Musculoskeletal Injuries in Adolescents: A Sports Medicine Model

Asheesh Gupta, Ron Paik, Gloria Balague, John Coumbe-Lilley, and Mark R. Hutchinson

Introduction

It has been said that the best place to study trauma in adolescents is to witness an American high school football any Friday evening in the fall. In virtually every minute of the game, another collision is occurring that places the athlete at risk of musculoskeletal injury. This weekend observance for trauma is much more fruitful than sitting at the street corner waiting for the next car accident to occur. For the purposes of this chapter, a sports medicine model will be used to discuss common musculoskeletal injuries in adolescents ranging from acute traumatic injuries to chronic overuse injuries. The chapter will be broken into two sections: musculoskeletal injuries and the psychological basis of injury, recovery, and prevention. Special issues including musculoskeletal injuries related to child abuse as well as more classic traumatic injuries related to accidental falls and motor vehicle accident will be discussed in the context of epidemiological and prevention comparisons to the athletic population. The impact of musculoskeletal injury on the life of an adolescent will be emphasized in not only discussing the temporary physical challenges and impairments of specific injuries but also by the need for prevention. The final section of the chapter is dedicated to the psychological impact of overuse and traumatic musculoskeletal on the adolescent both in the short and long term as well as some clues regarding optimization of recovery for youth.

A. Gupta, M.D. (✉) • R. Paik, M.D.
M.R. Hutchinson, M.D.
Department of Orthopaedics, University of Illinois, 835 South Wolcott, 270 Medical Sciences Building, Chicago, IL 60612, USA
e-mail: mhutch@uic.edu

G. Balague, Ph.D. • J. Coumbe-Lilley, Ph.D.
University of Illinois at Chicago, 601 S. Morgan Street, Chicago, IL 60607, USA

Section 1: Musculoskeletal Injuries in Youth

Epidemiology

In the United States an estimated 30 million youth participate in organized sports. The Youth Risk Behavior Survey was a large population-based study performed throughout the 1990s, enabling accurate measurement of the emerging trends in youth sports participation. Results from the 1997 survey reported that 62 % of US high school students participated in one or more sports teams, with most playing in a combination of both school and nonschool teams (Washington, Bernhardt, Gomez, et al., 2001). In addition, many more participate in recreational sports. Injuries are an inherent risk in sports, and approximately 80 % of sports injuries affect the musculoskeletal system. Many patients participate in multiple teams during a given sports season, the rest periods between seasons are short or nonexistent, and there is increasing demand for sporting success from par-

W.T. O'Donohue et al. (eds.), *Handbook of Adolescent Health Psychology*,
DOI 10.1007/978-1-4614-6633-8_42, © Springer Science+Business Media New York 2013

ents, schools, and sporting establishments. In a survey of children and adolescents age 5–17 years, the estimated annual number of injuries resulting from participation in sports and recreational activities was 4,379,000 with 1,363,000 classified as serious (requiring hospitalization, surgical treatment, missed school, or a half day or more in bed). Up to 36 % of injuries may be directly related to sports participation in patients in these age groups (Bijur et al., 1995). While the definition of what constitutes a sports injury is varied, some common elements such as need for medical attention, time lost from practice or game, and decreased level of activity are widely used in different definitions. Injuries are commonly grouped into either acute or chronic which are designated macrotrauma and microtrauma, respectively.

One of the most commonly used measures in determining the severity of a sports injury is time lost from participation in the sport. The National Athletic Injury Reporting System (NAIRS) uses the following categories for severity: nonreportable, no time lost; minor, 1–7 days lost; moderate, 8–21 days lost; major, more than 21 days lost; and severe, resulting in permanent disability. Another important documented aspect of sports injuries is incidence of injuries. The two ways in which incidence of injuries are reported are cumulative incidence and incidence of first injury. Cumulative incidence reports the number of injuries sustained by a defined group of athletes. For example, cumulative incidence would record the incidence of injuries of football players over a set period of time. Cumulative incidence is useful because it provides information on an individual athlete's risk of injury. Incidence of first injury is the risk of any one athlete in a group of being injured.

From incidence studies, it is clear that chronic overuse injuries are far more prevalent than acute sports injuries in those 17 years old and younger. Not only is there a higher incidence of chronic injuries in adolescents but the severity as measured by time lost from sports is also greater. Of all injuries in adolescents, 30–50 % are due to chronic overuse in both sports-related and non-sports-related injuries.

The greatest source of available data on musculoskeletal sports injuries comes from those suffered during interscholastic high school sports. For boys in all sports combined, there is a yearly incidence of injury in high school sports of 27–39 %. Organized sports account for 25–30 % of total injuries, while non-organized sports account for 40 % of total injuries. As one would expect contact sports account for the greatest number of injuries in adolescents. In an 8-year longitudinal study of high school sports, researchers reported that 48 % of athletes sustained at least one injury during their season: 64.5 % of all injuries were minor (no days lost), 30.3 % were mild (1–7 days lost), 3.1 % were moderate (8–21 days lost), and 1.9 % were severe (22 days lost). A study by the American Academy of Pediatrics suggested that female athletes have higher rates of injuries when compared with male athletes (American Academy of Pediatrics: Committee on Sports Medicine and Fitness, 2000). A recent study looking at injury claims from an insurance provider for youth soccer leagues showed that knee and anterior cruciate ligament injuries in female youth soccer players age 12 through 15 were more common than ACL injuries in males of the same age (Shea, Pfeiffer, Wang, Curtin, & Apel, 2004).

Soft tissue injuries such as strains, sprains, and contusions are the most common types of acute injuries. In a national study on sports and recreational injuries, researchers found that 59 % of sprains, 48 % of fractures and dislocations, and 25.5 % of lacerations are caused by sports and recreational activities in those under the age of 18. Furthermore, 36 % of all injuries are from sports. Compared with other injuries, sports did not account for a disproportionate number of serious or repeat injuries. This could serve as an indication to use sports as a model for injuries in adolescents.

Why Are Adolescents Different?

There are a number of significant differences between the adult and adolescent musculoskeletal system. The most significant difference between an immature skeleton and the adult skeleton is the presence of growth plates. The growth plate, also known as the physis, is composed of four zones: the resting cartilage or reserve zone, the proliferating cartilage zone, the zone of hypertrophy, and the metaphysis. In bone, there is a diaphysis (middle part of long bone), an epiphysis (end part of long bone), and a metaphysis (between the diaphysis and epiphysis) components. The physis is wedged between the metaphysis and epiphysis. The cartilage of the physis is relatively weak and susceptible to injury, especially during periods of active growth. In particular, the zone of calcification within the physis is the weakest and most commonly injured area; however, fractures confined to this region typically heal without complication.

In adults, the fully grown calcified bone is significantly stronger than ligaments and other soft tissue around the joint. Consequently, in adults, ligaments and soft tissue are more susceptible to injury than bone. In contrast, during adolescence, the ligaments and other soft structures around the joint are two to five times stronger than the physis. Therefore, damage to the physis is more common than damage to ligaments in those with immature skeletons.

It is also important to note that adolescent bone is less dense, more porous, and more vascular than adult bone. Increased porosity contributes to prevent the spread of fractures. The pediatric skeleton has a number of other advantages including the capacity for rapid and predictable fracture healing, increased tolerance of long-term immobilization, and increased tendency to recover soft tissue mobility spontaneously following most injuries, and joint surfaces are generally more tolerant of irregularity than those of adults.

Not only is the skeleton growing during adolescence but there are profound changes in height, weight, muscle mass, motor skills, and coordination. The adolescent growth spurt is variable in its onset and duration. As a result, two individuals of the same size could have vastly different bone and muscle maturity leading to a size–size mismatch in sports. In collision sports such as football, size–size mismatch is magnified and leads to an increased risk and severity of injury for the less developed individual. Size–size mismatch is more pronounced in boys than girls because as girls experience only a slight increase in muscle strength after menarche boys continue to acquire muscle strength throughout adolescence. Similarly in girls, motor performance remains relatively constant throughout adolescence where as boys continue to see improved motor performance throughout adolescence. While there is no clear pattern of strength and motor skill development in girls, there appears to be a positive correlation between biological maturity and muscle strength and motor performance in boys. This positive correlation suggests that as an athlete matures, they acquire a greater skill level in their sport which can lead to a higher level of competition played at a higher intensity. Furthermore, as athletes mature, their maximal speed increases leading to more violent collisions with increased momentum. Both increased intensity and speed in collision sports add to the risk and severity of injury.

While the focus of this chapter has been the physical injuries adolescents' experience, equally important are the psychological aspects of sports and injuries. Youth play sports for a variety of reasons including social acceptance, love of the sport, and hope of obtaining an athletic scholarship to college. With much pressure on athletes to perform at a high level whether it is from self, coach, friends, or family injuries can often be unexpected, difficult, and stressful. Most athletes have the proper motivation and desire to go through rehabilitation and get back to their sport as soon as possible. However, some athletes stagnate and may become depressed and require extra support to get through their injury. Athletes may go through a series of reactions after an injury similar to the context of death or other loss. The stages go in order from disbelief, denial, isolation, anger, bargaining, depression, to acceptance, and resignation with hope. During the recovery process, the physician must continue to motivate the athlete, help the athlete understand realistic outcomes, and listen to and manage the patient's reactions.

Common Acute Trauma Injuries

It is estimated that 15–20 % of all injuries to long bone are acute injuries of the growth plate. A large number of these acute injuries happen during sports participation. Acute injuries of the growth plate in the upper extremity are twice as common compared to those of the lower extremity. Boys suffer more acute injuries, and the greatest number of injuries for boys occurs at the age of 12 and 13, whereas for girls, the greatest number of injuries occurs at the age of 11. A system called the Salter–Harris classification was developed to classify acute injuries to the growth plate in adolescents. The Salter–Harris scheme is the most widely used system and has practical use in treatment and prognosis.

There are five types of Salter–Harris fractures that increase in severity from 1 to 5. A Salter–Harris type 1 fracture is least severe and is a transverse fracture across the growth plate commonly through the hypertrophic zone. The metaphyseal and epiphyseal bones are spared from fracture. Since the normal osteogenesis in the reserve and proliferative zones remain undisturbed in a Salter–Harris type 1 fracture, the prognosis is good. Type 1 Salter–Harris fractures are known for their rapid healing time, and a gentle reduction followed by alignment to protect the bone and joint from displacement is usually satisfactory for treatment. With protection, only 4–6 weeks are needed for the fracture to heal.

A Salter–Harris type 2 fracture transverses the growth plate much like a type 1 fracture; however, the fracture also enters the metaphysis. As in type 1 fractures, the reserve zone and zone of proliferation are undamaged and therefore the treatment is the same as a type 1 fracture. Salter–Harris type 3 and 4 fractures occur from sheer forces and differ from less severe fractures in that the fracture crosses the epiphysis into the joint. The articular joint is disrupted as the proliferative zone is violated. Long-term problems associated with type 3 and 4 fractures are growth arrest and high risk of articular degeneration. Surgical intervention is often indicated for type 3 and 4 fractures. A Salter–Harris type 5 fracture results from a crush injury to the reserve or proliferative zones of the growth plate and can cause growth arrest.

Acute patellar dislocation is one of the most common causes of acute hemarthrosis in the young athlete. When comparing patellar dislocation in male and female patients, some studies have suggested similar rates (Hinton & Sharma, 2003), and others have demonstrated that females have higher dislocation rates in the under 18 age group (Fithian, Paxton, Stone, et al., 2004). Risk factors for patella dislocation include ligamentous laxity, increased genu valgum, patella alta, lower extremity version abnormalities such as femoral anteversion and external tibial torsion, trochlear dysplasia, increased quadriceps angle, foot pronation, and patellar tilt (Hinton & Sharma, 2003). Both the medial retinaculum and the medial patellofemoral ligament (MPFL) are primary restraints to patellar dislocation. The risk of recurrent patellar dislocations appears to be significantly higher in females. A prospective cohort study following 189 pts were followed for 2–5 years. The group with the highest risk of dislocation was females age 10–17 years; 61 % dislocations occurred during sports and 9 % during dancing (Fithian et al., 2004). Standard knee radiographs should be taken to evaluate for osteochondral injuries, avulsions of soft tissue fragments, patella height, and trochlear dysplasia. MRI is also useful to evaluate for significant soft tissue injuries. Initial treatment consists of a brief period of immobilization followed by early rehabilitation. A recent prospective study on surgical intervention for first-time dislocators in children/adolescents did not demonstrate better outcomes compared with nonsurgical management (Palmu, Kallio, Donell, Helenius, & Nietosvaara, 2008). For patients with recurrent symptomatic patellar instability, surgical intervention may be beneficial.

Traumatic shoulder dislocations occur primarily in collision and contact sports in young athletes. It has been estimated that around 40 % of shoulder dislocations occur in patients younger than 22 years of age. A significant challenge to treating physicians is the fact that athletes with a history of pediatric dislocation have a 90 % chance of recurrent dislocation (Bishop & Flatow, 2005; Deitch, Mehlman, Foad, Obbehat, & Mallory, 2003; Rowe, 1956). This is theorized to be due to the fact that pediatric dislocations are believed to stretch the capsule and diminishes its ability to provide support for the shoulder joint. Surgical treatment of shoulder instability has been shown to be generally successful in young patients (Chen, Diaz, Loebenberg, & Rosen, 2005). Physical examination in combination with diagnostic testing may demonstrate concurrent injuries of the anterior bony labrum or labral lesions (Bankart injury, superior labral anterior and posterior tear, Hill–Sachs lesions), rotator cuff tears, and subscapularis or lesser tuberosity avulsions. Three view radiographs of the shoulder including an anterior–posterior, Scapular-Y, and axillary lateral can help determine direction of dislocation and any other bony abnormalities. MRI arthrogram is useful for evaluating capsular and labral tissues. In the acute setting, immediate reduction of the dislocation shoulder be attempted. If successful, physical therapy protocol should be initiated for strengthening and range of motion. Treatment of first-time dislocation in high-risk athletes remains controversial, and there is some evidence that early surgery may play a role in reducing the risk of secondary dislocation (Bedi & Ryu, 2009). Families should be counseled about the high risk of recurrent instability episodes with possible surgical intervention if nonsurgical treatment fails.

The treatment of anterior cruciate ligament (ACL) injuries in skeletally immature patients remains controversial. Recent studies indicate that the incidence of this injury may be increasing, and young female athletes start sustaining these injuries in significant numbers around 12–13 years of age. Nonsurgical treatment has historically shown to have poor results due to inherent instability leading to meniscal (particularly medial) and chondral injuries (Graf, Lange, Fujisaki, Landry, & Saluja, 1992; McCarroll, Shelbourne, Porter, Rettig, & Murray, 1994). One of the most challenging aspects of surgical reconstruction involves prevention of physeal injury leading to growth disturbance (Kocher, Saxon, Hovis, & Hawkins, 2002). Several physeal sparing techniques have been described in patients with significant growth remaining. For older patients, different techniques using grafts crossing the physis have been described. A recent study of patients at Tanner stage 3 or 4 who underwent ACL reconstruction using transphyseal technique demonstrated no physeal complications with excellent clinical outcomes (Kocher, Smith, Zoric, Lee, & Micheli, 2007).

Tibial eminence fractures occur predominantly in the skeletally immature patient. The mechanism of injury is similar to that of the previously described ACL injury. They are classified into three types: type I, minimal displacement of tibial eminence; type II, displacement of anterior third to one half of the tibial eminence, producing a beak-like deformity on the lateral radiograph; and type III, the avulsed tibial eminence is completely lifted from the underlying bone (Meyers & McKeever, 1987). A rare fourth kind has been described with complete rotation of the fragment. Entrapment of the intermeniscal ligament or anterior meniscus is possible, which may be an impediment to reduction of these fractures (Kocher, Micheli, Gerbino, & Hresko, 2003). These fractures may be associated with other soft tissue injuries, including bone contusions, ligament injury, and meniscal tear (Monto, Cameron-Donaldson, Close, Ho, & Hawkins, 2006).

Fractures of the medial epicondyle of the elbow are more common than frank elbow dislocations and account for 10 % of elbow fractures in children. The ulnar collateral ligament may avulse the medial epicondyle during elbow trauma. Nearly 50 % of medial epicondyle fractures are associated with dislocation of the elbow; the displaced fragment can then become incarcerated in the joint, preventing a concentric reduction. Acute medial epicondyle fractures and dislocations of the elbow can occur in young gymnasts, and isolated medial epicondyle fractures are occasionally seen in adolescent pitchers (Caine & Nassar, 2005). Nondisplaced fractures are treated with casting. In athletes such as throwers, gymnasts, and wrestlers who place high physical demands on the elbow, anatomic reduction of medial epicondyle fractures may be important for future athletic performance.

Common Chronic Overuse Injuries

Overuse injuries are common in adolescents who participate in sports. Repetitive activities can lead to tendinopathies, many of which have terms related to various sports such as golfer's or tennis elbow (medial and lateral epicondylopathy, respectively). Tendinopathies can occur throughout the body. The histopathologic changes vary from the early stages of inflammation (tendinitis) to chronic noninflammatory, fatty degeneration (tendinosis). Treatment options start with conservative treatments such as rest, physical therapy, and anti-inflammatories. Individuals with symptoms refractory to more conservative treatment or those who need more aggressive therapy due to the need to perform at a high level such as professional or collegiate athletes can consider treatments such as ultrasound, steroid or platelet-rich plasma injections, or surgery.

Overuse can result in osteochondroses in adolescents due to their skeletal immaturity. These pathologic conditions involving the physis can occur in various area such as Osgood–Schlatter disease of the tibial tubercle apophysis, Sever's disease of the calcaneus, osteochondritis dissecans of the capitellum of the elbow, and Little Leaguer's elbow (medial epicondyle of the humerus). Treatment for these conditions primarily involves rest and anti-inflammatories/analgesics. If displaced or fragmented, surgery may be required.

Prevention has been more of a recent focus, especially in the case of Little League shoulder and elbow. In hopes of decreasing the incidence of these conditions, USA baseball released recommendations in the mid-1990s for youth pitchers limiting the number and types of pitches thrown depending on age (Benjamin & Briner, 2005). Pitchers 8–10 years old should be restricted to fastballs, 50 pitches per game, and 75 pitches per week (Benjamin & Briner, 2005). Pitchers 10–11 years old can start throwing changeups, 75 pitches per game, and 100 pitches per week. Pitchers 13–14 years old can start throwing curve balls and 125 pitches per week. They are still restricted to 75 pitches per game. Pitchers 15–16 years old can start throwing sliders, forkballs, splitters, and knuckleballs and 90 pitches per game. There are no restrictions for number of pitches per week starting at this age. Pitchers 17–18 years old can start throwing screwballs and 105 pitches per game.

Stress fractures are another type of injury that can result from overuse. Stress fractures are categorized into two groups depending on the etiology. Fatigue stress fractures are the result of abnormal stresses in normal bone (Dixon, Newton, & Teh, 2011). Insufficiency stress fractures occur due to normal stresses in abnormal bone such as those with anorexia or osteoporosis (Dixon et al., 2011). All young women who present with a stress fracture should be carefully screened for the female athlete triad which includes inadequate energy availability compared to energy used (formally defined as eating disorders such as anorexia), poor bone metabolism usually evidenced by the initial stress fracture (formally defined as osteoporosis), and hormonal imbalances leading to menstrual irregularities (formally defined as amenorrhea). The current thought is that the Triad is a continuum of these milder definitions up to and including the extreme definitions (see below).

Stress fractures can occur anywhere in the body but are most commonly in areas that provide support during weight-bearing activities such as the tibia, femoral neck, or pars interarticularis of the spine. This may also include the upper extremity in gymnasts. Runners are at increased risk of tibia and femoral neck stress fractures (Dixon et al., 2011; Harrast & Colonno, 2010). Spondylolysis, fracture of the pars interarticularis, is more common in wrestlers, gymnasts, and weightlifters (Dixon et al., 2011).

Images are needed to diagnose stress fractures. Radiographs often are nondiagnostic since the majority of stress fractures are nondisplaced and cannot be seen on normal X-ray films. Bone scans have been used historically to make the diagnosis; however, MRI is currently the gold standard since it may provide a better indication of the severity of injury and predict return to play.

Treatment of stress fractures depends on the nature and area of the injury. High-risk areas such as the femoral neck can have catastrophic consequences (i.e., displacement which may lead to necrosis of the femoral head) if not surgically stabilized. Stress fractures of the anterior tibia, proximal fifth metatarsal metadiaphyseal area, sesamoids, and navicular are at high risk of nonunion (Harrast & Colonno, 2010). Surgical stabilization should be considered. Otherwise, nonoperative treatment with rest or bracing can be implemented.

Special Issues in Musculoskeletal Injuries in Adolescents

Child abuse is an area that treating physicians should remain vigilant for when evaluating musculoskeletal injuries. Abuse in adolescents may not be as difficult to assess as it is in children who have limited speaking ability. Child abuse as described in "The Child Abuse Prevention and Treatment Act" (CAPTA) amended by the "Keeping Children and Families Safe Act of 2003" is any recent act or failure to act, on the part of the parent or caretaker which results in death, serious physical or emotional harm, sexual abuse or exploitation, or an act or failure to act which presents an imminent risk of serious harm (Sink, Hyman, Matheny, Georgopoulos, & Kleinman, 2011). A child is a person under the age of 18 years, unless the child protection law of the state in which the child resides specifies a younger age for cases not involving sexual abuse.

Skin injuries are the most common manifestation of physical abuse. Burns are present in 10–25 % of cases, and bruising is found in 50–75 % of abuse victims (McMahon, Grossman, Gaffney, & Stanitski, 1995; Sink et al., 2011). Bruising in different stages should increase suspicion for abuse. In adolescents, there are no classic injuries that are specific of physical abuse like metaphyseal corner fractures in younger children or femur fractures in children less than one.

As briefly mentioned above, adolescent girls especially those in aesthetic sports (ballet, rhythmic gymnastics, synchronized swimming, and figure skating) or those sports who have weight categories or in which weight plays a role (crew, ski jumping, wrestling) are at increased risk for a condition termed the female athlete triad. The American College of Sports Medicine (ACSM) in 1992 first developed a special task force to look into the relationship among disordered eating, amenorrhea, and osteoporosis in female athletes, termed the female athlete triad (Beals & Meyer, 2007). They later developed a position paper on the female athlete triad, calling for more research (Beals & Meyer, 2007; Otis, Drinkwater, Johnson, et al., 1997). The new ACSM definition has now replaced disordered eating with low energy availability, amenorrhea with hormonal dysfunction and menstrual irregularities, and osteoporosis with poor bone metabolism and osteopenia which often presents as a stress fracture (Hoch et al., 2009; Otis et al., 1997). One study found that 78 % of high school female athletes had at least one component of the disorder. Only 1 of the 80 athletes had all three components (Hoch et al., 2009). Due to the relative high mortality that occurs in the most severe cases, the clinician should carry a high sense of suspicion when evaluating female athletes with any or all of the components.

Weight training in adolescents anecdotally is thought to be a concern due to the risk of growth disturbances and injuries. However, studies have shown little to no evidence that resistance training will negatively impact growth or maturation (Faigenbaum et al., 2009; Malina, 2006). Resistance training programs are safe overall with low incidence of injury. In one study of 354 middle school and high school football players, the injury rate was 0.082 injuries per person-year (Risser, Risser, & Preston, 1990). Lower back strain is the most prevalent injury in adolescents participating in weight training (Faigenbaum et al., 2009; Risser et al., 1990).

Supervision, good technique, and safe training equipment are important measures to prevent injuries in adolescents (Faigenbaum et al., 2009; Malina, 2006; Risser et al., 1990). Studies have shown that there is an increased risk of injury when home exercise equipment is used (Faigenbaum et al., 2009).

Targeting Prevention of Musculoskeletal Injuries in Adolescents

Motor vehicle accidents are the leading cause of death in adolescents in the United States, comprising 32 % of all deaths and 70 % of unintentional deaths (Sleet, Ballesteros, & Borse, 2010). Fatal injuries are more likely to occur when seat belts are not used, the driver has been drinking, or an inexperienced driver is driving other teenagers (Chen, Baker, Braver, & Li, 2000; Quinlan, Brewer, Sleet, & Dellinger, 2000; Sleet et al., 2010). Proper use of a seat belt could prevent around 40–60 % of motor vehicle deaths (Cummins, Koval, Cantu, & Spratt, 2008; Sleet et al., 2010). Unfortunately, adolescents are among the highest demographic of people who do not wear seat belts. In 2007, 11.1 % of high school students reported never wearing seat belts (Eaton et al., 2008; Jones & Shults, 2009; Sleet et al., 2010). Nonuse was more prevalent in males and African American students. The good news is that in addition to preventing mortality, seat belts prevent morbidity in motor vehicle accidents. Seat belt use results in a reduction in maxillofacial and lower extremity injuries (Cox et al., 2004). Restrained occupants had relative risks of 0.42, 0.28, 0.35, and 0.49 compared unrestrained occupants for maxillofacial, pelvis, femur, and tibia/fibula fractures, respectively (Cox et al., 2004; Estrada, Alonso, McGwin, Metzger, & Rue, 2004).

Adolescents are at increased risk for unhealthy behaviors. Alcohol is the most commonly used drugs among teenagers (Sleet et al., 2010). People aged 12–20 years old drink 11 % of all alcohol consumed in the United States, of which 90 % is ingested while binge drinking (Sleet et al., 2010). Binge drinking is described as men consuming five or more drinks and women consuming four or more drinks within 2 h. In 2007, 75 % of high school students reported they had consumed alcohol during their lifetimes, 10 % reported they had driven a vehicle under the influence of alcohol within the past 30 days, and 29 % of students reported they had ridden with a driver who had been drinking alcohol within the past 30 days (Eaton et al., 2008; Jones & Shults, 2009; Sleet et al., 2010).

Other unsafe behaviors can also lead to catastrophic injuries such as diving accidents. Diving was the fourth most common cause of spinal cord injuries in the United States (Barss, Djerrari, Leduc, Lepage, & Dionne, 2008). Of all spinal cord injuries that are a result of diving accidents, 60 % occur in people younger than 24 years of age (Barss et al., 2008; National Spinal Cord Injury Statistical Center, 2006). These incidents occur from diving into shallow water, resulting in a flexion–compression injury to the spine. This can occur in the setting of recreational activities in the pool or any natural body of water. The injury typically occurs at C5–7 due to the greater mobility of these segments (Brown, Brunn, & Garcia, 2001; Korres et al., 2006). Quadriplegia is the most common result of these injuries (Barss et al., 2008).

Safe practices and education are important to prevent musculoskeletal injuries. Only 37 % of those with spinal cord injuries after diving accidents were aware of the hazard (Barss et al., 2008). Another example is with bicycle helmets, which reduce head injuries. It has been reported that 85.1 % of high school students rarely or never wear them (Sleet et al., 2010). Males are more likely than females to not wear helmets (Eaton et al., 2008; Jones & Shults, 2009; Sleet et al., 2010). Peer pressure, negative modeling by family members, and community climate are the most common reason given for not wearing helmets (Kakefuda, Henry, & Stallones, 2009; Liller, Morissette, Noland, & McDermott, 1998; Sleet et al., 2010).

Musculoskeletal injuries also may occur in sports due to athletes incorrectly wearing safety equipment. One example is in ice hockey players. Lacerations to the anterior tibial and extensor tendons occur from players folding down their boot tongue for comfort reasons (Simonet & Sim, 1995). Instead of acting as protection, the tongue becomes an aiming device to glide an inadvertent ice skating blade into the unprotected anterior ankle. Other examples include proper helmet fitting, the use of mouth guards, appropriately fitting shin guards in soccer, and the use of eye protection in high-risk sports.

As further studies on injuries are produced, sports governing organizations continue to adjust rules to protect players. In 1976, the National Collegiate Athletic Association and the National Federation of State High School Associations implemented major rule changes in football prohibiting the use of the head as the initial contact point when blocking and tackling in response to several studies on cervical spine injuries (Rihn et al., 2009). In the 1980s and 1990s, ice hockey governing bodies began to implement rules against checking from behind after studies showed the increased incidence of cervical spine injuries (Tator, Provvidenza, & Cassidy, 2009; Watson, Singer, & Sproule, 1996).

Safe training practices can reduce injuries such as overuse injuries. Injuries can be minimized with qualified supervision, appropriate program design, sensible progression, and careful selection of training equipment (Faigenbaum et al., 2009). In addition, the risk of injury can be minimized by limiting the number of heavy lifts during a workout, allowing for adequate recovery between training sessions, and listening to each child's or adolescent's questions and concerns (Faigenbaum et al., 2009).

In order to provide safe supervision of adolescents, the coaches need to stay up to date on safe practices and innovations. Rules are constantly being updated to address injury concerns. For example, the NFL is constantly changing rules on kickoffs to reduce injuries. In 2009, the number of players allowed to form a blocking wedge was reduced to 2. In 2011, they moved the kickoff to the 35-yard line to decrease the number of high-impact collisions (NFL moves kickoffs to 35-yard line, touchbacks unchanged, 2011).

Coaches can be used as great instruments to teach proper technique and disseminate new information to players. In 2002, the equipment manufacturer Riddell developed a new helmet that has an extended shell onto the mandible area and a face-mask system that claims to dampen impacts (Krauss, 2004). Additionally, it has changes in interior padding to improve energy attenuation in side and posterior impacts. This new helmet is widespread in the NFL and NCAA but is slowly filtering down to the high school level (Krauss, 2004). The news of this helmet could be spread more quickly if coaches stay educated on new innovations on the market and inform their players.

Section 2: Adolescent Sports Injuries—Psychological Aspects

We have seen in the previous section the specifics of getting injured and recovering from injury in an adolescent population. In this section, we will address the psychological aspects of sports injuries in adolescents. Four major aspects will be covered: vulnerability to injuries, psychological reactions to athletic injury, injury recovery, and finally prevention of future injuries. The model used to describe and explain the connection between psychological variables and injury will be the Shaffer's (1997) adaptation of Wiese-Bjornstal, Smith, & LaMott (1995). Figure 1 displays the main elements of the model which were supported in Shaffer's research.

Vulnerability to Injuries

One of the main variables consistently associated with injury vulnerability is stress. Stress is commonly defined as the response occurring when the perceived demands from the environment or situation cannot be met with the perceived resources one has (Lazarus & Folkman, 1984). Another definition of stress that fits very well the injury situation is the following: psychological stress is a reaction to an environment where there is a threat of loss of resources, an actual loss of resources, or a lack of gain after an investment (Hobfoll, 1988). *Resources* can be physical health, finances, mobility/independence, self-perception, achievements, and social roles. This model of stress incorporates six dimensions which help explain why different things are stressful for different people and even why the same person at different point in time will react differently to the same stressor.

Besides the above-mentioned resources, *strain* is defined as the negative consequences of stressful events which can be physical or psychological. In the case of athletic injuries, both types of effects occur, increasing the level of strain. *Needs* is another dimension of the model that refers to the biological, emotional, and cognitive requirements of the individual, and these needs interact with specific environments (such as family expectations and level of sports participation) to generate the demands which are perceived as pressure. *Time* is the next dimension because events have different impact at different points in the developmental process. Adolescence is a time for establishing one's identity, and some events become central to that definition. These dimensions of resources, needs, strain, and time are also framed within the global dimension of *values*.

Values are seen as the main criteria one uses to evaluate oneself and the environment. The model

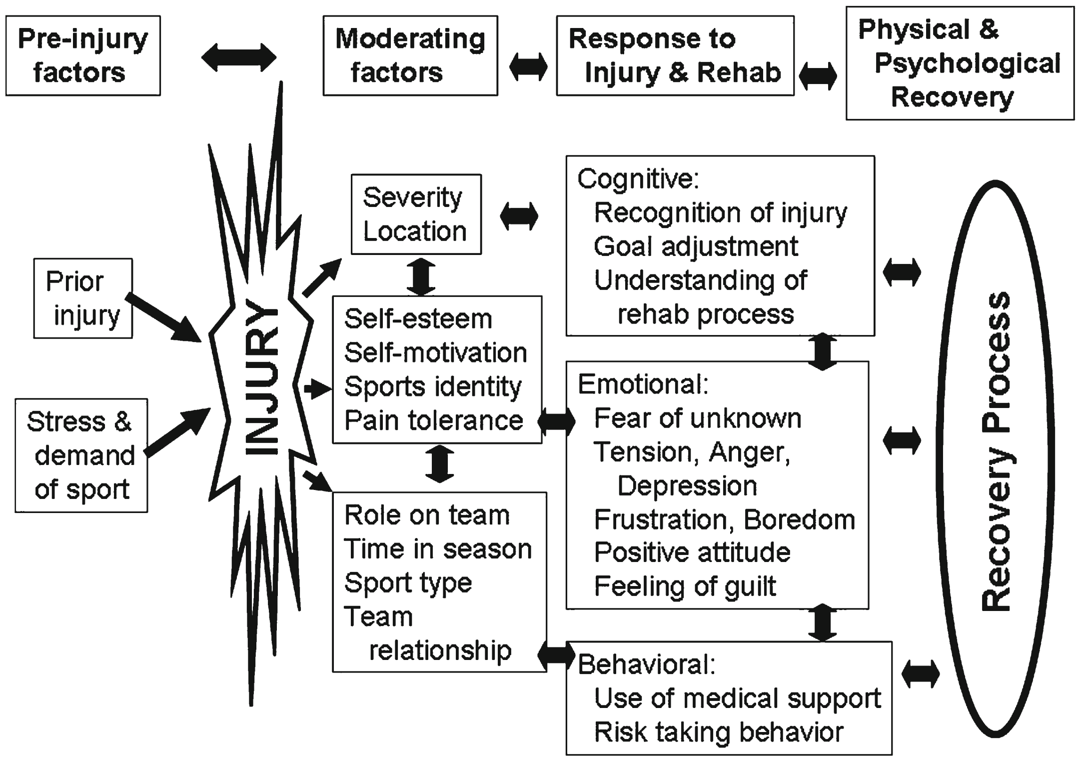

Fig. 1 Deductive analysis results supporting Wiese-Bjornstal et al.'s model

considers cultural and family values, personal values, and environmental constraints. We can agree that the value placed in athletic achievement has increased enormously in the last decades, and the specific values of the team or the family can significantly increase or decrease the stress level of an injured adolescent athlete. The final dimension of the model is *perception*, similar to what is described more commonly in the traditional stress literature. The difference here is that perception is just one of the dimensions, but it is tempered by actual events and objective environment situations. We can now look at the dimensions of the model in the context of vulnerability to injuries (Ford & Gordon, 1999).

Are There Some Athletes Who Are More at Risk of Athletic Injury than Others?

We can start with those who have been injured before and, therefore, are likely to worry more about reexperiencing the losses that accompany injury. This means that some of the cognitive resources are focused away from performance relevant cues, thus increasing the possibility of injury. Consistent with this are the results of Newcomer and Perna (2003), who found that athletes with a recent injury history exhibited a greater frequency of intrusive thoughts and avoidance behavior than did those without a recent injury history. The shift in attentional focus causes disruptions to the automaticity of the movement, changes in pace and rhythm, and even mechanical changes aimed at protecting the previously injured part, but that result in an inappropriate movement pattern. The same can be said of behaviors aimed at avoiding the conditions under which the original injury occurred, that is, a certain play or even competing, or running under specific weather conditions.

Are There Situational Factors that Can Place an Athlete at Risk of Injury?

Team culture that stresses that tolerating pain is not only acceptable but honorable and responding to it a weakness. Shaffer (1997) found that young wrestlers were willing to wrestle with pain and injury if they believed their coaches and/or parents would endorse that behavior and compliment them. The athletes' role on the team whether he is a starter or bench player may also play a role in injury risk. Evidence is mixed in this issue, with some studies showing that starters had higher levels of stress than nonstarters in a football study (Brewer, 2009), while some argue that players who come in from the bench are more likely to "try to prove themselves" and therefore at higher risk of injury. Finally, time in season may play a role (early versus postseason competition and championships). Early in the season, athletes may be forced through a period of double sessions and fitness training in large groups in which peer pressure pushes them beyond where the body would tell them to stop. Later in the season at what are considered "crucial" moments in the season, athletes are more willing to tolerate pain or to ignore warning signs of injury.

Can Individual Factors Play a Role in Predicting Risk of Injury?

Personal motivation and self-confidence clearly play a role in injury risk. There is likely to be an interaction between motivation, self-confidence, and climate of the team. In teams where there is a culture of "toughness," where paying attention to injury signs is considered a weakness, those athletes motivated by the approval of others and those athletes with lower levels of self-confidence are more likely to push themselves and put themselves at higher risk of injury.

Another factor related to injury is how much *being* an athlete is part of *who* the athlete defines they are. Athletic identity may be defined as the degree with which an individual identifies with the athlete role (Brewer, VanRaalte, & Linder, 1993). Vernau (2009) found that athletic identity significantly predicted injury both for males and females recreational basketball players. Griffith and Johnson (2002) found that athletic identity is independent of the level of sports performance, with Division III athletes showing levels of athletic identity as high as those of Division I players. The issue of athletic identity is complex. For those that felt it was a predominant part of who they were, they appeared to have a higher risk of injury; however, athletic identity also leads to a sense of social structure and support. To a limited degree, this may also have a protective effect based on the findings of Brewer (2009) that lack of social support is also one of the individual variables that seem to increase probability of athletic injury.

As we can see, the issue of vulnerability to injuries is a complex one, but integrating the concepts and results cited above, we can suggest the following Do's and Don'ts:

Decreasing vulnerability to injuries

The Do's	The Don'ts
Provide consistent support for the person, not just the athlete	Equate pain or injury with weakness and their tolerance with toughness
Encourage a broader identity	Reward results exclusively
Teach psychological skills, such as tension management, cognitive control, focusing and refocusing strategies	Expect the same from players of varied levels of skill or experience
Provide stress management tools	Ignore changes and pressures during the season

Recovering from Injury

Recovering from injury must extend beyond the physical and physiologic healing of the musculoskeletal injury but also include the whole athlete if the goal is to return them to full competitive play. This recovery will proceed through a series of expected phases and be dependent on the support network and social structure available to the individual athlete. Carrying on from the previous section, we will continue to show the typical responses that individuals experience during injury rehabilitation.

The First 24–48 h

In the 24–48 h following a moderately severe injury (defined as loss of play for 4–6 weeks), attention and help are often given to the individual, and there can be a period of enjoyment because of the assistance and attention received (Tracey, 2003). However, as distance grows from when the injury occurred, individuals experience a range of emotions that are heightened in intensity when the strength of their perceptions of their identity and self-worth are tied directly to their ability to perform. These emotions can range from despair, depression, anger, hostility, frustration, worry, and feeling sorry for oneself.

To mitigate the negative emotional affects that injury can cause. The key personnel involved in the adolescent's life following injury are critical to teaching and enabling them to return to play. At the time of the initial injury, the response of the medical staff is important because the child will read as much as they can from the first responders and who they perceive as the expert in the treatment to gain insight and confidence that the injury can be treated well. Secondly, the parental response is valuable because they can show caring for their child as a whole person without emphasizing the athletic identity to avoid heightening the negative influences of low self-esteem which is likely during injury rehabilitation and increases with long-term severe injuries that require months or longer periods of rehabilitation. Thirdly, coach and teammate responses are very important following an injury to show that the person is valuable to them whether they play or not. The last two points promote the concept that the child is more than a young athlete, they are a person that happens to play youth sports and treating them as more recognizes their whole self. These are positive attributes shown through social support.

Social Support

Social support has been found to be critical for injured athletes learning to cope, manage, and succeed through their injury experience. The sources of social support include medical staff, family, friends, coaches, teammates, and other injured athletes. The perception of the injured person determines the strength of the source of support. Which source means more? This depends on the value that person puts on that source, and it depends on the timing of the support, the manner in which it is shown and the consistency of its influence. This is a major source of self-efficacy and builds confidence through the rehabilitation process.

Tracey (2003) found that the sensory aspects of injury rehabilitation were very important to the growth of optimism and hope. Where movement was seen to improve, swelling and bruising reduced and pain felt to decrease. Positive thoughts and feelings increased and led to recommitment to adhering to the rehabilitation protocol which encouraged increased responsibility for self-care and self-management behaviors.

Educating

The individual should be informed, taught, and educated about their injury and how its optimal rehabilitation. Empowering the person by increasing self-awareness about the injury and instilling confidence by explaining the injury rehabilitation process has been found by Fisher, Domn, and Wuest (1988) and Duda, Smart, and Tappe (1989) to assist athletes tolerate pain and adhere better to rehabilitation protocols. This is important because the first hours of injury are critical to the emotional well-being of the person. When a rehabilitation plan is in place, this leads the use of psychological skills techniques outlined below that support the process and motivate adherence.

Psychological Skills Training

Goal setting has been shown to be influential on keeping energy and focus on adherence to treatment protocols (Evans & Hardy, 2002). Proximal short-term goals that concentrate effort on following the treatment protocol make the person more self-reliant especially when they are educated and trained to perform their own self-care.

Teaching young athletes visualization (imagery) skills and how to apply them to positive treatment and pain control outcomes has been found to be useful strategy to helping athletes cope and focus on the positive aspects of rehabilitation (Morris, Spittle, & Watt, 2005). Teaching imagery skills is linked directly with the sensory perceptions of athletes detailed above and helps to focus energy on productive thinking and future goals.

The following are our suggestions for more effective injury recovery:

The Do's of Injury Recovery

Educate and empower the child within the first 24–48 h after injury.

Promote consistent social support.

Emphasize the personally controllable aspects of the rehabilitation to the individual.

Plan the injury rehabilitation period: ensure that the individual feels in control of the plan.

Set return to proximal goals and monitor the rehabilitation plan.

Focus the possibilities child on future possibilities.

The Don'ts of Injury Recovery

Promote social isolation from family, teammates, and friends.

Emphasize the uncontrollable aspects.

Expect an adolescent to be completely responsible for their own rehabilitation.

Reinforce the loss of athletic performance.

The Psychological Approach to Injury Prevention and Supporting the Whole Young Athlete

Health professionals are encouraged to review the conceptual work and application of long-term athletic development (LTAD) pioneered by Istvan Balyi in Stafford (2005). The LTAD model has been accepted as an optimal way for children and adolescents to be trained in many countries with strong youth sports movements including Canada and the United Kingdom. The LTAD model has a strong science-based framework that concentrates parents, coaches, and medical professionals on the following aspects of child and adolescent growth and development:

Fundamental—basic movement literacy; emphasizes learning to move that include agility, balance, coordination, and speed. Girls 5–8, boys 6–9 years of age.

- Sports skills—building technique; focus on technical development for a given sport. Technical development is considered the primary concern of the child and adolescent. Girls 8–11, boys 9–12 years of age. Competition is still de-emphasized.
- Training to train—building the engine; boys and girls learn to condition themselves aerobically as their bodies manage aspects of physical, mental, and emotional growth and maturation. Competition is part of the environment, but training and improvement is the priority for participation. Girls 11–14, boys 12–15 years of age.
- Training to compete—optimizing the engine; youth sports participants focus on physical and technical conditioning and developing individual performance. The volume of training is high and the competition is low. Girls 14–16, boys 15–18 years of age.
- Training to win—maximizing the engine. This stage is about specializing performance for sport. Girls 16+, boys 18+ years of age.

The purpose of this model is to emphasize general sports preparation that develops into specialized sports performance as children develop. The benefits of this approach include but are not limited to the following:

- Increased enjoyment
- Reduced competitive stress and anxiety
- Fostered positive socialization in sport
- Improved technical ability
- Educated sports participants

These benefits mean that children are likely to be less vulnerable to injury when the focus is on personal growth and improvement and less on competition.

The Do's of Injury Prevention

- Educate the child about the demands and typical injuries associated with the sport.
- Promote personal improvement and growth.
- Encourage coaches and parents to ensure children are trained correctly.
- Emphasize effort goals over competitive goals.
- Refer parents to the best practices for injury prevention and conditioning provided by the National Strength and Conditioning Association and National Association of Athletic Trainers.

The Don'ts of Injury Prevention

- Emphasize competitive comparisons.
- Create unnecessary performance anxiety.
- Permit over training to go unchallenged.
- Use goals that the child has not control over.

In summary, this chapter has used a sports injury model in its approach to musculoskeletal injuries. This has allowed us to look at the incidence of musculoskeletal injuries in this age group, common musculoskeletal injuries in young athletes, as well as risk factors that place these young athletes at risk of injury. Perhaps, more importantly, the chapter has reviewed evidence-based injury prevention techniques regarding musculoskeletal injuries in youth sports. These interventions range from training techniques, early recognition and treatment of problems, and proper equipment, as well as proper coaching and parental feedback. The series of Do's and Don'ts guidelines on vulnerability to injury, injury recovery, and injury prevention can easily be extrapolated to musculoskeletal injuries in children who are not actively participating in sport but would benefit from a holistic approach to injury recovery and healing.

Acknowledgment Special acknowledgement to Neel Pancholi for his contributions to this chapter.

References

Section 1

American Academy of Pediatrics: Committee on Sports Medicine and Fitness. (2000). Injuries in youth soccer: A subjective review. *Pediatrics, 105*(3, pt1), 659–661.

Barss, P., Djerrari, H., Leduc, B. E., Lepage, Y., & Dionne, C. E. (2008). Risk factors and prevention for spinal cord injury from diving in swimming pools and natural sites in Quebec, Canada: A 44-year study. *Accident Analysis and Prevention, 40*(2), 787–797.

Beals, K. A., & Meyer, N. L. (2007). Female athlete triad update. *Clinics in Sports Medicine, 26*(1), 69–89.

Bedi, A., & Ryu, R. K. (2009). The treatment of primary anterior shoulder dislocations. *Instructional Course Lectures, 58*, 293–304.

Benjamin, H. J., & Briner, W. W., Jr. (2005). Little league elbow. *Clinical Journal of Sport Medicine, 15*(1), 37–40.

Bijur, P. E., Trumble, A., Harel, Y., Overpeck, M. D., Jones, D., & Scheidt, P. C. (1995). Sports and recreation injuries in US children and adolescents. *Archives of Pediatrics & Adolescent Medicine, 149*(9), 1009–1016.

Bishop, J. Y., & Flatow, E. L. (2005). Pediatric shoulder trauma. *Clinical Orthopaedics and Related Research, 423*, 41–48.

Brown, R. L., Brunn, M. A., & Garcia, V. F. (2001). Cervical spine injuries in children: A review of 103 patients treated consecutively at a level 1 pediatric trauma center. *Journal of Pediatric Surgery, 36*(8), 1107–1114.

Caine, D. J., & Nassar, L. (2005). Gymnastics injuries. *Medicine and Sport Science, 48*, 18–58.

Chen, L. H., Baker, S. P., Braver, E. R., & Li, G. (2000). Carrying passengers as a risk factor for crashes fatal to 16- and 17-year-old drivers. *Journal of the American Medical Association, 283*(12), 1578–1582.

Chen, F. S., Diaz, V. A., Loebenberg, M., & Rosen, J. E. (2005). Shoulder and elbow injuries in the skeletally immature athlete. *The Journal of the American Academy of Orthopaedic Surgeons, 13*, 172–185.

Cox, D., Vincent, D. G., McGwin, G., MacLennan, P. A., Holmes, J. D., & Rue, L. W., 3rd. (2004). Effect of restraint systems on maxillofacial injury in frontal motor vehicle collisions. *Journal of Oral and Maxillofacial Surgery, 62*(5), 571–575.

Cummins, J. S., Koval, K. J., Cantu, R. V., & Spratt, K. F. (2008). Risk of injury associated with the use of seat belts and air bags in motor vehicle crashes. *Bulletin of the NYU Hospital for Joint Diseases, 66*(4), 290–296.

Deitch, J., Mehlman, C. T., Foad, S. L., Obbehat, A., & Mallory, M. (2003). Traumatic anterior shoulder dislocation in adolescents. *The American Journal of Sports Medicine, 31*(5), 758–763.

Dixon, S., Newton, J., & Teh, J. (2011). Stress fractures in the young athlete: A pictorial review. *Current Problems in Diagnostic Radiology, 40*(1), 29–44.

Eaton, D. K., Kann, L., Kinchen, S., Shanklin, S., Ross, J., et al. (2008). Youth risk behavior surveillance—United States, 2007. *Morbidity and Mortality Weekly Report. Surveillance Summaries, 57*(4), 1–131.

Estrada, L. S., Alonso, J. E., McGwin, G., Jr., Metzger, J., & Rue, L. W., 3rd. (2004). Restraint use and lower extremity fractures in frontal motor vehicle collisions. *The Journal of Trauma, 57*(2), 323–328.

Faigenbaum, A. D., Kraemer, W. J., Blimkie, C. J., Jeffreys, I., Micheli, L. J., Nitka, M., et al. (2009). Youth resistance training: Updated position statement paper from the national strength and conditioning association. *Journal of Strength and Conditioning Research, 23*(5 Suppl), S60–S79.

Fithian, D. C., Paxton, E. W., Stone, M. L., et al. (2004). Epidemiology and natural history of acute patellar dislocation. *The American Journal of Sports Medicine, 32*(5), 1114–1121.

Graf, B. K., Lange, R. H., Fujisaki, C. K., Landry, G. L., & Saluja, R. K. (1992). Anterior cruciate ligament tears in skeletally immature patients: Meniscal pathology at presentation and after attempted conservative treatment. *Arthroscopy, 8*(2), 229–233.

Harrast, M. A., & Colonno, D. (2010). Stress fractures in runners. *Clinics in Sports Medicine, 29*(3), 399–416.

Hinton, R. Y., & Sharma, K. M. (2003). Acute and recurrent patellar instability in the young athlete. *The Orthopedic Clinics of North America, 34*(3), 385–396.

Hoch, A. Z., Pajewski, N. M., Moraski, L., Carrera, G. F., Wilson, C. R., Hoffmann, R. G., et al. (2009). Prevalence of the female athlete triad in high school athletes and sedentary students. *Clinical Journal of Sport Medicine, 19*(5), 421–428.

Jones, S. E., & Shults, R. A. (2009). Trends and subgroup differences in transportation-related injury risk and safety behaviors among US high school students, 1991–2007. *The Journal of School Health, 79*, 169–176.

Kakefuda, I., Henry, K. L., & Stallones, L. (2009). Associations between childhood bicycle helmet use, current use, and family and community factors among college students. *Family & Community Health, 32*(2), 159–166.

Kocher, M. S., Micheli, L. J., Gerbino, P., & Hresko, M. T. (2003). Tibial eminence fractures in children: Prevalence of meniscal entrapment. *The American Journal of Sports Medicine, 31*(3), 404–407.

Kocher, M. S., Saxon, H. S., Hovis, W. D., & Hawkins, R. J. (2002). Management and complications of anterior cruciate ligament injuries in skeletally immature patients: Survey of Herodicus Society and The ACL Study Group. *Journal of Pediatric Orthopedics, 22*(4), 452–457.

Kocher, M. S., Smith, J. T., Zoric, B. J., Lee, B., & Micheli, L. J. (2007). Transphyseal anterior cruciate ligament reconstruction in skeletally immature pubescent adolescents. *The Journal of Bone and Joint Surgery. American Volume, 89*(12), 2632–2639.

Korres, D. S., Benetos, I. S., Themistocleous, G. S., Mavrogenis, A. F., Nikolakakos, L., & Liantis, P. T. (2006). Diving injuries of the cervical spine in amateur divers. *The Spine Journal, 6*(1), 44–49.

Krauss, M. D. (2004). Equipment innovations and rules changes in sports. *Current Sports Medicine Reports, 3*(5), 27.

Liller, K. D., Morissette, B., Noland, V., & McDermott, R. J. (1998). Middle school students and bicycle helmet use: Knowledge, attitudes, beliefs, and behaviors. *The Journal of School Health, 68*, 325–338.

Malina, R. M. (2006). Weight training in youth-growth, maturation, and safety: An evidence-based review. *Clinical Journal of Sport Medicine, 16*(6), 478–487.

McCarroll, J. R., Shelbourne, K. D., Porter, D. A., Rettig, A. C., & Murray, S. (1994). Patellar tendon graft reconstruction for mid-substance anterior cruciate ligament rupture in junior high school athletes: An algorithm for management. *The American Journal of Sports Medicine, 22*(4), 478–484.

McMahon, P., Grossman, W., Gaffney, M., & Stanitski, C. (1995). Soft-tissue injury as an indication of child abuse. *The Journal of Bone and Joint Surgery. American Volume, 77*, 1179–1183.

Meyers, M. H., & McKeever, F. M. (1987). Fractures of the intercondylar eminence of the tibia. *The Journal of Bone and Joint Surgery. American Volume, 52*(8), 1677–1684.

Monto, R. R., Cameron-Donaldson, M. L., Close, M. A., Ho, C. P., & Hawkins, R. J. (2006). Magnetic resonance imaging in the evaluation of tibial eminence fractures in adults. *The Journal of Knee Surgery, 19*(3), 187–190.

National Spinal Cord Injury Statistical Center. (2006). *Facts and figures at a glance*. Birmingham: University of Alabama.

NFL moves kickoffs to 35-yard line; touchbacks unchanged. (2011) NFL.com. 2011-03-22. Retrieved May 23, 2011. http://www.nfl.com/news/story/09000d5d81ee38c1/article/.

Otis, C. L., Drinkwater, B., Johnson, M., et al. (1997). American college of sports medicine position stand: The female athlete triad: Disordered eating, amenorrhea, and osteoporosis. *Medicine and Science in Sports and Exercise, 29*(5), i–ix.

Palmu, S., Kallio, P. E., Donell, S. T., Helenius, I., & Nietosvaara, Y. (2008). Acute patellar dislocation in children and adolescents: A randomized clinical trial. *The Journal of Bone and Joint Surgery. American Volume, 90*(3), 463–470.

Quinlan, K. P., Brewer, R. D., Sleet, D. A., & Dellinger, A. M. (2000). Characteristics of child passenger deaths and injuries involving drinking drivers. *Journal of the American Medical Association, 283*(17), 2249–2252.

Rihn, J. A., Anderson, D. T., Lamb, K., Deluca, P. F., Bata, A., Marchetto, P. A., et al. (2009). Cervical spine injuries in American football. *Sports Medicine, 39*(9), 697–708.

Risser, W. L., Risser, J. M. H., & Preston, D. (1990). Weight-training injuries in adolescents. *American Journal of Diseases of Children, 144*(9), 1015–1017.

Rowe, C. R. (1956). Prognosis in dislocations of the shoulder. *The Journal of Bone and Joint Surgery. American Volume, 38*(5), 957–977.

Shea, K. G., Pfeiffer, R., Wang, J. H., Curtin, M., & Apel, P. J. (2004). Anterior cruciate ligament injury in pediatric and adolescent soccer players: An analysis of insurance data. *Journal of Pediatric Orthopedics, 24*(6), 623–628.

Simonet, W. T., & Sim, L. (1995). Boot-top tendon lacerations in ice hockey. *The Journal of Trauma, 38*(1), 30–31.

Sink, E. L., Hyman, J. E., Matheny, T., Georgopoulos, G., & Kleinman, P. (2011). Child abuse: The role of the orthopaedic surgeon in nonaccidental trauma. *Clinical Orthopaedics and Related Research, 469*(3), 790–797.

Sleet, D. A., Ballesteros, M. F., & Borse, N. N. (2010). A review of unintentional injuries in adolescents. *Annual Review of Public Health, 31*, 195–212.

Tator, C. H., Provvidenza, C., & Cassidy, J. D. (2009). Spinal injuries in Canadian ice hockey: An update to 2005. *Clinical Journal of Sport Medicine, 19*(6), 451–456.

Washington, R. L., Bernhardt, D. T., Gomez, J., et al. (2001). Organized sports for children and preadolescents. *Pediatrics, 107*, 1459–1462.

Watson, R. C., Singer, C. D., & Sproule, J. R. (1996). Checking from behind in ice hockey: A study of injury and penalty data in the Ontario University Athletic Association Hockey League. *Clinical Journal of Sport Medicine, 6*(2), 108–111.

Section 2

Brewer, B. W. (2009). *Sport psychology*. Oxford, UK: Wiley-Blackwell. doi:10.1002/9781444303650.

Brewer, B. W., VanRaalte, J. L., & Linder, D. E. (1993). Athletic identity: Hercules' muscles or Achilles heel? *International Journal of Sport Psychology, 24*, 237–254.

Duda, J., Smart, A., & Tappe, M. (1989). Predictors of adherence in the rehabilitation of athletic injuries: An application of personal investment theory. *Journal of Sport & Exercise Psychology, 11*, 367–381.

Evans, L. & Hardy, L. (2002). Injury rehabilitation: A goal setting intervention study. *Research Quarterly for Exercise and Sport, 73*(3), 310–319.

Fisher, A., Domn, M., & Wuest, D. (1988). Adherence to sports-injury rehabilitation programs. *The Physician and Sportsmedicine, 16*, 47–52.

Ford, U., & Gordon, S. (1999). Coping with sport injury: Resource loss and the role of social support. *Journal of Personal and Interpersonal Loss, 4*(3), 243–256.

Griffith, K., Johnson, C. (2002). Athletic identity and life roles of Division I and Division III collegiate athletes. *Journal of Undergraduate Research*, University of Wisconsin-La Crosse. Digital journal, http://murphylibrary.uwlax.edu/digital/jur/2002/griffith-johnson.pdf.

Hobfoll, S. E. (1988). *The ecology of stress*. Washington, D.C: Hemisphere.

Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal and coping*. New York, NY: Springer.

Morris, T., Spittle, M., & Watt, A. (2005). *Imagery in sport*. Champaign, IL: Human Kinetics Publishers.

Newcomer, R. R., & Perna, F. M. (2003). Features of posttraumatic distress among adolescent athletes. *Journal of Athletic Training, 8*(2), 163–166.

Shaffer, S. M. (1997). *Grappling with injury: What motivates young athletes to wrestle with pain*? ProQuest Information & Learning.

Stafford, I. (2005). *Coaching for long-term athlete development: To improve participation and performance in sport*. Leeds, England: Sports Coach UK.

Tracey, J. (2003). The emotional response to the injury and rehabilitation process. *Journal of Applied Sport Psychology, 15*, 279–293.

Vernau, D. P. (2009). *Gender, athletic identity, and playing through pain and injury in recreational basketball players.* Unpublished Doctoral Dissertation. Miami University.

Wiese-Bjornstal, D. M., Smith, A. M., LaMott, E. E. (1995). A model of psychological response to athletic injury and rehabilitation. *Athletic Training: Sports Health Care Perspectives*, *1*(1), 17–30. Retrieved, from https://www.sportcentric.com/vsite/vfile/page/fileurl/0,11040,5157-184732-201954-124688-0-file,00.pdf, Amateur Swimming Association Technical Swimming Committee (2004).