1

# The Concept of Sports Injury

## MAJOR CONCEPTS

After reading and studying this chapter, the reader will be familiar with the scope and breadth of the topic of sports injury. This chapter discusses the most popular definitions of sports injury currently in use, along with a variety of the most commonly used medical terms related to the type and severity of injury. These terms are used throughout the remainder of the book and can also prove useful to the coach when communicating with members of the medical community about sports injuries. The last sections of the chapter introduce the concept of epidemiology as it applies to the study of sports injury. A straightforward sports classification system is introduced that is based on the relative amount of physical contact that typically occurs during the activity. This chapter concludes with specific participation and injury data from the most popular school sports in the United States.


The Web site for this book offers many useful tools and is a great source for supplementary information for both students and instructors.

Organized competitive high school sports continue to be extremely popular among American children. Recent research indicates that approximately 7.5 million public school children are involved in these activities annually (National Federation of State High School Associations [NFSH], n.d.). Along with modest growth in high school sports programs, there has been massive growth in the number of adolescent and pediatric-aged children playing sports. As a result of community-based programs, a total of approximately 30 million school-aged children are involved in sports in the United States (Adirim & Cheng, 2003). Although these sports may involve children as young as 6 to 8 years, the level of competition is often extremely high as attested by the fact that it is common for teams to travel hundreds and sometimes thousands of miles to compete in tournaments. Further, it is not uncommon for children in sports such as tennis and gymnastics to invest as much as 20 hours a week in their chosen activity (Maffulli & Caine, 2005).

With the implementation of the Title IX Education Assistance Act of 1972, growth in the participation of female athletes in the United States was reported through the 1980s at 700% (Stanitski, 1989). Ironically, as a result of persistent stereotypes in both the lay and coaching communities that girls were not tough enough to play sports, many young female athletes were historically discouraged from participation. Even more disturbing is the fact that such negative stereotypes still persist in some sports organizations. Available evidence suggests that for some sports the injury rates are higher for girls, while in other sports the rates are higher for boys. High school data, for example, indicate that in sports in which both genders compete such as soccer and basketball, there are some differences in injury rates based on gender. For example, in basketball, girls sustain more concussions and knee injuries, while boys sustain more fractures and contusions (Borowski et al., 2008). Injury data from high school soccer show that overall the injury rates are very similar between genders. There is a notable exception, however, in that girls are found to have a much higher rate of knee ligament sprains. The rates for complete ligament sprains in the knee requiring surgery were 13 times higher in girls than in boys (Yard, Schroder, et al., 2008). The majority of these complete ligament sprains resulted from noncontact mechanisms of injury—a phenomenon that continues to be an area of intense research within the sports medicine community. Data support the premise that with respect to severe injuries, for example, those resulting in a loss of more than 21 days of sports participation, the aggregate rate for boys sports was higher than for girls (Darrow et al., 2009). However, when the data were restricted to comparisons of basketball, soccer, and baseball/softball, girls were found to have higher rates of injuries qualifying as severe. The authors of this study conclude that this finding is the result of the differences in rates between girls and boys basketball (Darrow et al., 2009). (See **Figure 1.1** and **Figure 1.2**.)

Despite the best efforts of parents, coaches, and officials, injury continues to be an unavoidable reality for a significant number of participants. Damore and colleagues (2003) conducted research examining a broader age distribution. They studied emergency department admissions of patients ranging in age from 5 to 21 years at four hospitals for two 1-month periods (October 1999 and April 2000). They recorded a total of 1421 injuries in a group of 1275 patients in the age range of their study. Of these injuries, 41% were attributed to sports participation. The average age for such patients in their study was 12.2 years, with sprains, contusions, and fractures being the most common injuries. Males sustained more injuries (62%) to the musculoskeletal system than did their female counterparts.

Radelet and colleagues (2002) studied injuries in a population of children (1659) involved in community

**FIGURE 1.1** Historically, females were discouraged from sports participation based on unfounded fears of gender-based vulnerability to injury.


**FIGURE 1.2** Although data show that in some sports females have a higher risk for some injuries compared to their male counterparts, it is also true that in other sports, rates for males are higher.

sports programs over the course of 2 years. Specifically, they monitored the injuries in children ranging in age from 7 to 13 years who were involved in baseball, softball, soccer, and football. An injury was defined as "requiring on-field evaluation by coaching staff, or causing a player to stop participation for any period of time, or requiring first aid during an event." They further defined an "athlete exposure" as one athlete participating in one event (game or practice). Their results, expressed as the rate of injury per 100 athlete exposures, were that soccer had the highest rate at 2.1 injuries, followed by baseball at 1.7, football at 1.5, and softball at 1.0. In all sports, there were more injuries in games than in practices, with contusions being the most common injury overall. It is also interesting to note that in soccer, there were no gender differences in injury rates.

## Definition of Sports Injury

Though logic seems to argue that determining what constitutes a sports **injury** would be simple, just the opposite is the case. Despite the efforts of many in the sports medicine community, a single, universally acceptable definition of sports injury remains unavailable. Debates about precise definitions among academicians may seem petty to the injured athlete; however, from a clinical and scientific viewpoint, having a standard set of definitions can greatly improve the usefulness and impact of future injury studies.

Most current definitions of sports injury incorporate the length of time away from participation (time lost) as the major determinant of injury severity In 1982, the National Collegiate Athletic Association (NCAA) established the Injury Surveillance System (ISS), which established a common set of injury and risk definitions for use in tracking collegiate sports injuries. To qualify as an injury under the ISS, that injury must meet the following criteria:

1. Occurs as a result of participation in an organized intercollegiate practice or game
2. Requires medical attention by a team athletic trainer or physician
3. Results in restriction of the student athlete's participation or performance for one or more days beyond the day of injury (Benson, 1995)

The NCAA monitors injuries at Division I, II, and III institutions across all regions of the country and produces an annual report of the findings.

The National Athletic Trainers' Association (NATA) commissioned two national surveys of high school sports injuries, each spanning 3-year periods (i.e., 1986–88 and 1995–97). The injury definitions used in the NATA studies are similar to those used in the ISS because they rely on estimates of time lost from play as the indicator of injury severity (Foster, 1996).

Even though time lost is a convenient method for identifying an injury, such a definition does not lend itself to an accurate reflection of the severity of the injury. Severity of injury determinations may be made by a variety of people, including the coach, physicians or other sports medicine personnel, parents, or perhaps even the athlete. A related problem is that no standard is currently in use by all organizations monitoring sports injuries for the amount of time—hours, days, weeks, or months—that must be lost to qualify as a specific level of injury severity.

From a scientific standpoint, using the amount of time lost as a definition of sports injury is subject to significant error as previously described, depending on the method of data collection and injury definitions employed. However, once an injury is identified, several qualifiers are available to enable sports medicine personnel to better describe the precise characteristics of the injury. These include the type of tissue(s) involved, injury location, and time frame of the injury, that is, either acute or chronic.

**injury** Act that damages or hurts.

A commonly used medical classification system for injuries uses two major categories: acute and chronic. **Acute injuries** have been defined as those "characterized by a rapid onset, resulting from a traumatic event" (American Academy of Orthopaedic Surgeons [AAOS], 1991). Acute injuries are usually associated with a significant traumatic event (**Figure 1.3**), followed immediately by a pattern of signs and symptoms such as pain, swelling, and loss of function. In the case of an acute injury, **critical force** has been defined as the "magnitude of a single force for which the anatomical structure of interest is damaged" (Nigg & Bobbert, 1990). The potential for critical force, and subsequent acute injury, is clearly seen in tackle football. Estimates demonstrate that the vertebral bodies in the human cervical spine have a critical force limit of 340–455 kilograms. Researchers, using devices to simulate a typical tackle, have estimated that compressive forces acting on the cervical spine can exceed these limits (Torg, 1982).

**Chronic injuries** have been defined as those "characterized by a slow, insidious onset, implying a gradual development of structural damage" (American Academy of Family Physicians [AAFP], 1992). Chronic sports injuries, in contrast to acute ones, are not associated with a single traumatic episode; rather, they develop progressively over time. In many cases, they occur in athletes who are involved in activities that require repeated, continuous movements, such as in running (**Figure 1.4**). Consequently, such injuries are sometimes called overuse injuries, implying the athlete, by virtue of excessive participation, has exceeded the body's ability to recover from repeated bouts of activity. Overuse injuries in tendons occur when the workload from exercise exceeds the ability of musculotendinous tissues to recover (Hess et al., 1989). Thus, activity serves to cause a progressive breakdown of the tissue, leading eventually to failure. Common sites for overuse injuries are the Achilles tendon, the patellar tendon, and the rotator cuff tendon in the shoulder (Hess et al., 1989). The Achilles tendon is subjected to tremendous stress during running and jumping (**Figure 1.5**). Research indicates that

**FIGURE 1.3** Acute injury in an athlete.

**FIGURE 1.4** Chronic injuries are common in high-impact sports such as running.

**FIGURE 1.5** Injuries to the Achilles tendon are common in track and field events.

these forces may exceed the physiologic limits of the tendon, thereby resulting in damage (Curwain & Stanish, 1984). Likewise, the patellar tendon must absorb repeated episodes of stress during sports. For instance, jumping and landing, as well as kicking a soccer ball (**Figure 1.6**), generate forces in this tendon that are many times greater than those produced during normal gait (Gainor et al., 1978). The rotator cuff tendons, specifically the supraspinatus tendon, is also vulnerable to injury from overuse. Any activity requiring repeated overhead movements of the arm, such as overhead strokes in tennis (**Figure 1.7**), places significant stress on this tendon. This is especially true during the deceleration phase of a swing or throw, after the arm has reached peak velocity. During this period of movement, muscles undergo **eccentric contraction**, a type of contraction identified as a causative factor in tendon injury (Curwain & Stanish, 1984). Such stress can cause damage in the supraspinatus tendon, resulting in a chronic injury.

FIGURE 1.6 Jumping and landing, as well as kicking a soccer ball, subject the patellar tendon to stress.

FIGURE 1.7 Tennis places significant stress on the rotator cuff.

DiFiori (1999) categorizes factors contributing to overuse injuries as either intrinsic, such as immature (growth) cartilage, lack of flexibility, lack of proper conditioning, psychological factors; and extrinsic, including such factors as excessive training or lack of adequate recovery, incorrect technique, and playing on uneven surfaces or surfaces that are too hard.

Probably the most commonly used terms for differentiating tissues involved in a given injury are **soft tissue** versus skeletal tissue. Soft tissue, as a category, includes muscles, **fascia**, tendons, **joint capsules**, ligaments, blood vessels, and nerves. Most soft-tissue injuries involve contusions (bruises), sprains (ligaments/capsules), and strains (muscles/tendons). Skeletal tissue includes

**acute injury** Characterized by rapid onset, resulting from a traumatic event.
**critical force** Magnitude of a single force by which an anatomic structure is damaged.
**chronic injury** One characterized by a slow, insidious onset, implying a gradual development of structural damage.
**eccentric contraction** The simultaneous processes of muscle contraction and stretching of the muscle–tendon unit by an extrinsic force.
**soft tissue** Includes muscles, fascia, tendons, joint capsules, ligaments, blood vessels, and nerves.
**fascia** Fibrous membrane that covers, supports, and separates muscles.
**joint capsule** Saclike structure that encloses the ends of bones in a diarthrodial joint.

any bony structure in the body. Therefore, under this system, a common ankle sprain would qualify as a soft-tissue injury; a fractured wrist would be deemed a skeletal injury. These injuries, and the forces that produce them, are discussed further in Chapter 8.

A notable exception to the general confusion in defining a sports injury has to do with injuries so severe that they are known as catastrophic. **Catastrophic injuries** often involve damage to the brain and/or spinal cord and are potentially life threatening or permanent. Another group of catastrophic injuries involves those linked to heat-related disorders. In the context of high school and college sports, catastrophic injury has been defined as "any severe injury incurred during participation in a school/college sponsored sport" (Mueller & Cantu, 2009). Research on catastrophic injuries in schools and colleges has been conducted since 1982 by the National Center for Catastrophic Sports Injury Research, based at the University of North Carolina (Muller & Cantu, 2009). Mueller and Cantu define direct catastrophic injuries as those that result directly from participation in the skills of a given sport. Indirect catastrophic injuries are those caused by systemic failure resulting from exertion while participating in a sports activity or by a complication that was secondary to a nonfatal injury (Mueller & Cantu, 2009). Given these definitions, a catastrophic injury can occur as either a direct result of participation (sustaining a neck fracture during a tackle in football) or an indirect result (suffering a systemic heatstroke during a cross-country run).

Though catastrophic sports injuries account for a small portion of all sports-related injuries, their potential for serious complications has resulted in an increased awareness by members of the sports medicine community. The most recent data available, for the 2008 season, indicate that at the high school level football produced 7 direct fatalities and 13 indirect fatalities. The majority of the direct fatalities resulted from brain injury, and the majority of the indirect fatalities resulted from heatstroke and cardiac-related problems. Other high school sports mentioned in the 26th annual report of the National Center for Catastrophic Sport Injury Research in 2009 as meriting special attention are wrestling, gymnastics, ice hockey, baseball, and track. Pole-vaulting is associated with the majority of track-related deaths (Mueller & Cantu, 2009).

## Injury Classifications

Regardless of the specific force involved in producing an injury, it is critical that all personnel involved in supervision of sports and physical activities, particularly coaches, be familiar with and fluent in the use of the basic terminology of connective-tissue injury. It is essential that personnel be able to recognize any injury and whenever possible correctly identify it as soon as possible after the injury occurs, and then clearly describe it when communicating with other members of the sports medicine team (e.g., the team physician or athletic

### Athletic Trainers SPEAK Out

*Sports-injury prevention is the cornerstone of the athletic trainer. Sports-injury prevention begins with a comprehensive sport-specific physical examination given by a qualified medical professional and continues through the selection and proper fitting of equipment and developing the physical components for sports competition. I have always said that if an athletic trainer can take an injured body part and rehabilitate that body part and individual back into full participation, then why can't an athletic trainer take an uninjured body part and individual and provide a strength and conditioning experience that brings that athlete to a top level of participation for physical activity and competition? With the knowledge, skills, and experience certified athletic trainers have in the area of athletic injury prevention they can assist the coach and work with the athlete in flexibility, strength, plyometric, and aerobic fitness in the prevention of sports injury and in the enhancement of sports performance.*

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trainer). It is also vital that sports personnel master a vocabulary of standardized terms universal to all members of the sports medicine team. In 1968, the Committee on the Medical Aspects of Sports, a branch of the American Medical Association (AMA), published *Standard Nomenclature of Athletic Injuries (SNAI)*. Though this text is no longer in print, it provided clearly defined, standardized terms that can and should be used by those providing care for sports injuries.

Because the vast majority of sports injuries involve damage to connective tissue, the terms that apply to these common conditions are listed hereafter. Obviously, a certain degree of variability is unavoidable in any clinical definition. However, these terms, when used properly, can greatly reduce the confusion that so often exists regarding specific injuries.

## Sprains

**Sprains** are injuries to ligaments, which surround all synovial joints in the body. The severity of sprains is highly variable depending on the forces involved. *SNAI* describes three categories of sprains, based on the level of severity.

### First-Degree Sprains

According to *SNAI*, first-degree sprains are the mildest form of sprain; only mild pain and disability occur. These sprains demonstrate little or no swelling and are associated with minor ligament damage.

### Second-Degree Sprains

Second-degree sprains are more severe; they imply more actual damage to the ligament(s) involved, with an increase in the amount of pain and dysfunction. Swelling is more pronounced, and abnormal motion is present. Such injuries have a tendency to recur.

### Third-Degree Sprains

Third-degree sprains are the most severe form of sprain and imply a complete tear of the ligament(s) involved. Given the extensive damage, pain, swelling, and **hemorrhage** are significant and are associated with considerable loss of joint stability.

## Strains

**Strains** are injuries to muscles, tendons, or the junction between the two, commonly known as the musculotendinous junction (MTJ). The most common location of a strain is the MTJ; however, the exact reason for this is unknown. As is the case with sprains, there is tremendous variability in the severity of strains incurred in sports. *SNAI* presents three categories of strains.

### First-Degree Strains

*SNAI* describes first-degree strains as the mildest form with little associated damage to muscle and tendon structures. Pain is most noticeable during use; mild swelling and muscle spasm may be present.

### Second-Degree Strains

Second-degree strains imply more extensive damage to the soft-tissue structures involved. Pain, swelling, and muscle spasm are more pronounced, and functional loss is moderate. These types of injuries are associated with excessive, forced stretching or a failure in the synergistic action in a muscle group.

### Third-Degree Strains

Third-degree strains are the most severe form and imply a complete rupture of the soft-tissue structures involved. Damage may occur at a variety of locations, including the bony attachment of the tendon (**avulsion** fracture), the tissues between the tendon and muscle (MTJ), or in the muscle itself. A defect may be apparent through the skin and will be associated with significant swelling. Obviously, this type of injury involves significant loss of function.

## Contusions

In all probability, common bruises or contusions are the most frequent sports injury, regardless of activity. **Contusions** result from direct blows to the body surface that cause a compression of the underlying tissue(s) as well as the skin (O'Donoghue, 1984). They can occur in almost any activity; however, collision and contact sports such as tackle football, basketball, and baseball are more to blame in this regard. Curiously, many athletes and coaches view contusions as routine, minor injuries, but they can be serious, even life-threatening, injuries when the tissues involve vital organs such as the kidneys or the brain.

**catastrophic injury** One involving damage to the brain and/or spinal cord that presents a potentially life-threatening situation or the possibility of permanent disability.

**sprain** Injury to a joint and the surrounding structures, primarily ligaments and/or joint capsules.

**hemorrhage** Discharge of blood.

**strain** Injury involving muscles and tendons or the junction between the two, commonly known as the musculotendinous junction.

**avulsion** Forcible tearing away or separation.

**contusion** Bruise or injury to soft tissue that does not break the skin.

Contusions are typically characterized as being associated with pain, stiffness, swelling, **ecchymosis** (discoloration), and **hematoma** (pooling of blood). If not treated properly, such injuries to muscle tissue can result in a condition known as **myositis ossificans**, which involves the development of bonelike formations in the muscle tissue.

## Fractures

Fractures and dislocations represent two categories of injuries involving either bones or joints of the body. Though such injuries can occur in any activity, they are more common in collision sports in which large forces come into play. **Fractures** have been defined as "a break of a bone" (Venes & Taber, 2009). Compound fractures are potentially more serious because of the risk of infection related to the open wound. Furthermore, control of bleeding may be necessary depending on the severity and location of the wound.

Acute fractures are relatively uncommon sports injuries. When they occur, however, appropriate first aid is essential to prevent complications such as shock, excessive blood loss, or permanent damage. Fortunately, with modern diagnostic procedures, identifying traumatic fractures is relatively easy. The National Safety Council (1991) provides the following descriptions of signs and symptoms:

- ***Swelling.*** Caused by bleeding; it occurs rapidly after a fracture.
- ***Deformity.*** This is not always obvious. Compare the injured with the uninjured opposite body part when checking for deformity.
- ***Pain and tenderness.*** Commonly found only at the injury site. The athlete usually can point to the site of pain. A useful procedure for detecting fractures is to feel gently along the bones; complaints about pain or tenderness serve as a reliable sign of a fracture.
- ***Loss of use.*** Inability to use the injured part. Guarded motion occurs because movement produces pain, and the athlete will refuse to use the injured limb. However, sometimes the athlete is able to move the limb with little or no pain.
- ***Grating sensation.*** Do not move the injured limb in an attempt to see if a grating sensation called **crepitation** can be felt (and even sometimes heard) when broken bone ends rub together.
- ***History of the injury.*** Suspect a fracture whenever severe forces are involved, especially in high-risk sports such as tackle football, alpine skiing, and ice hockey. The athlete may have heard or felt the bone snap.

Fractures may also be described in terms of the specific nature of the break in the bone. The major types of traumatic fractures are shown in **Figure 1.8**.

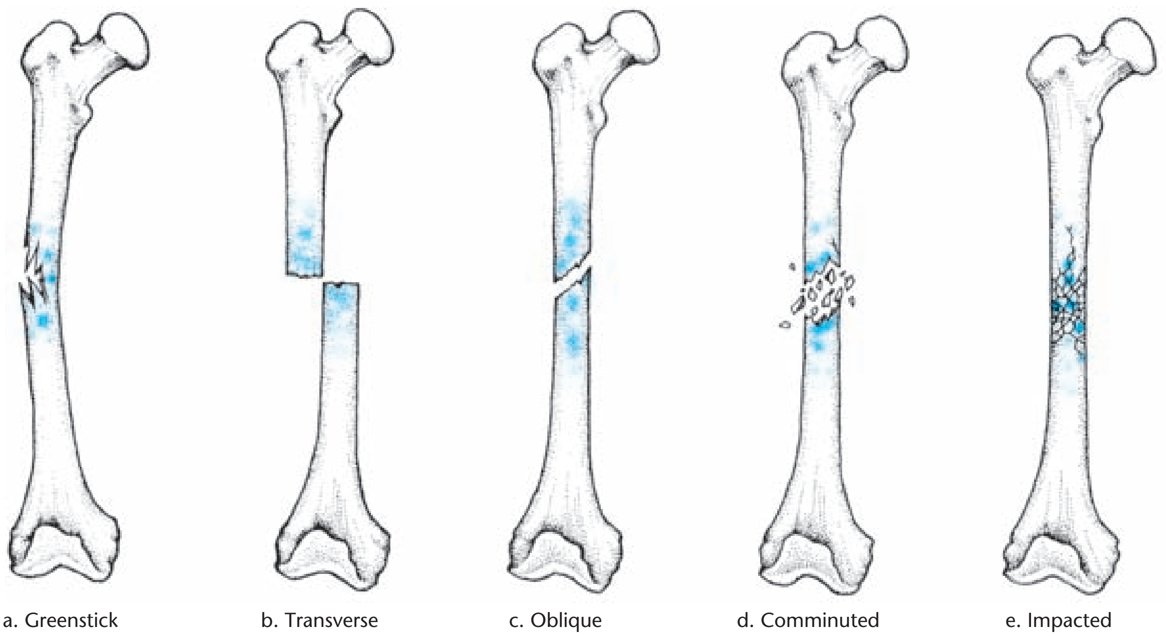


**FIGURE 1.8** Types of fractures.

### *Stress Fracture*

A **stress fracture** is typically linked to sports because it develops over a relatively long time period, as opposed to other fractures caused by a single trauma. Stress fractures occur when a bone is subjected to repeated episodes of overloading (stress) that exceed its rate of recovery. In effect, the bone starts to break down and eventually begins to fail. Because stress fractures take time to develop, the signs and symptoms are easily confused with other, less serious sports-related problems. This is especially true for stress fractures of the lower leg bones, which are often confused with shin splints. Although stress fractures can occur throughout the body, the majority occur in the lower extremities. Athletes at high risk for stress fractures are those who are in poor physical condition or overweight. However, even well conditioned participants may develop such a fracture, particularly when they have made a recent and sudden increase in the intensity of their training program. Stress fractures may even be related to diet.

The symptoms of a stress fracture are nebulous at best; nevertheless, certain factors are usually present when one is developing:

- ***Pain/tenderness.*** Athlete complains of pain and/or tenderness. A constant ache is not relieved with rest.
- ***Absence of trauma.*** Suspect such a fracture when there is no history of traumatic event, yet the symptoms persist.
- ***Repetitive activity.*** Athlete is involved in an activity that subjects the suspect area to repeated stressful episodes.
- ***Duration.*** Symptoms have slowly developed over a period of days, weeks, or even months.

Stress fractures often present the physician with a difficult diagnosis because, during the initial phases, X-ray examinations may not show the fracture. In fact, it may take several weeks or longer after the onset of symptoms for the fracture to be visible on X-ray (Venes & Taber, 2009). It is this healing process, known technically as a callus, that can be seen on an X-ray and that signals that a fracture has occurred (see **Figure 1.9**). As a result, the physician must base the diagnosis on the factors listed previously. The best approach is to treat athletes as if they have a stress fracture and repeat the X-ray evaluation on a weekly or biweekly basis until a callus is seen. In difficult cases, a bone scan or magnetic resonance imaging may be used to obtain a positive diagnosis.

Treatment of stress fractures involves rest and splinting or casting when necessary, followed by a slow, gradual return to participation. Athletes are often encouraged to maintain their fitness levels during recovery by cross training—that is, riding a stationary bike, jogging in shallow water, or swimming. All of these activities provide good stimulation of aerobic fitness while reducing stress on the skeletal system. Any program of recovery must be structured on an individual basis by the coach, athletic trainer, and physician.

**FIGURE 1.9** Stress fracture of the third metatarsal (approximately midshaft) in the left foot. Note callus formation around the site of the fracture.

### *Salter-Harris Fractures*

A category of fractures unique to the adolescent athlete involves the epiphyseal growth plate and is known as Salter-Harris fractures. These fractures are classified based on the specific location of the fracture line(s) across the epiphyseal region of the bone. Five types (I, II, III, IV, V) have been identified (**Figure 1.10**).

Type I involves a complete separation of the **epiphysis** from the **metaphysis**.

**ecchymosis** Black-and-blue discoloration of the skin caused by hemorrhage.
**hematoma** A localized collection of extravasated blood, usually clotted, that is confined within an organ, tissue, or space.
**myositis ossificans** Myositis marked by ossification within a muscle.
**fracture** A break or crack in a bone.
**crepitation** Crackling sound heard during the movement of a broken bone.
**stress fracture** Small crack or break in a bone related to excessive, repeated overloads; also known as overuse fracture or march fracture.
**epiphysis** Cartilaginous growth region of a bone.
**metaphysis** That portion of growing bone located between the shaft and the epiphysis.

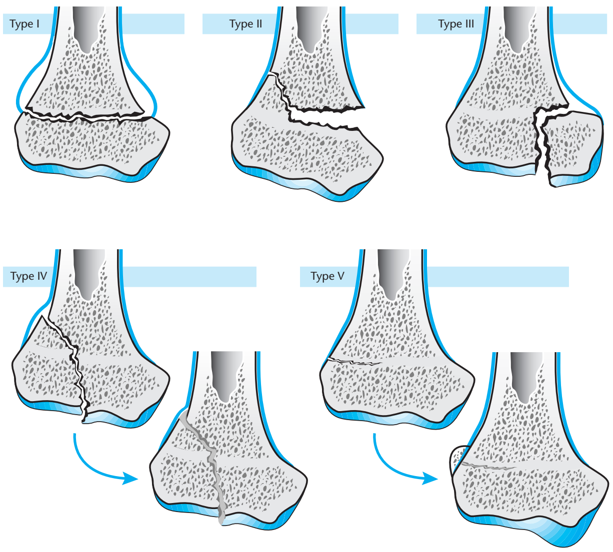


**FIGURE 1.10** Salter-Harris epiphyseal fractures.

Type II involves a separation of the epiphysis from the metaphysis as well as a fracture through a small part of the metaphysis.

Type III involves a fracture of the epiphysis.

Type IV involves fracture of both the epiphysis and metaphysis.

Type V involves a crushing injury of the epiphysis without displacement.

Salter-Harris fractures can result in long-term complications for bone growth if not cared for properly. These complications include premature closure of the growth plate or abnormal joint alignment, which can result in the possibility of different leg lengths when growth ceases. These injuries must be evaluated by a physician, who will determine the best method of management. If there is a fracture associated with displacement of the fragments, reduction is required. This may be accomplished either with or without surgical intervention, depending on the specifics of the pathology as determined by the physician. Salter-Harris fractures are discussed further in Chapter 20.

### Dislocations

**Dislocations** have been defined as "the temporary displacement of a bone from its normal position in a joint" (Venes & Taber, 2009). Two types of dislocations can occur, based on the severity of the injury. A **subluxation** takes place when the bones of a joint are only partially displaced. A **luxation** happens when the bones of a joint are totally displaced. In a sense, any dislocation, whether it is a subluxation or luxation, should be viewed as a severe type of sprain. Recall that sprains involve damage to the tissues surrounding joints—that is, capsules and ligaments. As such, dislocations present many of the same signs and symptoms as those seen in sprains. First aid treatment for dislocations combines care given for both sprains and fractures.

Dislocations can occur in any articulation; however, specific joints seem to be more vulnerable. Two joints in the shoulder complex, the glenohumeral and the acromioclavicular, are injured frequently in sports such as tackle football and wrestling. The small joints in the fingers are commonly dislocated in baseball and softball. Fortunately, such dislocations are relatively easy to evaluate because their most definitive sign is deformity of the joint. Deformity is typically easily identified because the joint can be quickly compared to the same joint on the opposite side of the body or an adjacent joint such as in a finger or toe. Symptoms of dislocation include joint dysfunction, as well as the feeling of the joint having been forced out of normal position. Often the athlete reports having heard a snapping or popping sound as well. If treated properly, full recovery typically occurs. It is important to note that at no time should the coach attempt to reduce (put back in place) any dislocation, no matter how minor it may appear to be. All dislocations should be diagnosed and reduced by a physician after a complete medical evaluation.

## Injury Recognition

From a practical standpoint, learning to recognize injury, regardless of the classification system used, is an essential skill to be mastered by the coach. To a great extent, the athlete's health and safety are determined by the decisions and subsequent actions of the coach because the coach is most often the first to arrive at the scene of an injury. In addition, the dramatic increase in sports-injury litigation should serve as further incentive for coaching personnel to be prepared for emergencies. The premise that most injuries are best treated with the "run-it-out" approach is dangerous, to say the least. Today's coach should treat all possible injuries as such, until proven otherwise. It is imperative that coaching personnel develop the knowledge and skills to discriminate injuries requiring medical referral from those not neces-

**WHAT IF?**

A student athlete asks you to explain the difference between a subluxation and a luxation of a joint.

sitating such evaluation. Moreover, it should be noted that such decisions are best left to qualified health specialists, such as athletic trainers certified by the Board of Certification (BOC). Every effort should be made to have such a specialist employed, either permanently or part-time, by the school or agency sponsoring the sports program.

## Epidemiology of Sports Injury

Scientific sports-injury research is a relatively recent phenomenon. The majority of the early studies, sometimes known as case-series studies, were based on information collected by medical personnel at hospitals or clinics (Walter et al., 1985). Although these data have provided valuable information, significant problems are associated with this type of data collection. Typically, only athletes with significant injuries seek medical attention at a hospital or clinic. Thus, a large number of athletes with injuries of minor to moderate severity may not be included in the study. Another problem with case-series research is the inability to accurately identify the cause or causes of a specific injury. For example, researchers at a particular clinic might conclude that less experienced athletes are more susceptible to injuries. However, without knowing the general level of experience of all athletes—injured as well as uninjured—it is impossible to determine what constitutes inexperience.

A better approach to sports-injury research involves the application of the principles of **epidemiology**. The science of epidemiology is the "study of the distribution of diseases, injuries, or other health states in human populations for the purpose of identifying and implementing measures to prevent their development and spread" (Caine, Caine, & Lindner, 1996). The sports epidemiologist collects information in an effort to identify **risk factors** that may have contributed to a particular injury. Hypotheses are then developed and tested to confirm a statistical relationship. Risk factors, such as collisions in tackle football or ice hockey, may be inherent in the sport. Equipment may increase the risk of injury—for example, a safety helmet with a faulty design or a diving board set too close to the pool deck. The athlete may also possess risk factors—for example, muscle imbalances, obesity, low skill level, or any of a variety of congenital conditions.

By determining statistical relationships between suspected risk factors and specific injuries, sports regulatory organizations can implement strategies designed to reduce or eliminate the risk of sports injuries. The incidence of spine injury in tackle football was significantly reduced by a rule change implemented in 1976 that made the practice of **spearing** (tackling and/or blocking with the head as the initial point of contact) illegal (Torg, 1982). In this case, the available data indicated that the technique of spearing placed the cervical spine (neck) of athletes at risk.

Curiously, it was also hypothesized that improvements in helmet technology in the early 1970s may have contributed to the increase in cervical spine injury because athletes were inclined to tackle with their heads down, essentially using their head as a weapon, in the belief they would not sustain a head injury.

Since the early 1970s, several organizations in the United States have sponsored large-scale injury surveillance systems. The earliest to employ epidemiological methods was the National Athletic Injury/Illness Reporting System (NAIRS), which was instituted in 1974. More recently, the National Collegiate Athletic Association Injury Surveillance System (NCAA-ISS) and the High School RIO (Reporting Information Online), an Internet-based reporting system (www.highschoolrio.com), have established ongoing sports-injury surveillance systems. Sports organizations such as the National Football League (NFL) and the National Hockey League (NHL) conduct ongoing injury surveillance annually as well.

The National Center for Catastrophic Sports Injury Research began operation in 1982 with a focus on the documentation of catastrophic injuries at the high school and college levels (Mueller & Cantu, 1993). This center monitors catastrophic injuries in the following sports:

| | |
|---|---|
| Baseball | Soccer |
| Basketball | Softball |
| Cross-country skiing | Swimming |
| Field hockey | Tennis |
| Football | Track |
| Gymnastics | Volleyball |
| Ice hockey | Water polo |
| Lacrosse | Wrestling |

**dislocation** The displacement of contiguous surfaces of bones comprising a joint.
**subluxation** Partial or incomplete dislocation of an articulation.
**luxation** Complete dislocation of a joint.
**epidemiology** The study of the distribution of disease or injury within a population and its environment.
**risk factor** Causative agent in a sports injury.
**spearing** A practice in tackle football whereby a player performs either a tackle or a block using the head as the initial point of contact.

The primary goal of all organizations involved in sports-injury research is to identify risk factors for injury and, whenever possible, to develop and implement strategies to eliminate or reduce these risk(s). It is hoped that the information collected by these organizations will lead to continued reductions in both the frequency and severity of sports injuries.

## Classification of Sports

Just as injuries can be defined and described using a variety of medical and scientific terms, sports can be classified based on their comparative risk of injury based on criteria such as the amount of physical contact between participants or the relative intensity of the activities. The American Academy of Pediatrics (AAP) classifies many popular sports into three categories based on the likelihood of collisions with participants or inanimate objects. The categories are contact/collision, limited contact, and noncontact. The first category, contact/collision, combines sports that involve intentional contact between participants such as tackle football, wrestling, martial arts, and ice hockey (collision sports) with sports such as basketball, lacrosse, and soccer, which often involve some contact between participants (contact sports), and the difference is the amount of force involved (AAP, 2001). Limited-contact sports are sports where contact between participants or with inanimate objects is "infrequent or inadvertent" (AAP, 2001). Examples of sports in this category include baseball and softball, downhill skiing, and volleyball. Noncontact sports, as the name implies, typically do not involve contact between participants. Examples of these sports include badminton, bowling, golf, and running (AAP, 2001). As such, the potential for impact-related injuries is lower in limited-contact and noncontact sports than in contact/collision sports. Note, however, that such classification systems do not imply that sports classified as something other than contact/collision are completely safe. To the contrary, not all injuries are related to the amount of physical contact between participants. For example, temperature-related injuries such as heat exhaustion and heatstroke can occur in virtually any sport when proper preventive measures are neglected. Also note that the AAP states that participation in boxing is not recommended (AAP, 1994).

Sports medicine personnel, coaches, administrators, and parents can use this information when athletes are found to have specific health-related problems during their preparticipation physical evaluations (PPE). For example, a child with a history of recent head injury, such as a concussion, would be ill-advised to participate in a contact/collision sport such as football. However, contrary to popular belief, noncontact sports can represent a risk to athletes as well. For example, a child with an identified, clinically significant congenital heart disorder might be advised to avoid aerobic activities such as track, swimming, and aerobic dance.

**WHAT IF?**

A student athlete asks you the classification of her three favorite sports, for example, softball, golf, and soccer.

## Extent of the Injury Problem: Some Examples

This section presents current statistical information on injuries in six popular interscholastic sports, beginning with tackle football.

### Tackle Football

Tackle football (**Figure 1.11**) continues to be popular, with approximately 1.5 million athletes participating, beginning as young as age 9 at the youth sport level, up through high school, collegiate, and professional levels (Stuart et al., 2002). The most recent data available from the National Federation of State High School Associations (NFHS) for 2008–09 indicate that in high school alone there were 1,140,027 participants (NFHS, n.d.).

Ramirez and colleagues (2006) conducted a 2-year duration study of high school football injuries that surveyed 87 schools in California. They report an overall injury rate of 25.5 injuries for every 100 players with the highest rates occurring during games. Earlier research conducted at the high school level found that 34% of the participants were injured, based on a study funded by the National Athletic Trainers' Association (NATA) (Powell & Barber-Foss, 1999). The NATA survey suggests that the percentage of high school–level players injured annually has dropped slightly compared with the 3-year period of 1985–87. Many of these injuries are directly attributable to the fact that participants obviously collide with one another as part of the game.

More recent research conducted by Shankar and colleagues (2007) at the high school level estimates that 517,726 injuries occurred in football during the 2005–06 season. In this study, researchers define an injury as having occurred either in practice or game, requiring the care of either the athletic trainer or a physi-

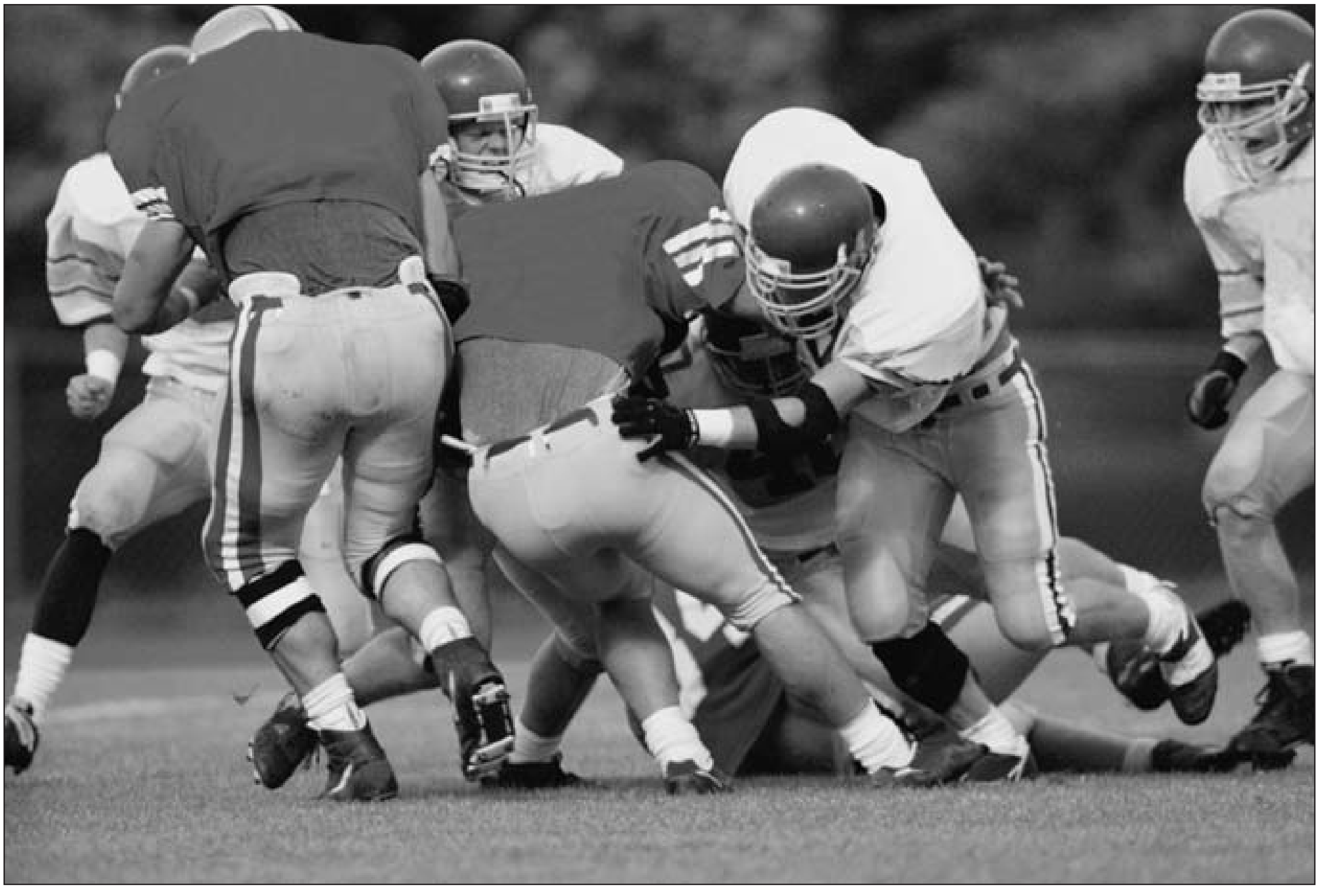

**FIGURE 1.11** Up to 34% of participants in interscholastic tackle football can expect to be injured.

cian, and it had to be severe enough to require the athlete to miss one day, or more, of participation beyond the day of the injury. They define an athlete exposure as participation in either a game or a practice. As such, injury rates were expressed in this study as the number of injuries for every 1000 athlete exposures. This is the most common way of expressing the rate of injury and it allows researchers to make comparisons between sources of injuries, for example, between practice and games. The majority (88.2%) of these injuries were classified as "new," meaning they were not reinjury of previous injuries (Shankar et al., 2007). The most commonly injured areas of the body were the knee and ankle, with ligament injuries (sprains) being the most common type of injury to both joints. In all, lower-extremity injuries accounted for 46.9% of all injuries. With respect to the upper extremity, the shoulder accounted for 12.4% of injuries, followed by the hand at 9.3%. The head/face and the torso/spine/neck combined for 23.1% of injuries (Shankar et al., 2007). (Head and neck injuries are discussed in detail in Chapter 9.) Similar to the findings of Ramirez and colleagues, Shankar and associates also found that the injury rate during games was five times the rate seen in practice (Shankar et al., 2007). This is a sobering finding and most certainly highlights the importance of having trained sports medicine professionals present at games whenever possible.

Recent research examining injuries in youth football provides a wealth of information. For example, Stuart and colleagues (2002) examined the injury rates in 915 players aged 9 to 13 years distributed across 42 teams. Over the course of one season, these researchers recorded a total of 55 injuries during games. Of these, the majority were contusions (60%), with muscle strains, sprains, fractures, abrasions, and concussions accounting for 20%, 9%, 7%, 2%, and 2%, respectively. The majority of the injuries involved the lower extremity, including four fractures, all **Salter-Harris** type (Figure 1.10). It is interesting to note that their data also indicate

**Salter-Harris Fracture** A category of fractures that involves the growth plate.

a relationship between age and injury: Older players were found to be at a higher risk for injuries. In addition, the highest relative risk of injury by player position was found for running backs and quarterbacks, followed by defensive backs and then linebackers.

Malina and colleagues (2006) studied 678 players aged 9 to 14 years (PONY Football League) over two consecutive seasons. An injury was defined as "any injury that causes cessation of a player's customary participation on the day following the day of onset." BOC-certified athletic trainers were on-site to record all injuries, both at home games and practices, to ensure accuracy of the data. A total of 259 injuries were recorded over two seasons, with 178 occurring in practice and the remaining 81 in games. Most injuries (64%) were minor, with moderate and major injuries at 18% and 13%, respectively. Injury rates were similar for players in the fourth and fifth grades at 13.3 and 12.9 per 1000 exposures, respectively, with rates doubling for the seventh and eighth grades at 26.1 and 27.4 injuries per 1000 exposures, respectively. It is also interesting to note that, excluding the sixth-grade cohort, game injury rates were more than double the rates seen in practice for all other grade levels. Further, the game injury rates for the seventh and eighth grades were the same as the game rates for high school participants reported by Powel and Barber-Foss (1999). However, when compared to the more recent high school data from Shankar et al. (2007), it appears that the injury rates for the youth sports players greatly exceed the rates seen at the high school level. Shankar et al. (2007) report that practice injury rates were 2.56 injuries per 1000 exposures and 12.04 per 1000 exposures for games. These numbers are significantly lower than the rates reported by Malina et al. (2006). In aggregate, these findings reinforce the notion that coaching personnel at the youth football level must be trained in first aid and cardiopulmonary resuscitation (CPR), and whenever possible, a BOC-certified athletic trainer should be on hand for both practices and games (Powell & Barber-Foss, 1999).

Understandably, an ongoing area of concern in tackle football is the incidence of injuries involving the brain and spinal cord. Recent research conducted by Mueller and Cantu (2009) finds that although there have been significant reductions in football-related fatalities and nonfatal catastrophic injuries since 1976, data for 2007 show a dramatic rise in the incidence of serious injuries involving the head and neck. In 2006, there were four such injuries reported; however, that number jumped to 19 in 2007 (Mueller & Cantu, 2009). Earlier research on high school sports conducted by Powell and Barber-Foss (1999) indicates an increase in the reported incidence of injuries to the head/neck/spine. Specifically, the authors found that 10.3% of all the injuries reported during the 3-year period of 1995–97 were classified as neurotrauma (injuries to the nervous system such as mild brain injury). In this category, football exceeded a number of other sports such as wrestling, baseball, soccer, and basketball.

Given the inherently violent nature of the sport, it may be impossible to eliminate head and neck injuries from football completely; however, these data certainly make it clear that more work needs to be done to implement effective strategies to reduce the incidence of serious injuries associated with football. Head and neck injuries are discussed in detail in Chapter 9.

## Basketball

Slightly fewer than 1 million high school students, boys and girls, participated in basketball programs in the United States during the 2008–09 school year (NFHSA, n.d.). Recent research by Borowski and colleagues (2008) is consistent with earlier work by Powell and Barber-Foss (1999). The data indicate that for both genders, basketball continues to be associated with a high percentage of injuries in the lower extremities. For example, the ankle/foot, knee, and hip/thigh/upper leg accounted for 62.8% of the injuries (genders combined) (Borowski et al., 2008).

Note that the incidence of knee injuries in basketball is consistently higher for girls than it is for boys (**Figure 1.12**). In addition, girls also demonstrate a higher percentage of knee injuries requiring surgery (Powell & Barber-Foss, 1999). It is notable that Borowski and asso-

**FIGURE 1.12** Basketball places the lower extremities of female players at particular risk.

ciates (2008) found that injuries to the knee were the most frequent injury requiring surgery. This finding is troubling for a number of reasons including the fact that major knee ligament injuries are typically season ending and can even jeopardize an athlete's ability to return to the sport. Aside from the financial implications, evidence suggests that for those athletes who sustain injuries to their anterior cruciate ligament (ACL) a significant percentage will go on to develop premature osteoarthritis in the knee. The data suggest that this will occur in as many as 26% of those who have surgical reconstruction of their ligament and in as many as 60% to 100% of those who do not have reconstructive surgery (Louboutin et al., 2009).

The most recent data (2005–06 season) available from the National Collegiate Athletic Association's Injury Surveillance System (NCAA-ISS) yield results similar to, but perhaps more striking than, the high school data. Women basketball players at the collegiate level were found to have injured their knees, specifically the ACL, at a much higher rate than their male counterparts did. Specifically, the women's injury rate during practice was approximately twice that seen in men's practice. The difference between women and men players' ACL injuries in games was even more striking in that the rate of ACL injury during games was three times higher for women than for men. As such, it appears that with respect to collegiate basketball, female athletes continue to exhibit a far greater risk for sustaining injuries to the ACL than do their male counterparts. Although a great deal of research has been and continues to be focused on explanations for these differences, no definitive cause has yet been identified. Research to date attempts to identify risk factors in female athletes associated with a higher risk for noncontact ACL injuries (Arendt & Dick, 1995; Griffin et al., 2000; Harmon & Ireland, 2000; Hewett, Myer, & Ford, 2006; Hewett, Ford, & Myer, 2006; Kirkendall & Garrett, 2000). For a more detailed discussion of the issue of ACL injuries, see Chapter 15.

## Baseball and Softball

Participation figures for the 2008–09 season show there were 474,274 participants in baseball and 370,467 in softball at the high school level (NFHS, n.d.). The latest available injury data collected during the 2005–07 baseball seasons demonstrate an overall injury rate of 1.26 injuries per 1000 athlete exposures (Collins & Comstock, 2008). For comparison, using the same data collection system (High School RIO) within the same time period, the overall rate of injury for boys in basketball was 1.83, soccer was 2.34, and football was 4.36 (Borowski et al., 2008; Shankar et al., 2007; Yard, Schroder, et al., 2008). As such, of the four sports described here, baseball had the lowest overall injury rate. Of the injuries reported, sprains and strains combined for 41.1% of the injuries, with contusions and fractures making up an additional 30.3% of the total.

The body areas most commonly injured were the shoulder, ankle, and head and face combining for 43.5% of all injuries. However, despite the low overall rate of injury, this latest research also highlights the finding that 11.6% of all injuries reported resulted from being struck by a batted ball. More alarming is the finding that 48% of those injuries were to the head/face (Collins & Comstock, 2008). When compared to earlier work by Powell and Barber-Foss (1999), Collins and Comstock (2008) found that the incidence of injuries to the head and face has increased significantly as well as has the incidence of fractures. In light of these findings, the authors recommend that pitchers, infielders, and batters all wear helmets with face shields or wear mouth guards and eye protection (Collins & Comstock, 2008).

Recent injury data for high school softball is not available; however, Marshall and associates (2007) published the results of a long-term study (1988–89 through 2003–04) of injuries associated with collegiate-level softball. A consistent finding regardless of NCAA division was that injury rates were nearly double in games versus practice; for example, in Division 1, these rates were 4.45 per 1000 athlete exposures versus 2.98 per 1000 athlete exposures, respectively. Overall, the lower extremities accounted for 42% of all injuries, whereas the upper extremity accounted for 33%. For both games and practice, the ankle was the most commonly injured body area and the injury type in both cases was a sprain. Fixed bases played heavily into the rate of ankle injuries: Of the 9% of game-related injuries caused by contact with a fixed base, 43.3% were classified as ankle ligament sprains (Marshall et al., 2007). Many of these ankle sprains resulted from feet-first sliding when base running.

Similar to the data from baseball, Marshall et al. note that being struck by a batted ball in 2003–04 accounted for 11.8% of all game-related injuries. Of these, pitchers and batters were most commonly injured by batted balls (Marshall et al., 2007). Head injuries associated with being struck by batted balls had the highest frequency in batters and third basemen (Marshall et al., 2007). As was the case with baseball, it seems prudent that appropriate safety equipment be worn at all times by those players shown to be at risk.

Approximately 4.8 million children between the ages of 5 and 14 years play baseball, softball, or tee-ball annually (AAP, 2001). According to the AAP, perhaps as many as 8% of these children are injured each year. Of these injuries, 26% are fractures and 37% are contusions/abrasions. It is worthy to note that the AAP has determined that children have an increased vulnerability to chest impacts from balls, perhaps because of the increased elasticity of the thorax in these young players (AAP, 2001). Between the years 1973 and 1995, 88 baseball-related deaths were reported in this age group. Forty-three percent resulted from direct ball impact with the chest. The AAP has made a number of recommendations designed to reduce the risk of such injuries, including the use of batting helmets and face protectors, both at bat and when on base; outfitting catchers with a helmet, face mask, and chest and neck protector; eliminating the on-deck circle; and adding protective screening around dugouts and player benches. Eye injuries are a major concern in baseball, which is the most productive sport in this regard. One-third of these injuries result from being struck by a pitched ball.

A persistent area of concern for decades has been the risk of injury to the elbow in adolescent pitchers. This fear was apparently based on the fact that many young pitchers complained of elbow pain and subsequent medical evaluation sometimes found evidence of overuse injuries in these children. It was thought that these injuries were related to throwing excessive numbers of curve balls and/or breaking pitches. Specifically, the area of concern is the medial humeral epicondyle (see Chapter 12) and the muscles that attach at this location. In the adolescent elbow, these attachments represent a growth plate; as such, they may be vulnerable to the repeated stresses that pitching can generate. Research by Adams (1965) raised serious concerns about elbow injuries among Little League pitchers. This condition, dubbed **Little League elbow**, created a considerable amount of worry among parents in the late 1960s. Two studies conducted by major medical groups examined the relationships between pitching mechanics and injuries and were published in the 1970s. These researchers found no relationship between pitching and elbow damage (Gugenheim et al., 1976; Larson et al., 1976). In contrast to these studies, research conducted by Micheli and Fehlandt (1992) endeavored to identify what causes injuries to tendons and **apophyses** (bony attachments of tendons) in a population of 445 children aged 8 to 19 years. Their conclusion was that for boys, baseball was associated with the highest occurrence of injury. Further, softball was the fourth most commonly associated sport for injury in girls. Overall, they found that in their study group the most common injuries were to the elbow (Micheli & Fehlandt, 1992). It has also been reported that those pitching with a sidearm technique (**Figure 1.13**) are three times more likely to develop elbow problems than those who pitch using the more traditional overhand style (Stanitski, 1993).

**FIGURE 1.13** The correct pitching technique combined with limits on the number of pitches per week can spare Little Leaguers possible elbow damage.

A common assumption within the lay community is that softball pitching (so-called underhand pitching) is inherently safer than is overhand pitching associated with baseball. However, although it is the case that rules are in place at the amateur level in baseball that limit the total number of innings pitched, softball has no such restrictions. In fact, one study noted that female pitchers pitch in as many as six games during a weekend tournament with a total of 1200–1500 pitches pitched over 3 days. (Werner et al., 2006). Pain in the **anterior** shoulder has been reported as a common symptom in softball pitchers and is associated with excessively high forces that are generated during the "windmill" style pitch, which stresses the attachment of the long head of the biceps brachii to the glenoid labrum (Rojas et al., 2009). Research found that the forces acting on the biceps brachii attachment were higher than those in the overhand throw (Rojas et al., 2009). Contrary to the work cited earlier on Little League elbow, Lyman et al. (2002) did find an association between elbow pain and pitching in a group of 476 youth pitchers between the ages of 9 and 14 years. They found that as pitch count increased through the season, so did the risk of elbow pain (Lyman et al., 2002). Fleisig et al. (2009) conclude that there are four factors that increase the risk of elbow injury in youth players: (1) number of pitches thrown, (2) pitching mechanics, (3) pitch type, and (4) physical condition of the player. However, it is critical to note that a number of studies that attempted to link curve balls with elbow injury failed to find a consistent link (Fleisig et al., 2009).

## Wrestling

Wrestling at the high school level drew 273,403 participants during the 2008–09 season (NFHS, n.d.). Its continued popularity is no doubt partly a result of the fact that participants are matched by body weight, thus allowing children of all body sizes to participate. However, given the nature of the sport, collisions/contact with opponents and mats do result in various injuries. In addition, joint injuries occur in takedown and escape maneuvers as well as in holds (**Figure 1.14**), which are essential parts of the sport.

Yard, Collins, and colleagues (2008) reported injury data on both high school and college wrestlers for the 2005–06 season and overall found that collegiate wrestlers are injured at a rate three times greater than their high school counterparts are. The knee is the most commonly injured body area at the collegiate level, representing 17.1% of all injuries, with shoulder strains/sprains and dislocations/subluxations combining for 16.2% of the injuries. Injuries of the head/face account for 7.4% of injuries, and concussions comprise 5.8%. At the high school level, shoulder strains/sprains account for 8.5% of injuries followed closely by ankle strains/sprains at 7.6% and knee sprains/strains at 7.0%. Curiously, concussions at the high school level accounted for 5.4% of injuries, falling within 0.4% of the collegiate percentage (Yard, Collins, et al., 2008). Injury rates were found to be much higher in matches than in practice for both high school and collegiate participants (two and five times higher, respectively) (Yard, Collins, et al., 2008).

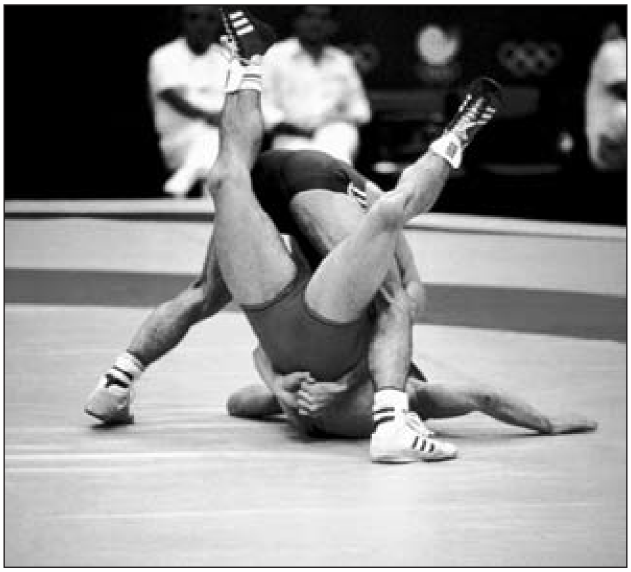

**FIGURE 1.14** In wrestling, takedown and escape maneuvers can result in injuries.

Other injuries common to wrestling are **friction** burns to the skin, skin infections, and irritation of the outer ear (sometimes referred to as cauliflower ear). Mandatory headgear that provides ear protection, improvements in mat surfaces, and vigilant cleaning and maintenance of facilities have significantly reduced the incidence of these problems. As a result of an increase in the incidence of reported cases of skin infections caused by methicillin-resistant Staphylococcus aureus (MRSA) in recent years, everyone involved with the sport of wrestling, including the athletes, has become more vigilant with respect to spotting skin infections early. The available data indicate that although MRSA continues to be a threat, many other skin-related infections occur with much greater frequency. High school wrestling data, for example, list skin infections as 8.5% of all reported "injuries," with impetigo accounting for 30.0%, herpes at 20.5%, and ringworm at 20.0% (Yard, Collins, et al., 2008). The same study found that at the collegiate level, skin infections made up 20.3% of all reported "injuries." Herpes was the most common, at 47.1% of all reported skin infections, with impetigo accounting for 36.8%, tinea corporis at 7.4%, cellulitis at 5.9%, and MRSA cases at 2.9%.

At the high school level, the majority of skin infections were on the head/face and neck (Yard, Collins, et al., 2008). Many skin infections are highly contagious through direct contact with an infected person or contaminated equipment such as wrestling mats and clothing. It is critical that coaches, athletes, and support personnel such as athletic trainers remain vigilant to identify potential skin infections and treat them accordingly before they can spread to others. Athletes with active skin infections should be removed from participation and referred to a physician for diagnosis and, when necessary, treatment, and these athletes should not return to participation until cleared to return by a physician. Wrestling mats should be cleaned daily after practice with an appropriate

**WHAT IF?**

A parent asks you for advice about which high school sport is the safest for his daughter. Based on available data, what would you tell him?

**Little League elbow** Condition related to excessive throwing that results in swelling of the medial epicondyle of the elbow, that is, medial humeral epicondylitis.
**apophysis** Bony outgrowth to which muscles attach.
**anterior** Before or in front of.
**friction** Heat producing.

disinfectant product designed specifically to kill MRSA and other common pathogens. The position statement of the National Athletic Trainers' Association on community-acquired MRSA infections is available at http://nata.org/sites/default/files/MRSA.pdf.

Because wrestling incorporates specific weight categories, the sport has historically been plagued with problems associated with rapid and excessive weight loss by participants. This issue is discussed further in Chapter 6 and Appendix 2.

## Volleyball

The sport of volleyball continues to be extremely popular at the high school level. The latest participation figures show that for the 2008–09 season, there were 474,274 participants (NFHS, n.d.). Volleyball involves jumping, diving, and overhand arm swinging (serves and spiking) and as such qualifies as a limited-contact sport. Injury data from the 1995–97 NATA study (Powell & Barber-Foss, 1999) found that 14.9% of the volleyball participants sustained some type of participation-related injury. Of those, the majority (51.5%) were classified as sprains, which was the highest percentage of sprains for the 10 sports surveyed. Of these sprains, 41.8% involved the ankle/foot, exceeding girls' basketball in this regard for the same survey. Knee injuries in volleyball constituted 11.1% of the injuries reported in the survey (Powell & Barber-Foss, 1999).

High school data reported approximately 10 years later (2005–08) demonstrate a strikingly similar percentage of volleyball injuries involving the ankle at 42.6%, which was about 2% less than the rate seen in girls basketball and approximately 20% higher than that seen in girls soccer (Swenson et al., 2009). In a study of severe injuries (resulting in a loss of more than 21 days of participation) in high school athletes, Darrow et al. (2009) reported that volleyball produced the lowest percentage of severe injuries (3.9%) of all the sports in the study that surveyed boys' football, boys' and girls' soccer, girls' volleyball, boys' and girls' basketball, boys' wrestling, boys' baseball, and girls' softball. The knee and ankle were involved in approximately 60% of the severe injuries related to volleyball with fractures and complete and incomplete ligament tears making up more than 82% of reported events (Darrow et al., 2009).

## Soccer

Soccer, commonly called football outside the United States (**Figure 1.15**), has grown in popularity throughout the United States with recent estimates of nearly 14

**FIGURE 1.15** The most common injuries among soccer players involve the knee, shin, and ankle.

million participants younger than age 18. According to the NFHS, during the 2008–09 season, a total of 728,358 boys and girls participated in soccer programs at their respective high schools (NFHS, n.d.).

Although soccer does not involve intentional collisions between players, incidental collisions frequently occur, and as such, it is classified by the AAP as a contact/collision sport (AAP, 1994). Protective equipment is limited, with most body areas exposed to external trauma. High school data representing participation in 2005–07 found an overall injury rate (genders combined) of 2.39 injuries per 1000 athletic exposures. This was further divided into injuries during competition, which yielded a rate of 4.77 per 1000 athletic exposures versus a rate seen in practice of 1.37 (Yard, Schroder, et al., 2008). Incomplete and complete ligament sprains along with contusions accounted for nearly 60% of all the injuries, genders combined. The lower extremity (thigh, knee, ankle) and the head/face combined for approximately 69% of the injuries. A stunning finding was that during competitions, girls sustained complete ligament sprains at a rate of 26.4 per 100,000 athlete exposures, compared to a competition rate of for boys of 1.98 (Yard, Schroder, et al., 2008).

With respect to knee injuries, specifically the ACL, available data indicate that female youth participants sustain higher numbers of these injuries than their male counterparts do. Research based on youth soccer insurance claims found that female participants dramatically increased the number of claims for ACL injuries at age 14, and compared with males, females demonstrated a higher ratio of knee injury compared to all injuries and a higher ratio of ACL injury compared to all injuries (Shea et al., 2004).

A unique aspect of the game involves the skill known as heading, in which a participant contacts a ball with the head, in most cases after it has been kicked into the air. Some medical experts have hypothesized that this practice may lead to possible head injury. Historically, little reliable research has been conducted attempting to confirm this hypothesis (Jordan et al., 1996; Smodlaka, 1984). However, research examining the incidence of head injury from all causes in soccer, as well as evidence of decreased neurocognitive function, has increased significantly in recent years. Boden, Kirkendall, Garrett (1998) examined the rate of concussions in soccer at the collegiate level and found that the majority of the concussions reported resulted from collisions with an opponent rather than from intentional heading of the ball. Although prevention of concussion must remain a priority across all sports, available data in soccer indicate that there is not much difference in the rate of concussion between boys and girls, with concussion representing about 3% of all injuries reported (Le Gall, Carling, Reilly, 2008). Research has also found that although heading the ball continues to result in concussion, collisions between players is the most common cause of concussion (Koutures, Gregory, & Council on Sports Medicine and Fitness, 2010). In recent years specialized helmets for soccer players have been introduced in an effort to reduce the incidence of head injury. However, data based on sound science fail to support their universal use at this time (Koutures et al., 2010).

In recent years, a number of deaths and severe injuries have been related to improperly constructed movable soccer goals. For the period from 1979 to 1994, at least 21 deaths were reported; an additional 120 nonfatal injuries occurred that were directly related to movable goals (Consumer Product Safety Commission [CPSC], 1995). The majority of these injuries and fatalities occurred when the goals tipped over and struck the victims. As a result, numerous soccer organizations—such as the Federation Internationale de Football, the National Federation of State High School Associations, and the National Collegiate Athletic Association—have established strict criteria for the construction of soccer goals. In addition, the Consumer Product Safety Commission has published guidelines for the design and construction of movable soccer goals.

## REVIEW QUESTIONS

1. Damore and colleagues (2003) conducted research on emergency department admissions in a population of patients ranging in age from 5 to 21 years. What percentage of these admissions was attributable to sports injuries?
2. What are the most commonly used criteria for defining a sports injury?
3. Describe briefly two major problems that arise regarding the most commonly used definitions of sports injury.
4. What are the three criteria necessary for an injury to be classified as such under the NCAA's Injury Surveillance System (ISS)?
5. Define and differentiate between acute and chronic forms of injury.
6. What constitutes a catastrophic sports injury?
7. What specific tissue types are involved in sprains and strains? How is the severity of these injuries defined?
8. What makes a stress fracture unique when compared with other types of fractures?
9. Define and differentiate between subluxation and luxation.
10. Using the sports classification system presented in this chapter, what is the classification for the sport of basketball?
11. What is the science of epidemiology?
12. According to Shankar et al. (2007), what are the most commonly injured areas of the body in tackle football?
13. True or false: According to Shankar et al. (2007), the injury rate in football practice is five times higher than in games.
14. In basketball, what injury most often results in surgery?
15. What were the conclusions of Micheli and Fehlandt (1992) regarding the relationship between elbow injuries and participation in baseball?
16. What piece of equipment related to soccer has been found to play a direct role in the majority of deaths related in this sport?

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