted. Time-release medications are examples of drugs that maintain an average plasma level over a period of time. As a result, the effects of time-release medications do not decline before the next dose. The effects continue throughout the dosing schedule. As long as plasma levels remain above the MEC, the therapeutic response continues. Once plasma levels drop below the MEC, however, the therapeutic response gradually diminishes. As metabolism continues, drug levels decline until excretion eliminates the drug from the body.

Maximal Efficacy

Maximal efficacy is the dose at which a response occurs and continues to increase in magnitude before reaching a plateau or threshold. Once the response reaches the threshold, the increase in response does not continue, even if more medication is given. Maximal efficacy serves as an index for the maximal response that a drug can produce. This explains why taking more than the recommended dose of a drug does not produce increased effects. In fact,

taking more than the recommended dose can lead to toxicity.

Half-life

The time required for the amount of a drug in the body to reduce by 50% is called the drug's **half-life**. Half-lives can be as short as a few minutes or as long as a week. The longer the half-life of a drug, the slower it leaves the body. For example, acetaminophen has a half-life of 2 hours. Therefore, every 2 hours, 50% of the acetaminophen in the body is excreted. As such, 2 hours after ingesting 200 mg, approximately 100 mg remain, and after another 2 hours, 50 mg remain. If acetaminophen is administered with repeated doses over a period of time, it accumulates in the blood and reaches a threshold. This threshold declines if the dosing is diminished or discontinued. It must be noted that not all drugs have a half-life. For example, alcohol is excreted by the body at a constant rate regardless of the amount present. One aspirin tablet generally is 5 g or 325 mg, with a half-life of approximately 3.15 hours. Although the half-life of a drug depends on its volume distribution as well as its clearance, a single aspirin can remain in the body for several hours after ingestion.

See **Half-life of Aspirin** available on the companion Web site at thePoint.

Potency

When comparing two similar drugs, the drug that is more potent requires a lower dosage to produce the same effects. Potency serves as an index for the amount of drug that can be administered to elicit a desired response; it is not synonymous with maximal efficacy. Achieving pain relief with acetaminophen requires a higher dosage than that with morphine, because morphine is much more potent than acetaminophen, requiring less dosage to elicit a given response. The more potent medication, however, is not necessarily the best medication. A variety of factors must be considered, such as side effects, dosing, other available medications, and the patient's specific health factors.

For a drug to exert a therapeutic effect it must reach a certain blood plasma level. This level is considered to be the therapeutic range or the range between minimal effective concentration and toxic concentration. Maximal efficacy is the maximal response of a drug no matter how much more of the drug is taken. Some drugs are more potent than others. A drug that requires a lower dosage for desired effects is more potent than a similar drug that requires a higher dosage.

DRUG INTERACTIONS

Why is drug interaction a major consideration in the pharmacokinetic process?

It is not unusual for an individual to use two or more drugs simultaneously, leading to the potential for a **drug interaction**, which refers to the ability of one drug to alter the effects of another drug. Such an interaction may intensify (synergistic action) or reduce (inhibit) the effects of the drug. In some cases, a drug interaction may become life threatening. Individual response to a drug interaction can be influenced by several factors, many of which alter pharmacokinetic processes (i.e., absorption, distribution, metabolism, and excretion). These factors include the following:

- Genetics and age
- Current illness or disease
- Quantity of drug ingested
- Duration of the drug therapy
- Time interval between taking two or more drugs
- Which drug is taken first

For example, if an individual is taking a muscle relaxant for a low back spasm and drinks alcohol, the depressant effects of both the muscle relaxant

and the alcohol intensify, leading to increased drowsiness. In contrast, if two stimulants are combined, such as a nasal decongestant and caffeine, an increased central nervous system (CNS) stimulation effect may result in nervousness, heart palpitations, and even insomnia. Some drugs, such as the H_2-antagonist cimetidine (e.g., Tagamet), which is used to promote stomach ulcer healing by suppressing secretion of gastric acid, can reduce the hepatic (liver) metabolism of many drugs. Taken with NSAIDs, Tagamet may intensify the side effects of the NSAIDs.

Although most medications are not affected by food, drug interactions with food also may occur. Some drugs (e.g., tetracycline antibiotics) should not be taken with milk or milk products, because calcium combines with the medication and inactivates it. Other medications, such as NSAIDs, should be taken with food or plenty of fluids to reduce stomach irritation. Some antifungal medications require food to increase absorption of the medication. As such, it is always important to ask the physician or pharmacist for instructions on taking a medication.

Individuals often find themselves taking more than one drug at a time. Drug interaction refers to the ability of one drug to alter the effects of another drug. The resultant interaction could intensify or reduce the effects of a drug. Drug interactions can alter pharmacokinetic processes (i.e. absorption distribution metabolism and excretion). In some cases drug interaction may become life threatening.

ADVERSE DRUG REACTIONS

A college athlete takes a medication prescribed by a physician. The athlete develops hives and problems with his breathing. What condition might the athlete be experiencing and what is the appropriate management of this condition?

Prescription and OTC medications have the potential to produce adverse

reactions. Adverse drug reactions range from mild to severe. Mild reactions are associated with side effects such as drowsiness, nausea, and an upset stomach. These reactions often are temporary and can be tolerated for short periods of time. If the reactions do not dissipate in a few days, a physician should be contacted immediately. About 80% of all allergic drug reactions are caused from β-lactam antibiotics, NSAIDs, and sulfonamides.[2]

Severe reactions are life threatening and are characterized by respiratory depression rash (e.g. hives or urticaria) allergic reactions (e.g. anaphylaxis) and shock. If a severe reaction occurs activate the emergency action plan.

Adverse drug reactions often are immediate and may be local or systemic. Local reactions are isolated to a limited area and often are associated with topical medications. Systemic reactions affect the entire body, such as heart palpitations and acute bronchospasm. Adverse drug reactions that do not occur immediately usually are associated with long-term use of a drug, such as GI irritation from long-term use of some NSAIDs.

Certain drugs, such as tetracycline, sulfa drugs, and even NSAIDs, may make an individual more susceptible to ultraviolet rays from the sun, resulting in a decreased exposure interval needed to develop a sunburn, rash, or allergy to the sun. These reactions can occur with the first dose or up to 1 week after taking the medication. Aspirin and other NSAIDs cause urticarial in approximately 1% of the population.[2] Other drugs may increase an individual's risk of heat illness or dehydration. Diuretics also can lead to dehydration in an exercising individual. Before participation in physical activity, it is important to know if a medication increases the risk of sun sensitivity, heat illness, or other complications. This information is available from a pharmacist.

Unlike prescription medications, most OTC medication labels identify the risk of adverse drug reactions; however, a physician or pharmacist should be consulted before taking two or more drugs simultaneously. Depending on the severity of the adverse reaction, the individual should be taken to the nearest medical facility. Most adverse reactions subside once the medication is discontinued.

The athlete is having a severe adverse reaction to the medication. Management of this condition includes checking and monitoring vital signs treating for shock and initiating the emergency action plan.

DRUG NAMES

Are there differences in the effectiveness of brand name and generic drugs?

The U.S. Food and Drug Administration (FDA) is responsible for supervising the manufacturing, labeling, and distribution of chemical substances, including therapeutic medications. Drugs are classified either as prescription or as nonprescription/OTC products. Prescription medications must be prescribed by a licensed practitioner and generally are dispensed by pharmacists. OTC drugs, which can be purchased directly by the consumer, usually are used to treat minor problems. Unlike prescription medication, containers holding OTC medication provide a variety of critical information (Box 11.2).

BOX 11.2 Information Found on Medication Containers

Prescription Medication Container

- Patient name
- Pharmacy name, address, and telephone number
- Name of medication
- Dose information and directions for use
- Number of refills (if any)
- Warnings for use (if any)
- Date prescription filled
- Practitioner who prescribed the medication
- Additional information depending on individual state laws

Over-the-Counter Medication Container

- Product name
- Manufacturer name and address
- Net contents
- Directions for safe and effective use
- Name of habit-forming drugs
- Cautions and warnings
- Name and quantity of active ingredients

Every medication has a chemical, generic, and brand name. The **chemical name** describes the actual scientific compound; because of the complexity of chemical names, they are seldom used. The **generic name** is considered to be a drug's official name and is preferred over brand names for general use. **Trade names**, or **brand names**, are specific names used by the individual manufacturer. They are created by drug companies for ease of use by consumers and physicians, and they generally are shorter than the generic name, are capitalized, or carry the registered trademark symbol (®). In addition, generic drugs can appear under more than one trade name. For example, the common OTC medication acetaminophen can be identified with the following names:

Chemical name	49-hydroxyacetanilide
Generic name	acetaminophen
Trade or brand name	Tylenol; Panadol

Generally, the OTC products are of lower strength than their respective prescription counterparts. Use of doses higher than those indicated on OTC medication labels is not wise unless prescribed by a physician or other licensed practitioner, because this increases the risk of side effects and adverse reactions. In most cases, the prescription generic drug is therapeutically equivalent to, but is less expensive than, the primary brand-name drug.

Drugs differ not by generic or brand names but, rather, by the route of

administration and the rate and extent of absorption. Drug names are used for written and verbal communication and for verifying the contents of drug containers.

In most cases a generic drug provides the same therapeutic effects as the brand-name equivalent. The generic form usually is less expensive.

GUIDELINES FOR THE USE OF THERAPEUTIC MEDICATIONS

A college basketball team is preparing to take a 4-day out-of-state trip for a tournament. Some of the athletes are taking prescription medications. What instructions should be provided to the athletes traveling with prescription medications?

State laws vary tremendously regarding who can prescribe, administer, and dispense medications; therefore, legal ramifications also vary. In general, prescription medications can be prescribed only by a licensed practitioner and dispensed only by a registered pharmacist. Depending on state regulations, only authorized persons (e.g., nurses, physician assistants, or physicians) can administer medications. **Administration of medication** is defined as providing one dose of a medication to a patient. **Drug dispensing** is defined as providing more than one individual dose.

Certified athletic trainers cannot administer or dispense prescription medications, nor should they be assigned duties that may put them in a situation to do so. Physicians cannot delegate the duties associated with prescription drug control or dispensing to certified athletic trainers. These duties extend beyond the role delineation and employment requirements of a certified athletic trainer and put the athletic trainer at risk for legal liability.[3]

Using Over-the-Counter Medications

Depending on state regulations, athletic trainers may be authorized to administer OTC medications. Before providing someone with an individual dose, however, the athletic trainer should have reason for doing so based on a written protocol developed in concert with the supervising team physician. These drug protocols should be part of the athletic training policy and procedures manual and should be readily available and used as a reference when administering any OTC medication. The drug protocols should include the following:

- Identification of the medical condition
- Screening questions that should be asked to identify the potential for any adverse effects
- General signs and symptoms of the condition
- Suggested treatment
- Suggested OTC medication
- Banned substance note
- Approval signature/date of the supervising physician
- Documentation for rescue inhalers (albuterol, Flovent, etc.)
- ADHD/attention deficit disorder (ADD) documentation from supervising physician on file

Before administering an OTC medication, it is important to determine if the individual is allergic to any type of medication (e.g., aspirin, sulfa drugs, and penicillin). The response should be noted and documented. When furnishing medication, both written and oral directions for the use of the medication should be provided to the individual. Following administration of medication, the athletic trainer should keep a written record, or "medication log," of the transaction, including the date, name of the individual, sport/activity, name of the medication, manufacturer, dosage, lot number (if available), expiration date of the medication, reason for administering the medication, and signature of the

person administering the drug.[3] All drug distribution records should be maintained in accordance with appropriate legal guidelines.

See **Example of a Drug Protocol** available on the companion Web site at thePoint for an example of developing a drug protocol for a specific condition.

In addition, the athletic trainer should follow up with the individual to make sure that the medication is working and that the individual is following the appropriate drug dosing regimen. This is especially important when taking antibiotic and antifungal agents. Incomplete therapy can result in developing a resistance to the medication or a recurrence of the infection. Even though an individual may be feeling fine, the infection is not necessarily gone. The entire course of the prescribed treatment must be completed. **Box 11.3** lists tips for proper use of medications.

BOX 11.3 Tips for Proper Use of Medications

- Use only as directed.
- Keep medication in the original container; do not alter the label.
- Do not use if the container has been tampered with.
- Do not use the medication if discolored or if the expiration date has passed.
- Measuring spoons or cups should be used when measuring liquid medication.
- Never share your medication with another person.
- When directed, oral medications should be taken with food.
- If a corticosteroid is injected into a joint, do not stress the joint too soon following the injection because pain will be masked.
- If an overdose occurs, immediately contact the nearest poison control center and transport the patient to the nearest medical facility.

Poison Control Plan

In addition to having drug protocols developed and implemented, it is equally important to have a poison control plan that is readily available at all times. This plan should be part of the athletic training policies and procedures manual. Poison control centers are available in every state and can be contacted through the local health department. Proper procedures and protocols should be discussed for various poison situations. These procedures should be developed in written form, posted in the athletic training facility, and practiced on a regular basis. Box 11.4 lists information that should be provided over the phone to the poison control center if a potential medical poisoning occurs.

BOX 11.4 Steps for the Management of a Medication Poison Situation

- Call the nearest poison control center.
- Provide the poison control center with the following information:
  - Your name and location
  - Name, age, and approximate weight of the person who has taken the medication
  - Name and dosage of the medication
  - Approximate time the medication was taken
  - Any signs and symptoms of the patient, including vital signs
- Proceed with the directions provided by the poison control center.

Traveling with Medications

It is important to plan ahead when traveling to ensure that an adequate supply of a particular medication is available in case of emergency (Box 11.5). If an individual forgets a medication or if a medication is depleted, it is not easy to obtain a refill. Each state has specific rules and regulations concerning the prescription and refill of medications. Physicians usually cannot prescribe

medications from state to state, nor can pharmacists fill out-of-state prescriptions. If an individual needs prescription medication while traveling, seeking assistance from the host team physician may be warranted. Another solution is to have the individual's personal physician call the host team physician to discuss the situation. In either case, prescription medications should remain in the original containers and be kept either by the individual or by the athletic trainer.

BOX 11.5 Tips for Traveling with Prescription Medications

- Medications should not be placed in checked luggage.
- Take a copy of any written prescriptions.
- Plan ahead and make sure there is a source of medication while traveling.
- Keep medications in the original container for identification purposes.
- A large-enough supply should be taken to cover emergency situations.
- Keep medications in a safe and secure location.

Storing Medications

All prescription and OTC medications should be kept in the original container and stored in a locked cabinet or other secure place. They should be kept away from heat, direct light, dampness, and freezing temperatures. A dry environment with temperatures between 15° and 31.7°C (59° to 86°F) is suggested.[4] All stocked medications should be examined at regular intervals, and expired medications should be discarded. If medications are kept in athletic training, emergency, or travel kits, they should be routinely inspected for medication quality and security. When stocking medications, it is important to avoid overstocking. Overstocking often is determined by the quantity of expired medications in stock and by the quantity of medications in stock relative to the amount actually used during a given period. Overstocking wastes both medication and money.

Resources on Medications

The Physician's Desk Reference is no longer used since prescription medications change on a frequent basis. Physicians currently use Epocrates to access the most current diagnostic and treatment information in an online format. Medication can be reference for harmful interactions, pill identification, and ICD-9 codes.[5] The Food and Nutrition Information Center (fnic.nal.usda.gov) is an Internet source for drug information and provides consumer guidelines for drug use. A current list of banned substances can be retrieved from the NCAA (www.ncaa.org), United States Olympic Committee (USOC; www.teamusa.org), and Drug Free Sport (www.drugfreesport.com) Web sites.

In preparing to take a 4-day out-of-state trip for a college basketball tournament the athletes taking prescription medications should be provided with the following instructions: Ensure an ample supply of medication for the entire trip do not place medication in checked luggage take a copy of your written prescription keep medications in a safe and secure location and keep medications in their original containers.

COMMON MEDICATIONS USED TO TREAT SPORT-RELATED INJURIES

Following a head-first slide into second base a softball player sustains an abrasion to the left forearm. What is the treatment for this injury and what medication should be used as part of the treatment protocol?

A variety of different types of medications are used to treat soft-tissue injuries in sports. The more common medications include **analgesics** and **antipyretics**, NSAIDs, corticosteroids, anesthetics, antiseptics, topical antibiotics, and antifungal agents.

Analgesics and Antipyretics

Two of the more common analgesic–antipyretic medications are acetaminophen (e.g., Tylenol) and aspirin. Acetaminophen inhibits the synthesis of prostaglandins in the CNS but does not inhibit their synthesis in peripheral tissues. As a result, it acts as an analgesic and reduces fever, but it has no anti-inflammatory or antiplatelet (i.e., anticlotting) properties. Because it does not cause GI irritation, acetaminophen often is used as a replacement for aspirin. Overdosage of this medication can lead to liver damage and death.

Aspirin (i.e., acetylsalicylic acid) is a commonly used analgesic, antipyretic, and anti-inflammatory medication. Unfortunately, its use can lead to GI bleeding, nausea, vomiting, and development of gastric ulcers. In high doses, **tinnitus** and dizziness may result. Regardless of the circumstances, most practitioners prefer that no individual younger than 18 years receive aspirin. If aspirin is used in a child younger than age 18 years during chickenpox or influenza, the risk of **Reye syndrome** increases. This is a severe disorder characterized by recurrent vomiting that begins a week after onset of the condition, from which the child either recovers rapidly or lapses into a coma, with the possibility of death. Individuals who are intolerant to aspirin, particularly asthmatics, may have an anaphylactic reaction to it. In addition, because aspirin prolongs blood clotting time, it should not be used by individuals who engage in contact sports.

Nonsteroidal Anti-inflammatory Drugs

NSAIDs are aspirin-like drugs that suppress inflammation and pain, produce analgesia, and reduce fever. They are among the most commonly used drugs in the treatment of soft-tissue injuries and are distributed as both OTC and prescription medications. Use of OTC NSAIDs can, at times, be high. In a recent study, nearly 75% of high school football players who were surveyed reported using OTC NSAIDs daily without adult supervision.[6–8]

NSAIDs were developed in an attempt to decrease the GI and hemorrhagic effects produced by aspirin. Most NSAIDs produce the same effects as aspirin but without many of the side effects. Individuals may respond differently to

various types of NSAIDs, which differ chemically and pharmacokinetically based on their duration of action, potency level, OTC and prescription status, and dosing regimen.

Therapeutic Effects

NSAIDs interfere with the biosynthesis of prostaglandins and other related compounds by inhibiting COX, an enzyme responsible for the synthesis of prostaglandins. Prostaglandins are lipid-like compounds produced by almost every living cell, with the exception of red blood cells (RBCs). Under normal conditions, these lipid-like compounds regulate cell function. During inflammation of a soft tissue, increased prostaglandin activity seems to mediate inflammation by increasing blood flow, capillary permeability, and the permeability effects of histamine and bradykinin. Because NSAIDs inhibit prostaglandin activity, they reduce inflammation and pain. The anti-inflammatory effects of NSAIDs result from the inhibition of COX-2. The adverse GI reactions are caused by inhibition of COX-1. One NSAID (e.g., celecoxib) appear to inhibit the COX-2 enzyme without inhibiting the COX-1 enzyme. The more traditional NSAIDs (e.g., naproxen and ibuprofen) reduce pain and inflammation by blocking COX-2, but unlike celecoxib, they also inhibit COX-1. This inhibition of COX-1 can lead to stomach irritation and ulcers.[2,3]

NSAIDs provide analgesia without sedation or the euphoria that often is associated with narcotic analgesics, such as morphine, meperidine (e.g., Demerol), codeine, and oxycodone (e.g., Percodan and Tylox). Narcotic analgesics containing propoxyphene (e.g., Darvon and Darvocet) were banned in 2010. Narcotic analgesics have the potential to produce physical dependence and tolerance; nonnarcotic analgesics, such as NSAIDs, do not normally produce dependence.

NSAIDs may reduce fever without reducing normal body temperature. The hypothalamus has a set point that determines body temperature; if this set point is elevated by fever-promoting substances (e.g., endogenous pyrogens), fever develops. NSAIDs inhibit prostaglandins and, as a result, lower the set point of the hypothalamus and reduce fever. In addition, NSAIDs have some

antiplatelet (i.e., anticlotting) properties. In contrast to the strong antiplatelet properties of aspirin, however, the effects of NSAIDs are much lower in intensity. They are considered to be safe when used to treat acute soft-tissue injuries.

Adverse Effects

Side effects of NSAIDs can include GI irritation, increase in blood pressure, renal impairment, hypersensitivity reactions (e.g., asthma, urticaria, and rhinitis), and toxicity. Other side effects can be seen in **Box 11.6**. NSAIDs should be taken with food, milk, or a glass of water to decrease the risk of GI irritation. Alcohol should never be taken with NSAIDs, because it increases the risk of GI irritation and development of gastric ulcers. In the elderly, NSAIDs should be used cautiously, because the risk of serious ulcer disease in adults older than 65 years is increased with higher doses of NSAIDs.

BOX 11.6 General Adverse Reactions to Nonsteroidal Anti-inflammatory Drugs

- **Gastrointestinal:** nausea, vomiting, diarrhea, constipation, epigastric pain, indigestion, intestinal ulceration, jaundice, bloating, and dry mouth
- **Central nervous system:** dizziness, anxiety, light-headedness, vertigo, headache, drowsiness, insomnia, depression, and psychic disturbances
- **Cardiovascular:** congestive heart failure, decreased or increased blood pressure, and cardiac arrhythmias
- **Renal:** hematuria, cystitis, elevated blood urea nitrogen, polyuria, dysuria, oliguria, and acute renal failure in those with impaired renal function
- **The senses:** visual disturbances, blurred or diminished vision, diplopia, swollen or irritated eyes, photophobia, reversible loss of color vision, tinnitus, taste change, and rhinitis
- **Skin:** rash, erythema, irritation, skin eruptions, exfoliative dermatitis, Stevens-Johnson syndrome, ecchymosis, and purpura

- **Metabolic/endocrinological:** decreased appetite, weight increase or decrease, hyperglycemia, hypoglycemia, flushing, sweating, menstrual disorders, and vaginal bleeding
- **Other:** thirst, fever, chills, and vaginitis

Adapted from Roach S. *Pharmacology for Health Professionals*. Philadelphia, PA: Lippincott Williams & Wilkins; 2005; with permission.

The risk of renal impairment is relatively low with most NSAIDs. Signs of renal impairment include reduced urine output and rapid increase in serum creatinine and blood urea nitrogen. Signs and symptoms of a hypersensitive reaction or toxicity include dyspnea, rapid and irregular heartbeat, hematuria, upper abdominal tenderness, and jaundice. If any of these signs and symptoms develop, immediate medical attention is required.

Use and Availability

NSAIDs are used to treat mild-to-moderate pain associated with joints, muscles, and headaches. In addition, they often are used to treat inflammation associated with rheumatoid arthritis, tendinitis, and bursitis conditions. They are not, however, effective for the relief of severe pain.

NSAIDs are available in both OTC and prescription strengths and are routinely taken orally. Prescription strength NSAIDs can be prescribed only by a licensed practitioner. These NSAIDs are prescribed on a case-by-case basis and should not be shared among individuals with similar soft-tissue injuries or conditions. Sharing medication is not recommended, because individuals respond differently to the same medication. Nonprescription NSAIDs include ibuprofen (e.g., Advil, Motrin, and Motrin IB), ketoprofen (e.g., Orudis KT and Actron), and naproxen sodium (e.g., Aleve).

See **Common Nonsteroidal Anti-inflammatory Medications** available on the companion Web site at thePoint for a listing of the common NSAIDs used in treating soft-tissue injuries among sport participants.

Pain relief usually is noted within 30 minutes after ingestion and lasts for

several hours, depending on the dosage and duration of the particular NSAID. Both OTC and prescription products should be used only for short-term (i.e., 10 days maximum) treatment of inflammation and pain associated with soft-tissue injuries. When used as an antipyretic, NSAIDs should be used for only 3 days.[2] If pain, inflammation, or fever does not subside or increases within these time periods, consult a physician immediately. Ketorolac is an NSAID that can be injected intramuscularly (i.e., Toradol) and carries the same indications and risks as other NSAID medications.

As with most medications, and as mentioned previously, NSAIDs should not be used in combination with alcohol. A physician or pharmacist should be consulted before combining NSAIDs with other medications.

Corticosteroids

Corticosteroids are steroid hormones that are produced naturally within the adrenal cortex but that also can be produced synthetically. They are powerful drugs that affect nearly the entire body.

Therapeutic Effects

Corticosteroids are lipid-soluble and block the body's natural response to inflammation by inhibiting the synthesis of chemical mediators (e.g., prostaglandins, leukotrienes, and histamine). As a result, swelling, warmth, redness, and pain associated with inflammation are decreased. The manner in which corticosteroids suppress inflammation, however, is much broader in scope than the manner in which NSAIDs do so. Corticosteroids inhibit prostaglandin synthesis, as do NSAIDs, but corticosteroids also act in several other ways to decrease inflammation.

Adverse Effects

Side effects of corticosteroids, which often resemble those of the condition for which they are prescribed to treat, include itching, burning, dry skin, and fluid retention. Side effects that are rare include an increase or decrease in appetite, dizziness, restlessness, facial or body hair growth, GI irritation, menstrual

irregularities, and optic pain. Most of these side effects disappear soon after the medication is discontinued. Because oral NSAIDs and corticosteroids have similar effects on the GI tract, concurrent use severely increases the risk of GI irritation and ulceration. In addition, chronic use of corticosteroids can suppress the body's immune system, making the user more susceptible to infection.

Availability and Use

Corticosteroids are indicated for skin disorders, nasal inflammation, rheumatic disorders (e.g., bursitis, arthritis, and tendinitis), and skin infections. They are administered through oral and nasal inhalation, intra-articular injection, subcutaneous injection, intravenous injection, topically, and orally.

Corticosteroids should not be used by individuals who are infected with HIV or have AIDS, heart disease, hypertension, diabetes, gastritis, peptic ulcers, lupus, or other infections (e.g., bronchitis or flu). By reducing inflammation and pain, corticosteroids also may delay exercise-induced pain, placing an individual at increased risk for further injury. Corticosteroids are not banned by the NCAA, but the USOC bans all types, with the exception of most topical (e.g., ear, eye, and skin) agents. The USOC allows inhaled, local, or intra-articular injections if written permission is provided.[9,10]

See **Common Corticosteroids** available on the companion Web site at thePoint for a list of the common corticosteroids administered through oral and nasal inhalation or injections.

Local Anesthetics

Anesthetics, frequently called "pain killers," inhibit the activity of sensory nerve receptors in the skin. Under normal conditions, the skin does not respond well to aspirin or other oral analgesics. When irritated, the same sensory nerve endings in the skin can lead to **pruritus** from a weak stimulation or to skin pain from a strong stimulation. The skin responds more readily to topical medications. Local anesthetics are categorized by route of administration and may be injectable, topical, or sprayed. Injectable anesthetics are prescription

medications that can be administered only by a licensed professional (i.e., physician, physician assistant, nurse practitioner, or nurse).

Injectable Anesthetics

In the treatment of sports-related injuries, injectable anesthetics most commonly are used for **infiltrative anesthesia**, a process that produces numbness by interfering with nerve function in a localized, subcutaneous, soft-tissue area. Infiltrative anesthesia commonly is used for the treatment of soft-tissue injuries, such as hip pointers and turf toe. In addition, they are used as an anesthetic before minor surgical procedures, such as suturing or aspiration of bursal or joint fluid. They are classified by the duration of action—namely, short-, intermediate-, and long-term action. Side effects are minimal when used as directed. Large quantities of the drugs must be absorbed to produce any associated side effects, such as tremors, drowsiness, hypotension, or hypersensitivity and anaphylactic reactions.

Topical Anesthetics

Topical anesthetics are OTC and prescription medications that are applied to the skin. Topical anesthetics or analgesics often are used to relieve pain associated with musculoskeletal injury (e.g., strains, sprains, tendinitis, and bursitis). When used for these purposes, topical medications are called **counterirritants**. These medications stimulate nerve endings in the skin that respond to pain and to warm and cold sensations, which in theory distracts the user from the original pain or itching. Essentially, these products irritate the skin to relieve pain and itching. Counterirritants come in various forms, including lotions, rubs, liniments, and creams. Popular examples include Ben-Gay, Mineral Ice, Flexall 454, Menthol, Cramergesic, and Icy Hot. The FDA suggests that these drugs are safe when applied three to four times per day, but they are not suggested for long-term use. If pain persists after 7 days, a physician should be consulted immediately.

In addition to the counterirritant properties, topical anesthetics can further be classified according to whether they reduce itching, pain, or both. Most topical anesthetics are easily identified in their brand names by the suffix "-

caine" (e.g., Americaine, Lanacane, Xylocaine, and Solarcaine).

Spray Anesthetics

In addition to creams, lotions, and liniments, a few spray anesthetics are on the market (e.g., aerofreeze, ethyl chloride, and fluoromethane). These products temporarily freeze the skin in an effort to decrease pain; however, the duration of action is quite limited and lasts for only approximately 1 minute. These products are not recommended for use, because the freezing action can damage the skin and delay healing.

Adverse Effects

Topical anesthetics are relatively safe when used as directed. Common side effects are limited to skin irritation (e.g., rashes or hives). These normally disappear once use of the product is stopped. Systemic absorption can occur if large amounts of these products are used over a large surface area or if used on deep wounds. Systemic absorption is toxic and may produce convulsions and paralysis of the CNS.

Individuals who are allergic to aspirin should not use methyl salicylate products, because the body may absorb the salicylate, the major ingredient in aspirin. In addition, products that produce warm sensations should never be used in combination with a heating pad or occlusive dressing. This may increase systemic absorption and result in skin and muscle necrosis. These products should never be used before exercise in hot, humid conditions or immediately following exercise. Application is appropriate after the body cools down. The NCAA and USOC permit the use of topical anesthetics; the NCAA also permits intra-articular injections of local anesthesia when medically justified.[9,10]

Muscle Relaxants

Unlike local anesthetics that inhibit sensory nerve receptors in the skin and subcutaneous tissue, muscle relaxants actually block afferent messages that travel from the muscles to the brain. Skeletal muscle relaxants are classified as

either central or direct acting. Central agents exert their effects within the spinal cord, whereas direct-acting muscle relaxants affect the skeletal muscle cell. Both types are available by prescription only. Muscle relaxants prescribed for muscle spasms associated with musculoskeletal injury are central acting. They decrease local pain, spasm, and tenderness and, in doing so, allow increased range of motion. Examples of common muscle relaxants are chlorzoxazone (e.g., Parafon Forte and Muscol), cyclobenzaprine (e.g., Flexeril), diazepam (e.g., Valium), methocarbamol (e.g., Robaxin), and orphenadrine (e.g., Norflex). These drugs often are used in combination with rest and physical therapy (e.g., thermotherapy, cryotherapy, and electrotherapy) to relieve pain from acute muscle spasms associated with musculoskeletal conditions. Because central-acting muscle relaxants produce their effects by acting on the CNS, they often produce a general depression of CNS functions. As a result, common side effects include dizziness, drowsiness, and sedation. Muscle relaxants are not banned by either the NCAA or the USOC; however, they may be prohibited by international federations of certain sports.

See **Common Muscle Relaxant Medications** found on the companion Web site at thePoint for a list of the common muscle relaxants and their possible side effects.

Topical Antibiotics

Antibiotics are substances that kill disease-producing bacteria and are used to prevent and treat infections. Two basic types of bacteria cause most skin infections, namely, *Streptococcus* and *Staphylococcus*. Because it is difficult to predict which type of bacteria may be producing a skin infection, most topical antibiotics contain several active ingredients that treat both organisms; when purchasing, use triple antibiotic. Topical antibiotics are used on small open wounds, such as abrasions, and can be purchased as creams, ointments, or powders. Bacitracin, Neosporin, Neomycin, and Polysporin are examples of OTC topical antibiotics. These products are not designed to be used on deep wounds, because internal absorption of some of these antibiotics can be toxic. Topical antibiotics should be used in small amounts, generally three times

daily, and for not more than 1 week.[2] Topical antibiotics are not banned by the NCAA or USOC.

See **Common Topical Antibiotics** found on the companion Web site at thePoint for a list of the common topical antibiotics and their possible side effects.

Oral Antibiotics

In the event of infection, oral antibiotics may be needed to treat infection or cellulitis. Selecting and administering oral antibiotics in a prudent manner is necessary due to the increase in antimicrobial resistance. Identifying the specific antigen allows the practitioner to prescribe first-choice medications needed to treat the infection. For the treatment of cellulitis caused by *Streptococcus* or *Staphylococcus*, cephalexin, erythromycin, or co-trimoxazole (if methicillin-resistant *Staphylococcus aureus* [MRSA] is present) may be used to treat the infection.

Antiseptics and Disinfectants

The terms antiseptic and disinfectant sometimes are used interchangeably, but they are not the same. **Antiseptics** are applied to living tissue to stop growth of microorganisms or destroy bacteria on contact and prevent infection. They are most appropriate in the cleansing and treatment of large, open skin wounds and come in sprays, powders, and swab-on liquids. Isopropyl alcohol, Betadine, and tincture of iodine are common OTC antiseptics. Antiseptics are for external use only and are not banned by the NCAA or USOC.

Disinfectants are chemical agents applied to nonliving objects. They most commonly are used to disinfect surgical instruments and cleanse medical equipment and facilities. Common disinfectants used in athletic training are alcohol products, Whizzer, and Iso-Quin. The companion Web site at thePoint provides information about disinfecting techniques used in the athletic training room to prevent the spread of infectious diseases related to bloodborne pathogens.

Antifungal Agents

Tolnaftate (e.g., Tinactin), miconazole nitrate (e.g., Micatin), and clotrimazole (e.g., Lotrimin and Mycelex) are agents that treat infections caused by fungal cells. In humans, fungal cells are either molds or yeasts. Tinea pedis, tinea cruris, and tinea corporis are caused by fungal molds, whereas candidiasis and moniliasis are caused by fungal yeasts. Products used to treat fungal molds usually are applied twice daily, with symptoms disappearing within a few days of initial treatment. Following disappearance of symptoms, the molds often can still be found within skin cracks and nail beds. For this reason, physicians suggest regular, continued application of antifungal agents as part of a preventive protocol. Before applying antifungal agents, the infected area should be cleansed thoroughly with mild soap and water. If the infection does not clear within 1 week (e.g., tinea cruris) or 1 month (e.g., tinea pedis and corporis), another antifungal agent should be used or a physician should be consulted.

See **Common Antifungal Agents** found on the companion Web site at thePoint for a list of these agents and their possible side effects.

Historically, drugs used to treat vaginal yeast infections were by prescription only, but a variety of antiyeast agents can now be purchased over the counter. Examples include clotrimazole (e.g., Gyne-Lotrimin, Mycelex-7), miconazole nitrate (e.g., Monistat), and tioconazole (e.g., Vagistat-1). Oral medications (e.g., Diflucan) are available as a prescription medication and can also be used to treat vaginal yeast infections. Approximately 25% of females of childbearing age will develop a yeast infection. Predisposing factors include pregnancy, obesity, diabetes, debilitation, and the use of certain drugs (e.g., oral contraceptives and systemic antibiotics). Depending on the product, it should be used once daily for 1 to 14 days. If a course of treatment does not resolve the problem, the possibility exists that some other microorganism is present, and a physician should be consulted immediately.

Antifungal agents are relatively safe when used as directed. Some can be toxic if they are absorbed systemically and, as such, should be for external use

only. Side effects usually resemble a worsening of the condition being treated, including increased redness, irritation, and itching. These products are not banned by the NCAA or USOC.

Treatment for the softball player who sustained an abrasion to the left forearm should include initiating proper first aid care for an open wound using universal precautions cleaning the abrasion with sterile saline and applying a topical triple antibiotic (e.g. Bacitracin Neosporin) keeping the wound clean and covered.

PERFORMANCE-ENHANCING SUBSTANCES (ERGOGENIC AIDS)

Ephedrine is found in many OTC sinus and cold medications. What adverse effects are associated with the use of ephedrine?

Ergogenic aids are substances taken in nonpharmacological doses specifically to enhance energy production, energy use, or recovery to provide a competitive edge. A substance is considered to be performance-enhancing if it benefits sport participation by increasing strength, power, speed, or endurance or by altering body weight or composition. Even substances that change behavior, arousal level, and/or perception of pain should be considered as performance-enhancing.[16] Some substances are legal and may be a part of one's normal diet (e.g., caffeine, alcohol, and tobacco). Taken in excess, however, even these substances can produce adverse effects in a healthy individual.

Caffeine

Coffee, tea, chocolate, and energy drinks are common beverages and foods found in the American diet. Each contains caffeine—the most widely abused drug in the world. Caffeine is a low-level CNS stimulant that increases alertness and feelings of well-being. It is used as a stimulant in fatigue states

(e.g., Vivarin and NoDoz), in combination with analgesic compounds (e.g., Excedrin and Anacin), and in diet pills. Caffeine also is found in many new products, including energy drinks, sport gels, and alcoholic beverages.

Caffeine is rapidly absorbed, with peak levels being achieved in 30 to 60 minutes and a half-life of 3.5 hours.[11] Caffeine stimulates the secretion of adrenaline (epinephrine) and, except in the renal afferent artery, causes vasoconstriction. This response could produce a number of secondary metabolic changes that could promote an ergogenic action, such as enhancing the contractility of skeletal and cardiac muscle and assisting in fat metabolism.[12] Therefore, caffeine is considered to be an ergogenic aid for prolonged endurance exercise activities in doses of approximately 3 to 6 mg per kg body mass.[13] Ergogenic dose effects are found at approximately half the banned dose level, which equals three cups of coffee or six to eight caffeinated soft drinks.[14] Many individuals take caffeine in pill form.

When used in large doses (15 to 30 mg per kg), caffeine overdose may lead to agitation, delirium, seizures, dyspnea, cardiac arrhythmia, myoclonus, nausea, vomiting, hyperglycemia, and hypokalemia. With lower doses of caffeine, such as those via coffee consumption, adverse reactions may include tachycardia, palpitations, insomnia, restlessness, nervousness, tremor, headache, abdominal pain, nausea, vomiting, diarrhea, and diuresis.[15] Caffeine is considered by the NCAA and International Olympic Committee (IOC) to be a "restricted or controlled drug" when urine levels exceed 15 and 12 µg per mL, respectively.[14] Similar to most stimulants, caffeine does produce tolerance and can be addictive, with users experiencing withdrawal symptoms on cessation of use.

Tobacco

Tobacco is a low-level CNS stimulant and is widely used in the United States. Nicotine is the stimulating chemical and addictive substance in the product. Methods of consumption include cigarettes, cigars, and smokeless tobacco (i.e., loose-leaf tobacco [chewing], moist or dry powdered tobacco [snuff or "dipping"], and compressed tobacco ["plug"]). Nicotine is absorbed in the

lungs when using cigarettes and cigars and through the oral mucosa when using smokeless tobacco.

Initially, small doses of nicotine stimulate, and large doses depress, the autonomic ganglia and myoneural junctions. The amount of nicotine in tobacco products varies widely. On average, one cigarette contains 1 mg of nicotine, and a pinch of smokeless tobacco contains 35 mg. Contrary to popular belief, smokeless tobacco is not a safe alternative to cigarette smoking, because the nicotine is more swiftly absorbed into the bloodstream, resulting in a more immediate stimulant effect.

Major League Baseball imposed a ban on the use of smokeless tobacco products in the minor leagues, and the NCAA has an all-sport ban on the use of smokeless tobacco during NCAA practices and games. The use of smokeless tobacco by adults has slowly declined since the late 1990s and rapidly declined in adolescents and teens during this same time period.[16] Side effects associated with the use of smokeless tobacco are similar to those of other products that contain nicotine, including feelings of well-being, increased heart rate, increased blood pressure, and addiction.[17] The use of smokeless tobacco also can lead to **halitosis**, permanently discolored teeth, oral abrasions, periodontal bone disease, tooth loss, and **leukoplakia**. Leukoplakia is a disease of the mouth characterized by white patches and oral lesions on the cheeks, gums, and/or tongue, which can lead to oral cancer.

Alcohol

Alcohol is the most abused recreational drug in the United States, and it is the number one drug of choice among intercollegiate athletes.[1] Alcohol is involved in more than one-third of the deaths attributed to unintentional injury, homicide, and suicide, which together account for 76% of mortality in the 15- to 19-year-old age group. More than half (58%) of 12th-grade students and one-fifth (20%) of 8th-grade students report having been drunk at least once in their life.[18]

When ingested, alcohol is rapidly absorbed, unaltered, into the body. Most absorption takes place in the stomach and small intestine. Absorption rates

depend on several factors:

- Type and concentration of the alcohol
- The rate at which the beverage is consumed
- Current stomach contents
- Factors influencing the emptying of the stomach (e.g., levels of carbonated beverages, food, and emotional state)
- Body weight
- Gastric motility

Alcohol is metabolized at a constant rate, typically l oz of alcohol per hour. This equals one 12-oz beer (excluding lagers and malt liqueurs), 2.5 oz of wine, or 1 oz of distilled spirits. The rate of metabolism is related to the actions of liver enzymes, which can vary between individuals. Factors influencing these enzymes include age, menstrual cycle, heredity, race, liver disease, and previous experience with alcohol consumption.[19,20]

Alcohol is lipid-soluble. As such, it quickly crosses the blood–brain barrier and instantly acts as a CNS depressant. Alcohol is distributed unmodified throughout body fluids, tissues, and organs. The majority of alcohol is metabolized in the liver (90%), with the remainder being excreted through urine, sweat, and one's breath.

Unlike other ergogenic aids, alcohol rarely is used as such. In a 1982 American College of Sports Medicine Position Statement on alcohol use in sports, it was found that

1. Alcohol in small (i.e., 1.5 to 2.0 oz) to moderate (i.e., 3 to 4 oz) amounts has negative effects on psychomotor skills, including reaction times, hand–eye coordination, accuracy, balance, and complex coordination.
2. Alcohol has little or no benefit regarding energy metabolism or oxygen consumption.
3. Alcohol does not improve muscular work capacity and may decrease performance levels as well as impair temperature regulation during

prolonged exercise in cold environments.

Therefore, it has been concluded that alcohol lacks ergogenic properties for the majority of sport-related activities. Alcohol may be an ergogenic aid in some aiming sports; however, no conclusive evidence has appeared to support this theory. Alcohol is considered to be an NCAA-banned substance in riflery but not in other NCAA sports.

Marijuana

Marijuana is a naturally occurring cannabinoid that contains the active ingredient δ9-tetrahydrocannabinol (THC). Marijuana is considered an illegal drug in all states except Colorado, Alaska, Oregon, and Washington, where the drug may be taken recreationally as a euphoriant. Medically, marijuana has been used as an antiemetic agent in conjunction with chemotherapy for patients with cancer and for lowering intraocular pressure in patients with glaucoma.

The active ingredient THC primarily affects the CNS and cardiovascular system. Adverse effects to the CNS include impaired motor coordination, decreased short-term memory, difficulty concentrating, and decline in work performance. Adverse effects to the cardiovascular system include tachycardia and changes in blood pressure (e.g., systolic blood pressure increases in a supine position and decreases in a standing position). The effects depend on the route, dose, setting, and previous experience of the user. Adverse effects on sport and physical activity performance include reduction of maximal exercise performance, with premature achievement of maximal volume of oxygen uptake (VO_{2max}), and no appreciable effect on tidal volume, arterial blood pressure, or carboxyhemoglobin compared to controls. Marijuana can inhibit sweating, leading to an increase in core body temperature.

Marijuana is not banned by the IOC but is considered a prohibited street drug by the NCAA; marijuana is tested by the NCAA. Because of its high lipid solubility, marijuana can be detected for up to 2 to 4 weeks by drug testing.

Diuretics

Diuretics, commonly known as “water pills,” help to rid the body of unneeded

water and salt through the urine, allowing the heart to pump blood more freely. In general, diuretics are used to treat high blood pressure, heart failure, kidney and liver problems, and glaucoma. Diuretics are categorized as follows:

- Carbonic anhydrase inhibitors
- Loop diuretics
- Osmotic diuretics
- Potassium-sparing diuretics
- Thiazides and related diuretics

Carbonic anhydrase inhibitors prevent the action of carbonic anhydrase, an enzyme that produces free hydrogen ions, which are then traded for sodium ions in the kidney tubules. As a result, sodium, potassium, bicarbonate, and water are excreted in the urine. Carbonic anhydrase inhibitors (e.g., acetazolamide and methazolamide) often are used to treat glaucoma, because these agents can decrease the production of aqueous humor in the eye, which in turn decreases intraocular pressure.

Loop diuretics (e.g., furosemide and ethacrynic) are more powerful. These agents are especially useful during emergencies, such as in the treatment of edema associated with chronic heart failure, cirrhosis of the liver, and renal disease.

Osmotic diuretics (e.g., mannitol and urea) are used to promote diuresis in the prevention and treatment of the oliguric phase (i.e., low urine production) of acute renal failure. These agents also are used to reduce cerebral edema as well as intraocular pressure before and after eye surgery.

Potassium-sparing diuretics work in two ways. First, certain medications (e.g., triamterene and amiloride) depress the reabsorption of sodium in the kidney tubules and, in doing so, increase sodium and water excretion. Second, they depress the excretion of potassium, hence the name potassium-sparing. For example, spironolactone, another potassium-sparing diuretic, acts on the hormone aldosterone, which enhances the reabsorption of sodium in the distal tubules of the kidney. When this action is blocked, sodium (but not potassium)

and water are excreted. Potassium-sparing diuretics are used in the treatment of chronic heart failure and hypertension.

Thiazides and related diuretics inhibit the reabsorption of sodium and chloride, leading to moderate increases in the excretion of sodium, chloride, and water. They often are used in long-term treatment of hypertension, edema caused by chronic heart failure, hepatic cirrhosis, corticosteroid and estrogen therapy, and renal dysfunction.

Use of diuretics should be closely monitored by a physician. Abuse of diuretics can impair thermoregulation; exacerbate exercise-related dehydration; decrease stroke volume; increase arrhythmia; cause a reflex increase in total peripheral resistance, which may decrease muscle blood flow; and contribute to electrolyte depletion.[21] In addition, adverse reactions may involve fever, rash, photosensitivity, blurred vision, nausea, vomiting, headaches, vertigo, and diarrhea.[3]

Anabolic-Androgenic Steroids

Anabolic-androgenic steroids include more than 30 natural and synthetically made derivatives of testosterone. They most commonly are used to stimulate growth and accelerate weight gain. When naturally secreted from the pituitary gland (men, 4 to 10 mg per day; women, 1 mg per day), testosterone produces secondary sex characteristics. Tetrahydrogestrinone (THG) has received considerable media attention as a performance-enhancing substance. Although difficult to detect, there have been various reports of its use by high-profile athletes in several sports, including track and field, football, tennis, and baseball. After developing a way to detect THG in the urine following the 2004 Olympics, the FDA, Major League Baseball, and the World Anti-Doping Agency have banned this substance.[22]

Physiologically, anabolic steroids promote rapid synthesis of protein in the body by binding to androgen receptors at the cellular level, stimulating the production of ribonucleic acid, which in turn increases the synthesis of protein. In healthy individuals who do not exercise, steroids increase appetite and feelings of well-being but have no effect on muscle size or strength. Among

individuals who are involved in high-intensity training, anabolic steroids can increase body weight, lean body mass, and muscle size as well as strength[23]; however, anabolic steroids provide little benefit in terms of aerobic capacity. Other adverse effects include bouts of uncontrolled anger and explosive behavior, increased appetite and sexual desires, and a lowered tolerance to pain.[24,25] Short- and long-term physical effects, such as those listed in **Box 11.7**, are dependent on the type of steroid used, the frequency of use, and the age of initiation.[26] Some of these effects are irreversible even after discontinuation of steroid use.

BOX 11.7 Physical Effects of Anabolic Steroid Use

Short Term

Acne

Gynecomastia

Male pattern baldness

Enhanced facial and body hair growth

Menstrual irregularities

Decreased breast development in women

Deepening of the voice

Increased risk of muscle strains/ruptures

Long Term

Cardiovascular disease

Liver disease

Testicular atrophy

Impotence/sterility

Decrease in sperm

Enlargement of clitoris

Uterine atrophy

Early closure of physis in children (shorter adult height)

Anabolic steroids most commonly are used in 6- to 12-week cycles with pyramid or stacking techniques.[26] The term stacking denotes the simultaneous use of two or more types of anabolic steroids, which could include both oral and intramuscular injections, and the pattern of increasing a dose through a cycle is referred to as pyramiding. An individual using the pyramid technique begins with a lower daily dose, then moves to a higher dose in the middle of a cycle, and then ends with a lower dose at the end of a cycle. Pyramiding may lead to doses 10- to 40-fold greater than those used for medical indications. A common belief is that pyramiding and stacking maximize steroid receptor binding and minimize toxic side effects. These benefits have not been substantiated scientifically, but this has not appreciably influenced dosing patterns.

Human Growth Hormone

Human growth hormone (hGH) is a popular antiaging drug and commonly is used to enhance muscular strength and growth as well as for its musculoskeletal healing properties. hGH is used in growth hormone–deficient children (to stimulate skeletal and soft-tissue growth), growth hormone–deficient adults, the elderly, children with chronic renal failure, and children with large cutaneous burns (to accelerate wound healing). It also is used to increase lean body mass and decrease fat in patients postoperatively and is approved for treatment of wasting syndrome secondary to HIV infection.[11]

In its natural form, hGH is secreted from the anterior pituitary gland and mediates a plethora of metabolic and growth processes, with effects on the

majority of body tissues. The hormone increases protein synthesis by enhancing uptake and transport of amino acids. Synthetic or recombinant hGH is administered intramuscularly or subcutaneously, with a typical dose being 0.30 mg per kg per week.[27]

The most common side effect of hGH is **acromegaly**, a condition described as gigantism and characterized by costal and mandibular growth; vertebral, phalangeal, and frontal bone overgrowth; widening of joint spaces; accelerated osteoarthritis; and soft-tissue swelling. As little as a twofold increase in recommended dosage may result in acromegaly, which leaves a narrow therapeutic window. The risk of acromegaly is significant for individuals consuming up to 20 mg per day. Other side effects include hypertension, hyperglycemia, glycosuria, diabetes, arthritis, menstrual irregularities, vision loss, sleep apnea, ventricular hypertrophy, myopathies, and characteristic coarsening of bones in the face, hands, and feet.[11,15]

In the athletic environment, hGH often is used in combination with various testosterone derivatives and is extremely difficult to detect in routine urine drug tests. Therefore, it is becoming increasingly popular among athletes. Efforts are being made, however, to develop a noninvasive technique to detect the use of hGH. Testosterone and hGH are not banned by the NCAA if prescribed by a physician.

Amphetamines

Amphetamines are powerful CNS stimulants that are banned by the NCAA and IOC. They are used for therapeutic purposes to treat a variety of conditions, such as refractory obesity, narcolepsy, ADD, and severe depression. Sport participants may use amphetamines to mask fatigue and pain and to improve certain mental tasks.[28,29]

Classified as sympathomimetics, amphetamines influence involuntary actions of the CNS (i.e., heart rate and blood pressure). Most users take amphetamines orally, but injectable and inhaled forms (e.g., cocaine and crack) also are available. Serious side effects include a lowered threshold for arrhythmias and provocation of angina, which may lead to sudden cardiac

death, stroke, tremors, insomnia, psychosis, psychological addiction, and rhabdomyolysis. Little evidence suggests that many sport participants use amphetamines, but evidence does clearly indicate the use of less potent amphetamine-like products, such as ephedrine. Amphetamines are readily detected by urine tests because both unchanged amphetamines and metabolites appear in the urine.

Ephedra

Derived from the ancient Chinese herb ephedra, or ma huang, the ephedrine alkaloids (e.g., pseudoephedrine, norephedrine, methylephedrine, methylpseudoephedrine, and norpseudoephedrine) can have powerful effects on the body. Ephedra is a CNS stimulant that increases serum levels of norepinephrine and can, directly or indirectly, increase blood pressure, heart rate, cardiac output, and peripheral vascular resistance.[22] Traditionally used as a bronchodilator and nasal decongestant, ephedra is found in many OTC sinus and cold medications. It is used therapeutically to treat chronic postural hypotension, enuresis, and narcolepsy. Ephedra in dietary supplements was banned by the FDA in 2004.

Side effects of ephedra can be life threatening, because it increases heat production and body temperature and, as such, increases the risk of heat illness, especially in warm environments. Mild adverse effects include heart palpitations and irregular heartbeats, dizziness, headache, insomnia, nervousness, and skin flushing or tingling. Moderate to severe adverse reactions include tachycardia, life-threatening arrhythmias, hypertension, stroke, seizures, and death.[30] Recently, ephedra has been shown to be ergogenic for anaerobic exercise, especially when taken with caffeine; however, the potential for toxicity is high.[31] It is important to note that synthetic ephedrine derivatives are used to produce the street drugs ecstasy and methamphetamine, which are used as stimulants. Ephedra is banned by the IOC, NCAA, Major League Baseball, NASCAR, and the National Football League.

Blood Doping and Erythropoietin

The primary purpose of blood doping and use of erythropoietin is to stimulate the production of RBCs so that more oxygen is available for use during long-distance aerobic activities (e.g., cycling) to enhance oxygen-carrying capacity and skeletal muscle performance. Before the increased popularity of erythropoietin, two techniques were used to produce the desired effects of blood doping:

1. Homologous transfusions use blood from another person or donor and transfuse it into the identified individual. Two major concerns with this procedure are the compatibility of the transfusion between the donor and recipient and the risk of contracting HIV and hepatitis.
2. Autologous transfusions remove blood from the individual, freeze the blood, and reinfuse the blood several weeks later, after the recipient's body has had ample time to make new RBCs. Following the transfusion, the recipient has an increased concentration of RBCs.

Transfusions can improve performance during endurance exercises by increasing hemoglobin concentration, which leads to increased maximal oxygen consumption and total exercise time as well as improved tolerance in some extreme environmental conditions.[11] The IOC bans blood doping, but enforcement is limited by the lack of effective techniques for detection.

Intravenous use of recombinant human erythropoietin stimulates RBC production within days, and effects can be seen for as long as 3 to 4 weeks. Erythropoietin is used therapeutically in several conditions, including anemia secondary to end-stage renal disease; anemia secondary to prematurity, multiple myeloma, and cancer; and AIDS treated with zidovudine. Its use also increases the yield of autologous blood donors both safely and effectively over a 21-day period and can reduce the need for transfusions in patients undergoing hip replacement. Miscalculations in dosing and dehydration may result in a hematocrit level as high as 80% and can cause severe hyperviscosity leading to encephalopathy, stroke, seizures, and tissue hypoxia.[22] Rapid clotting also may lead to pulmonary embolism, myocardial infarction, and peripheral clot

formation (i.e., vascular thrombosis). In addition, intravenous use increases other inherent risks (e.g., infection with hepatitis, infection with HIV, and endocarditis).

The prevalence of erythropoietin use is unknown. Various media reports concerning its use among athletes have appeared, but no scientific reports indicate its prevalence. According to the position statement of the American College of Sports Medicine on "The Use of Blood Doping as an Ergogenic Aid," any blood-doping procedure used to enhance athletic performance is unethical and unfair and exposes the individual to serious health risks.[32] Darbepoetin, a related substance, causes similar effects and was detected during the 2002 Winter Olympics in cross-country skiers, who subsequently were disqualified. Because recombinant human erythropoietin and darbepoetin can now be detected, newer strategies to evade detection and boost performance are likely to be used in the near future.

Creatine

Creatine is a nonessential dietary element found in protein-rich sources, such as meat and fish. It is the most widely used and marketed nonsteroidal, nonstimulant ergogenic aid in young athletes, and it has been reported to be used in 41% of 219 Division I intercollegiate athletes.[33] It is synthesized primarily in the liver and is stored predominantly in skeletal muscle. Hydrolysis of muscle phosphocreatine results in rapid production of adenosine triphosphate (ATP), which is needed for muscle contraction. As muscle stores of phosphocreatine become depleted, performance decreases. Oral creatine supplementation can increase muscle phosphocreatine stores by 6% to 8% and, in doing so, causes faster regeneration of ATP. This can result in shorter recovery periods and increased energy for repeated bouts of exercise. Increased muscle creatine also buffers the lactic acid produced during exercise, delaying muscle fatigue and soreness.[14] In anaerobic exercise, creatine depletion is a limiting factor.[34]

The total daily requirement of creatine is 2 g per day, approximately half of which comes from in vivo production and the other half from dietary sources.[34]

Supplemental dosing varies. One method involves ingesting loading doses of 20 g daily, divided in four doses, for 5 to 10 days, followed by a maintenance dose of 5 g per day. Another method eliminates the loading phase and involves ingesting 3 g per day. Lower doses take longer to reach the desired intramuscular creatine levels.[33]

Creatine purports to be a safe ergogenic aid in adults. The adverse effects are few and dose-dependent, including weight gain and GI distress (e.g., nausea, bloating, cramping, and diarrhea). Although increased muscle cramping originally was thought to be a side effect of creatine use, recent studies with college football players showed that creatine supplementation did not appear to increase the incidence or injury or cramping and, when combined with resistance and anaerobic training, may positively affect cell hydration status and enhance performance variables further than the augmentation that is seen with training alone.[35,36] No other serious long-term, detrimental effects in the absence of other nutritional supplements have been consistently documented.[37] Several areas of concern, however, include the potential for renal damage in those with preexisting renal dysfunction, rhabdomyolysis, cardiovascular impact if the creatine is taken up by the myocardium, increased risk of heat illness because of potential dehydration, and increased risk of exertional compartment syndrome as a result of fluid retention that may accompany loading doses of the substance.[38] In the most recent position statement on creatine use, the American College of Sports Medicine discouraged creatine use in people younger than 18 years of age because of unknown potential adverse health effects.[38]

Even though ephedrine is found in many OTC sinus and cold medications, adverse effects are associated with its use. The mild adverse effects of ephedrine include heart palpitations and irregular heartbeats, dizziness, headache, insomnia, nervousness, and skin flushing or tingling. Moderate-to-severe adverse reactions to ephedrine include tachycardia, life-threatening arrhythmias, hypertension, stroke, seizures, and death. Combining caffeine with ephedra greatly increases the severity of side effects.

DRUG TESTING

In 1965, Beckett developed the first chromatographic drug testing procedures for the Tour of Britain cycling competition. Three years later, the IOC drug testing program was implemented during the 1968 Summer Olympic Games. Following the lead of the IOC, the NCAA began drug testing at championship events in 1986. The intent of drug testing programs is threefold:

1. Drug testing discovers those individuals who may be experiencing problems.
2. Testing is performed to screen participants for evidence of drug use/abuse.
3. Drug testing protects individuals from injury or from causing injury to others.

Various drug testing methods (e.g., urine tests, blood tests, human hair tests, and radioimmunoassay) are available. Urine testing is the method of choice. It is noninvasive, and large volumes of urine can be collected easily. Analysis for the presence of drugs and their metabolites is usually seen in high concentrations in the urine. Two disadvantages of urine testing are the ease of tampering with the sample and the potentially humiliating experience for the individual.

Current drug testing uses gas chromatography/mass spectrometry (GC/MS). Factors influencing test accuracy include individual urine output/volume, urine pH, dosage, timing and formulation of used substances, occasional or chronic substance use, substances taken simultaneously, variability of testing equipment, individual metabolism, recent trauma, and shock. Although GC/MS may approach 100% accuracy, individuals have attempted to avoid detection using several methods:

- **Masking agents.** Diuretics often are used to counteract steroid-induced fluid retention and reduce the concentration of banned substances.[39]

- **Determination of drug half-life.** If drug testing is announced, individuals can determine the length of time during which a specific drug can be detected in the urine.
- **Substitution of urine.** Several methods can be used to substitute "clean" urine (e.g., self-catheterization and innovative "delivery systems"). In efforts to eliminate this problem, collection is conducted under constant supervision and close observation.

The NCAA does not require drug testing programs at its institutional membership schools. Many colleges and universities along with professional sport teams, however, have implemented drug testing programs. In addition, the NCAA does perform drug testing at NCAA championship events and randomly selected regional events. The NCAA also visits all NCAA Division I schools twice per year to randomly drug test selected football and track-and-field athletes. Athletic trainers working with athletes should be familiar with the NCAA, USOC, and IOC banned substance lists. It must be noted that many OTC products and nutritional supplements may have substances that are banned by the NCAA and/or USOC; athletes should always make sure that the ingredients in these products are not banned before using them. Information concerning the NCAA drug testing program and the banned substance lists is available on the NCAA Web site (www.ncaa.org) and the USOC Web site (www.usoc.org).

See **Drug Clearance Times** found on the companion Web site at thePoint for specific drugs and their approximate elimination time.

SUMMARY

1. Medications have chemical, generic, and brand names.
2. Pharmacokinetics is the process that explains a drug's entry into the body as well as its absorption, distribution, metabolization, and excretion.
3. The pharmacokinetic process determines the means by which a drug

reaches a target site to either facilitate or inhibit an action.

4. The half-life of a drug, lipid solubility, therapeutic range, dosage, potency, and maximal efficacy all play a role in determining the drug's action and effect.
5. Common medications for the treatment of soft-tissue injuries include analgesics and antipyretics, NSAIDs, corticosteroids, muscle relaxants, topical antibiotics, antiseptics, and antifungal agents. Each of these drugs comes in both prescription and OTC forms.
6. Athletic trainers are not allowed to prescribe or dispense prescription medication.
7. Depending on state regulations, athletic trainers may be authorized by the team physician to administer a one-dose pack of an OTC medication when approved protocols warrant their use.
8. When providing OTC medications, a record log should be kept that indicates the individual's name, date, medication administered, reasons for administering the medication, and signature of the athletic trainer administering the medication.
9. OTC medications should be stored as directed on packaging labels and placed in a secure, locked cabinet.
10. Prescription medications should be kept in a secured and locked location under the direct supervision of a licensed physician or pharmacist.
11. Therapeutic medications, if not used as directed, can cause adverse reactions and, in some cases, toxicity and death.
12. Ergogenic aids are substances or devices that enhance energy production, energy use, or recovery to provide a competitive edge.
13. Current drug testing uses GC/MS.

APPLICATION QUESTIONS

1. An 18-year-old female gymnast sustained a second-degree lumbar strain. What two types of medications is the team physician likely to prescribe for this athlete? In filling the prescription, the generic brand of the medications will be supplied. What are possible generic names for each type of medication? What side effects may occur with each medication?
2. You are an intercollegiate athletic trainer. While in the weight training room, you overhear a member of the basketball team asking a teammate about the use of diuretics to help lose weight. How would you respond to this scenario? What suggestions can you make to help the athlete safely lose weight without the use of diuretics?
3. A 55-year-old male preparing for a tennis tournament complains of chronic pain associated with medial epicondylitis. What type of therapeutic medication might be used to relieve the pain and inflammation associated with this condition? Does the age of the individual present any additional concerns?
4. What are the responsibilities of an athletic trainer when using therapeutic medications for the treatment of sport-related injuries? When indications are used as part of the treatment protocol, how can athletic trainers protect themselves from possible litigation?

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