# Sports Medicine for Pediatric and Adolescent Athletes

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INTRODUCTION

Sports medicine is the clinical discipline involving the sciences of exercise and sports that concerns both athletic performance and care of injury. The American College of Sports Medicine defines sports medicine as a multidisciplinary field dealing with the physiologic, biomechanical, psychological, and pathologic variables associated with exercise and sports.

Annually, 25 million scholastic athletes and 20 million community-based pediatric and adolescent athletes participate in organized sports in the United States; with this high volume of activity, sports participation carries an inherent risk for injury. In an 8-year longitudinal study of high school sports, researchers reported that 48% of athletes sustained at least 1 injury per season, with 35% incurring an injury resulting in at least 1 day of activity lost. Although most sports injuries (80%) sustained by pediatric and adolescent athletes involve the musculoskeletal system, the majority of injuries are relatively benign and easily treated with conservative measures (eg, protection, rest, elevation, compression). In contrast, sports injuries involving the central nervous system, although rare, have a major impact on the affected athlete and are some of the most catastrophic athletic injuries seen, causing 70% of traumatic deaths and 20% of permanent disability related to sports. These statistics underscore the importance of injury prevention programs and education. Specifically, the preparticipation physical evaluation (PPE) is a major clinical tool used by physicians to ensure the safety and maintain the health of pediatric and adolescent athletes in training and competition.
This manual will explore the topic of sports medicine, focusing on issues that are particularly relevant for pediatric and adolescent athletes. It will discuss in some detail the various elements of the PPE, underscoring what the physician should try to rule out or detect. Additionally, the manual will examine the most common sports injuries sustained by pediatric and adolescent athletes; the symptoms, signs, diagnosis, and treatment of such injuries will be considered.

PREPARTICIPATION PHYSICAL EVALUATION

GENERAL CONSIDERATIONS

The PPE has been an integral part of competitive sports, especially in pediatric and adolescent competitive sports, for decades. Its primary purpose is not to disqualify athletes with life-threatening conditions but to ensure that athletes of all ages and skill levels are able to compete in their sport of choice safely, with minimal risk of injury. Disqualification is a choice of last resort. In adolescents, the PPE often establishes primary care for athletes who may not see a physician regularly; the evaluation thus provides those adolescents with an opportunity to talk to a physician about sports-related or developmental issues and provides physicians with the opportunity to identify any health risks inherent in a particular sport.

The most recently revised joint publication prepared by the Preparticipation Physical Evaluation Task Force—whose membership includes representatives from the American Academy of Family Physicians, the American Academy of Pediatrics, the American Medical Society for Sports Medicine, the American Orthopaedic Society for Sports Medicine, and the American Osteopathic Academy of Sports Medicine—provides an excellent outline for primary care physicians regarding appropriate steps in the PPE.

MEDICAL HISTORY

Obtaining a thorough medical history is the most critical step in the PPE. Numerous studies have documented that approximately 70% of potential problems noted during PPEs are discovered by history alone. Consequently, the student athlete and parent(s) should complete comprehensive history forms prior to the evaluation. Information obtained from athletes and their parents is often quite different. One study reported that only 19.8% of histories were in complete agreement, differing significantly (59%) in information regarding cardiovascular and musculoskeletal issues.

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The screening medical history should focus on obtaining information on past hospitalizations, previous surgeries, current medications, use of nutritional supplements, medical and family history, and a complete review of systems to identify medical and musculoskeletal conditions that could make sports participation unsafe for an athlete. Proper documentation of medications and nutritional supplements taken by the athlete is important for several reasons. First of all, it can offer insight into the presence, severity, and control of chronic disorders (eg, diabetes mellitus, asthma, seizures, hyperlipidemia). A thorough medical and nutritional history also allows for the identification of nonprescription medications athletes may be taking.
such as decongestants and potentially dangerous ergogenic substances (eg, anabolic steroids, human growth hormone [both of which have been linked to arrhythmias]).11,12 In the evaluation of adolescent athletes’ cardiovascular system, physicians should try to identify during their history taking those athletes at risk for sudden cardiac death. Each academic year, approximately 1 per 200,000 high school athletes will experience sudden cardiac death.13 A variety of unsuspected congenital cardiovascular diseases are usually responsible for this event. The most common disorders identified thus far are hypertrophic cardiomyopathy and congenital coronary artery anomalies.9,12–15 Because of heightened concern about sudden death in competitive athletes, the American Heart Association consensus panel in 1996 recommended obtaining a complete personal and family history and performing a thorough physical examination to identify cardiovascular disorders known to cause sudden cardiac death or disease progression in young athletes (Table 2).14 Evidence suggests, however, that the present screening process used by many US colleges and universities omits more than 40% of relevant items when obtaining a cardiovascular history, including familial heart disease and a personal history of exertional chest pain, dyspnea, or fatigue.16 In the past, athletic trainers and nurses in sports medicine conducted preparticipation evaluations. However, given the potentially disastrous consequences of an inadequately performed evaluation, the only appropriate personnel to conduct these evaluations are trained primary care providers.

With the increased incidence of eating disorders in adolescents, the strict diet and weight restrictions adhered to by wrestlers are of concern, as is their potential use of anabolic steroids for weight gain. Therefore, the PPE is an optimal time to inquire about body image, perceived ideal weight, and recent weight changes. Female athletes should be screened for amenorrhea during the medical history portion of the PPE. Primary amenorrhea (ie, absence of menses at age 16 years [or older]) or secondary amenorrhea (absence of menses for more than 3 cycles) should prompt further consideration of the female athlete triad (ie, anorexia, amenorrhea, osteoporosis).8,11,12,17 Any athlete with a prior history of heat-related illness (eg, cramping, syncope, exhaustion, heat stroke) or any unconditioned young athlete is at risk for heat-related illness. Recognition of these athletes is vital so that team trainers can ensure aggressive hydration before, during, and after practice or competitive events.8

### PHYSICAL EXAMINATION

### General Considerations

The physical examination should serve both as a follow-up to concerns raised in the history taking part of the evaluation and as a screening test for any medical condition that might limit safe participation in sports. In general, the PPE should de-emphasize aspects of the physical examination that do not influence whether an athlete can compete in a particular sport.6,18

The medical examination should begin with a determination of vital signs (ie, height, weight, blood pressure, heart rate, pulse, respiratory rate). Blood pressure in the adolescent patient is an important marker for detecting underlying, silent pathology. If the initial value is elevated, 2 subsequent readings should be obtained before diagnosing hypertension.18 Severe hypertension requires exclusion from sports participation until blood

### Table 2. AHA Recommendations for the PPE

#### Cardiovascular history
Inquire about and seek parental verification of a:
- Family history of premature death (sudden or otherwise)
- Family history of heart disease in surviving relatives, significant disability from cardiovascular disease in close relatives younger than 50 years, or specific knowledge of the occurrence of cardiac conditions (eg, hypertrophic cardiomyopathy, long QT syndrome, Marfan syndrome, clinically relevant arrhythmias) in relatives
- Personal history of heart murmur
- Personal history of systemic hypertension
- Personal history of excessive fatigability
- Personal history of syncope, excessive/progressive shortness of breath (dyspnea), or chest pain/discomfort (particularly with exertion)

#### Physical examination
Perform precordial auscultation with the patient in supine and standing positions to identify heart murmurs consistent with dynamic left ventricular outflow obstruction.
Assess femoral artery pulses to exclude coarctation of the aorta.
Inspect for physical stigmata of Marfan syndrome.
Assess brachial artery blood pressure with the patient in the sitting position.

AHA = American Heart Association; PPE = preparticipation physical evaluation.
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pressure is better controlled; for patients younger than 30 years, the physician must consider a secondary cause of hypertension. Athletes with less-than-severe hypertension who have no end-organ damage or heart disease generally have no restrictions placed on them regarding the physical activities in which they engage.

Once vital signs are obtained, the general medical examination should focus on athletes’ sports-readiness. General markers affecting overall health should be noted, particularly excessive thinness or obesity and phenotypic manifestations of multisystem illnesses. Of the remaining specific areas of the physical examination, the cardiovascular and musculoskeletal examinations are perhaps most important and thus should receive the greatest attention in relation to sports participation.

**Cardiovascular Examination**

The cardiovascular examination should include the following components: (1) precordial auscultation with the athlete in both the supine and standing positions to identify heart murmurs consistent with dynamic left ventricular outflow obstruction; (2) assessment of the femoral artery pulses to exclude coarctation of the aorta; (3) inspection for the physical stigmata of Marfan syndrome; and (4) brachial blood pressure measurement with the athlete in the sitting position (Table 2).

Heart murmurs are common in adolescents, but any systolic murmur of grade 3/6 in severity (or higher), any diastolic murmur, and any murmur that becomes louder on performance of Valsalva’s maneuver is a signal of a potential, serious underlying cardiovascular problem that requires referral to a cardiovascular specialist. Although the murmur of hypertrophic cardiomyopathy can sometimes sound like a normal murmur, it is often more intense when the athlete is in the standing than in the supine position.

**Musculoskeletal Examination**

A general musculoskeletal screening examination can be performed quickly and safely in all athletes to assess joint range of motion, strength, and symmetry. History alone has been shown to be 92% sensitive for detecting significant musculoskeletal problems. The 2-minute orthopaedic examination entails inspection, observation of range of motion, and testing of strength and stability of the major joints.

**Examination of Other Systems**

Visual acuity needs to be assessed, because adolescents with visual acuity less than 20/40 in either eye must be referred for further evaluation; they are not excluded from participation in sports unless visual acuity is so severely impaired that it interferes with depth perception. The pupils should be examined to detect anisocoria. If a marked difference in pupil size is noted in otherwise normal eyes, it should be documented in case of future head injury.

A general evaluation of the oral cavity, ear canal, and tympanic membranes can show possible signs of eating disorders (eg, oral ulcers, gingival atrophy, decreased enamel) and of smokeless tobacco use (eg, leukoplakia) and can also indicate the need for possible sport-specific precautions (eg, if a ruptured tympanic membrane is detected in a swimmer).

Auscultation of the lungs should be performed in order to confirm clear breath sounds bilaterally. However, normal results on this examination do not exclude exercise-induced asthma. Once again, obtaining a thorough history can be the most helpful screening tool in excluding this disorder. In addition to asking questions concerning a history of exercise-induced asthma, physicians can use exercise-challenge testing to detect evidence of the condition; most athletes do not have significant pulmonary pathology, and asthmatic conditions tend to be present only during strenuous exercise.

All athletes should have the skin of their thorax, back, face, and extremities examined for any evidence of infectious lesions or dermatosis. Athletes who participate in contact sports or swimming should be disqualified from participation if impetigo, furunculosis, or herpes gladiatorum is diagnosed. Once these treatable conditions resolve, sports medicine clearance should follow.

The abdomen should be palpated to detect any masses or splenomegaly, especially if the athlete has recently had mononucleosis or abdominal trauma; this step can help prevent splenic rupture, especially in contact sports. Patients who have undergone any recent abdominal surgery should not be allowed to participate in competitive sports until they are cleared to participate by the surgeon who performed the procedure. Examination to detect any hernias is appropriate, especially in soccer players. Finally, testicular protection should be encouraged in appropriate sports (eg, football, hockey).

A more thorough neurologic examination, beyond that obtained through other components of the physical examination, is usually reserved for athletes with a significant neurologic history (eg, recurrent head injury; neuropraxia, seizures).

**LABORATORY SCREENING**

Laboratory screening during a routine PPE is no
overuse. Moreover, more time is lost from sports activities, and 30% to 50% of all injuries in adolescents result from microtrauma and adolescent populations, overuse injuries are far more common than acute injuries. It is estimated that overuse injuries (or insidious type) make up 25% of recommendations for follow-up examination.

To understand pediatric and adolescent sports injuries, one must first understand the growing musculoskeletal system. Compared with their adult counterparts, children who are athletes have an additional risk for injury because of the vulnerable growth cartilage at the epiphyseal plate, joint surfaces, and sites of major muscle tendon insertions (apophysis). In general, children, ligaments are stronger than bone, and both ligaments and bone are relatively stronger (and considerably more elastic) than the epiphyseal plate. With severe trauma, the epiphyseal plate gives way. Consequently, growth plate damage is more common than ligamentous injuries in this age group.

Discussion of sports injuries—whether occurring in adolescents or adults—is made easier by categorizing injuries into 2 main types. The first type, acute traumatic injury (or macrotrauma), results from a single event. This category of injury usually involves the immediate onset of pain, often accompanied by deformity and impaired function (depending on the severity of the trauma). The second major category of sports injury is the chronic, overuse type (or microtrauma); its onset is most often insidious and results from repetitive stress. In pediatric and adolescent populations, overuse injuries are far more common than acute injuries. It is estimated that 30% to 50% of all injuries in adolescents result from overuse. Moreover, more time is lost from sports activity because of overuse injuries than acute trauma.

However they are categorized, pediatric and adolescent sport injuries most commonly involve the knee and the ankle. In a study of athletes participating in interscholastic sports, the knee and the ankle were the most frequently injured anatomic areas for both boys and girls, although the order of the 10 most often injured anatomic sites varied between the sexes.

### COMMON KNEE INJURIES

#### General Considerations

The knee is among the most common sites of serious injury in pediatric and adolescent sports. Because knee injuries can have a significant effect on the long-term function of the knee as a child progresses from adolescence to adulthood, making a correct diagnosis and proceeding with appropriate treatment is essential.

**Patellofemoral Pain Syndrome**

The most common cause of chronic anterior knee pain in children is patellofemoral pain syndrome (PPS). This condition occurs far more commonly in active athletes than in nonathletes. This syndrome is particularly common in female athletes and in those participating in sports that involve a great deal of running (eg, track and field, soccer). The cause of this disorder is controversial, with some authors attributing it to articular damage of the patella (ie, chondromalacia patella) and others to nerve injury in the lateral patellar retinaculum.

Warning signs of PPS include persistent pain, recurrent effusions, and jerky and painful patellar motion. The acute or gradual onset of poorly localized, unilateral or bilateral anterior knee pain—usually preceded by a recent increase in physical activity—is most typical of PPS. The pain classically is exacerbated after sitting for prolonged periods (known as the theater sign), ascending or descending stairs, and squatting for prolonged periods. Generally, the pain has been present for a few weeks at the time of presentation.

Physical examination typically reveals anterior knee pain on isometric contracture of the quadriceps and pain on direct posterior compression of the patellofemoral joint, with peripatellar soft-tissue tenderness and weakness/atrophy of the vastus medius obliquus muscle. Radiographs are indicated only if there is joint effusion, limited range of motion, or persistent pain despite adequate treatment. If radiographs are obtained, they should include anteroposterior, lateral, and tangential (ie, Merchant’s or sunrise) views. The differential diagnosis of PPS includes a meniscal tear (with or without locking) involving joint line tenderness, patellar malalignment (ie, clinical and radiographic...
malalignment), patellar tendinitis (jumper’s knee, inferior pole tenderness) involving local tenderness at the patellar tendon, and quadriceps tendinitis (ie, local tenderness at the insertion site on the superior pole of the patella).26

Adequate treatment of PPS generally includes rest, application of ice, administration of nonsteroidal anti-inflammatory drugs, use of knee sleeves with patella cutouts, and physical therapy focusing on quadriceps strengthening (without irritating the patellofemoral joint) and hamstring stretching. Sports activities that might aggravate the injury (eg, open-chain knee extensions, full squats, full lunges) should be avoided.21,27

Osgood-Schlatter Disease

Osgood-Schlatter disease is a traction apophysitis affecting the insertion of the patellar tendon over the tibial tuberosity. The immature (ie, adolescent) patellar tendon–tibial tubercle junction is highly susceptible to repetitive microinjury, usually from excessive jumping, kneeling, or squatting, which can lead to minor avulsions at the site and a subsequent inflammatory reaction. Osgood-Schlatter disease occurs in adolescents active in sports during a period of rapid growth; the average age of onset is 13 years.22,23

Symptoms of Osgood-Schlatter disease include unilateral (in 80% of cases) knee pain with swelling around the tibial tuberosity (although knee pain that is not directly over the tibial tubercle also occurs). Jumping, squatting, and kneeling after a period of rest to relieve this symptom actually aggravates pain.12 Physical examination typically reveals localized tenderness and sometimes swelling over the tibial tubercle. Radiographs are usually not indicated; however, if there is severe anterior knee pain with more swelling than expected, films should be obtained to rule out infection or tumor.24 The differential diagnosis of Osgood-Schlatter disease includes infection (a rare condition characterized by an elevated erythrocyte sedimentation rate) and neoplasm (also rare and usually unilateral).24

The first step in management of Osgood-Schlatter disease is to educate the patient (and parents) about the usual time course of the disease (ie, 12 to 24 months to resolution of symptoms). Specific therapy to relieve pain includes maintenance of knee motion, ice massage, use of a knee pad (or pads, in rare cases of bilateral knee pain), avoidance of excessive squatting or jumping, and balancing activity with symptoms.22,23

Sinding-Larsen-Johansson Disease

Sinding-Larsen-Johansson disease is a traction apophysitis resulting from repetitive microinjury at the proximal patellar tendon–distal patella junction. This condition commonly appears in athletes age 10 to 13 years. The chief symptom of this disorder is knee pain with swelling at the inferior pole of the patella that is aggravated by jumping, squatting, or kneeling and is relieved by a period of rest.

Physical examination usually reveals tenderness at the inferior pole of the patella, with mild tightness of the quadriceps tendon. Radiographs are usually unnecessary, unless there is severe anterior knee pain with more swelling than expected; in this case, films should be obtained to rule out infection or tumor.24 Plain radiographs typically show elongation or fragmentation (or both) of the nonarticular distal patellar pole. The differential diagnosis and management of Sinding-Larsen-Johansson disease is generally the same as the differential diagnosis and management of Osgood-Schlatter disease.

COMMON ANKLE INJURIES

Sever’s Disease

Sever’s disease, also known as calcaneal epiphysitis, is a traction apophysitis of the posterior aspect of the calcaneus caused by excessive tightness of the calf muscles and plantar fascia. This disorder is common in field sports (particularly soccer) and in basketball and gymnastics. Involvement is frequently bilateral. Sever’s disease is among the most common causes of foot pain in young children and adolescents, occurring most often in children age 10 to 14 years.22,24

Symptoms are systemic and include the insidious onset of chronic, aching heel pain that is aggravated by running, especially during deceleration. Findings on physical examination include exquisite tenderness localized over the posterior aspect of the calcaneus (ie, at the Achilles tendon insertion), with occasional tightness of the heel cord and relative weakness of the ankle dorsiflexors. When there is bilateral involvement and a typical history, radiographs are generally unnecessary. However, when there is only unilateral involvement, a plain radiograph is recommended to rule out a unicameral bone cyst or tumors.25 The differential diagnosis includes Achilles tendinitis (also associated with Reiter’s syndrome or other seronegative spondyloarthropathies), infection (usually unilateral and suggested by an elevated erythrocyte sedimentation rate), and neoplasm (usually unilateral).25

The first step in management of Sever’s disease should be to inform the athlete and parents that symptoms generally resolve in 12 to 18 months. Recommended physical therapy for affected patients includes flexibility exercises to improve ankle dorsiflexion and strengthening exercises for the ankle dorsiflexors. Elevation of the heel with an
in-shoe pad is also recommended, as is the use of proper footwear that is flexible and cushioned. Ice massage and administration of anti-inflammatory drugs should be used as required.2

**Ankle Sprain**

An ankle sprain is characterized by torn lateral collateral ligaments of the ankle, caused by inversion or rolling in of the plantar-flexed ankle. The anterior talofibular ligament is injured first; the calcaneofibular ligament becomes involved as more displacement occurs. The posterior talofibular ligament usually is not injured, except in cases of severe or chronic laxity.27 Epidemiologic studies indicate that ankle sprains occur with the highest frequency in athletes age 15 to 35 years, with a peak incidence in athletes age 15 to 19 years.29

The most common presenting signs and symptoms in patients with an ankle sprain are an antalgic gait and swelling over the involved ligaments. Ecchymosis may be present. Each of the affected structures should be carefully palpated. Anterior drawer testing should be performed, and results should be compared with those of the opposite, unaffected side. Radiographs should be obtained routinely to evaluate the patient for fractures and symmetry of the ankle mortise. Ankle injuries require further evaluation if there is a persistence of symptoms over 3 or 4 months, which can be caused by several factors requiring orthopaedic evaluation.30 The differential diagnosis of an ankle sprain includes occult fractures, chronic ligamentous laxity, osteochondral injury, and soft-tissue impingement from fibrous adhesions.

The initial treatment of an ankle sprain should consist of compression, rest, application of ice, and elevation of the affected foot. Administration of nonsteroidal anti-inflammatory drugs and use of braces are frequently helpful. Crutches can be used until pain subsides sufficiently to permit weight bearing to tolerance. Cast immobilization usually is required only for severe sprains. Rehabilitation programs generally progress through range of motion exercises, with full weight bearing attempted as pain and edema decrease. After full range of motion is attained, a strengthening and proprioceptive program is started.30

**LITTLE LEAGUE ELBOW**

Little league elbow results from a wide range of pathologic processes within the elbow, including medial epicondylitis, medial epicondylar avulsion, medial epicondylar apophysitis, Panner’s disease (osteochondrosis of the humeral capitellum), and flexor-pronator tendinitis. All of these conditions are related to stress placed on the skeletally immature elbow. Medial epicondylitis, medial epicondylar avulsion, and medial epicondylar apophysitis can be seen as part of the same continuum.27,31 More than half of high school pitchers report a history of significant elbow pain by the end of their scholastic careers. However, typical symptoms are not confined to baseball pitchers but can occur in javelin throwers and tennis players as well.2

The symptoms of little league elbow include progressive medial pain, diminished throwing effectiveness, and decreased throwing distance. Generally, there is tenderness over the involved humeral condyle. Mild swelling and limitation of elbow motion may be present. Results of anteroposterior and lateral radiographs of the elbow can be normal, or they can show avulsion fracture/fragmentation and heterotopic ossification of the medial epicondyle (medial epicondylitis) or fragmentation and irregularity of the humeral capitellum (Panner’s disease). The presence of an intra-articular loose body with locking requires further evaluation. The differential diagnosis of this condition includes an atypical tumor, a subluxating ulnar nerve, and ulnar neuritis.

Rest and early diagnosis are the mainstays of management of little league elbow. Application of ice, administration of nonsteroidal anti-inflammatory drugs, and prohibiting throwing for 3 to 6 weeks usually allows adequate healing. Osteonecrosis of the capitellum in adolescents is more likely to cause residual symptoms, although, in children younger than 10 years, the same condition has a good prognosis.31

**COMMON SHOULDER INJURIES**

**Shoulder Impingement Syndrome**

Shoulder impingement syndrome is an overuse injury of the shoulder caused by repetitive microtrauma in overhead activities. A common theory holds that there is a subtle glenohumeral instability that allows for excessive translation of the humeral head. This increase in translation leads to chronic inflammation of the rotator cuff tendons and results in edema and swelling in the subacromial space.21,32 Shoulder impingement syndrome is a common cause of shoulder pain in athletes who participate in competitive swimming, tennis, gymnastics, and most sports involving overhead throwing.

Patients with shoulder impingement syndrome have a gradual onset of shoulder pain that worsens with activity. Some affected athletes have shoulder discomfort at rest and nocturnal pain, especially when the condition is associated with instability. In most athletes, the pain is usually diffuse and is described as being deep in the shoulder. At times, the pain associated with shoulder impingement syndrome is predominantly superolateral...
or posterior.\textsuperscript{21} Tenderness under the acromion process and over the long head of the biceps tendon signal shoulder impingement syndrome, as can pain on resistance with either abduction of the arm to 90 degrees (Hawkins sign), forward flexion at 30 degrees, or internal rotation (Neers or empty can sign). Pain is also elicited with abduction, internal rotation, or flexion of the arm and forward flexion of the internally rotated arm (impingement signs). Results of radiographs are usually normal. The differential diagnosis of shoulder impingement syndrome includes frozen shoulder (a rare condition characterized by severe loss of motion), tear of the rotator cuff (also rare and marked by weakness of the supraspinatus), infection (rare and marked by an elevated erythrocyte sedimentation rate), and neoplasm (also rare).

Treatment of shoulder impingement syndrome includes rest, application of ice, administration of nonsteroidal anti-inflammatory drugs, and physical therapy directed at resolving specific patterns of weakness and inflexibility that tend to develop in affected athletes about the shoulder. Surgical intervention seldom is required.\textsuperscript{21} Failure to respond to conservative treatment after 6 weeks is an indication for orthopaedic referral.

**Little League Shoulder**

Little league shoulder is caused by a stress fracture of the physis of the proximal humerus and is related to overuse. The condition is most likely caused by repetitive, high-intensity, rotational stress through the physeal region in pediatric and adolescent athletes participating in sports involving overhead throwing (eg, baseball pitchers, badminton players).

Athletes with little league shoulder develop the gradual onset of shoulder or proximal arm pain during the act of throwing or serving. Tenderness over the lateral aspect of the proximal humerus is the most common clinical finding (70%).\textsuperscript{33} Radiographs typically show a widening of the proximal humeral physis (compared with radiographs of the contralateral shoulder) on views illustrating internal and external rotation.\textsuperscript{33} The differential diagnosis is the same as that of shoulder impingement syndrome.

Treatment consists of relative rest from throwing for at least 3 months, application of ice, administration of nonsteroidal anti-inflammatory drugs, and physical therapy directed at resolving specific patterns of weakness and inflexibility that develop about the shoulder in affected athletes.\textsuperscript{21} As with shoulder impingement syndrome, failure to respond to conservative treatment after 6 weeks is an indication for orthopaedic referral.

**COMMON HEAD INJURIES**

**Definition of Concussions**

A concussion is a clinical syndrome characterized by immediate and transient posttraumatic impairment of neural function (eg, alteration of consciousness, disturbance of vision or equilibrium) caused by involvement of the brainstem.\textsuperscript{4} Concussions result from accelerative (eg, being struck by a moving object) or decelerative (eg, striking the head against a stationary object) injuries. Approximately 90\% of head injuries are concussions. The incidence of concussion in high school athletes is high (concussions in football players alone are estimated to be > 250,000/year).

**Classification Systems**

The Colorado system of grading concussions is based on severity; a scale of 1 to 3 is used. Grade 1 (mild) concussion involves no loss of consciousness (LOC) or amnesia and is characterized by a brief period of confusion. Grade 2 (moderate) concussion is characterized by confusion with retrograde amnesia but no LOC. Grade 3 (severe) concussion is characterized by LOC of any duration.

Of the other classification systems also used to grade concussions, the Cantu system is most common. According to this system, grade 1 concussion involves no LOC, grade 2 concussion involves LOC lasting less than 5 minutes, and grade 3 concussion involves LOC of 5 minutes or longer or posttraumatic amnesia lasting 24 hours or longer.\textsuperscript{34}

**Clinical Manifestations and Differential Diagnosis**

In general, signs and symptoms of a concussion will depend on the grade of the concussion and any associated LOC. Symptoms of a grade 1 concussion (in both Colorado and Cantu systems) include brief periods of confusion, with the athlete appearing to be “shaking it off” after being involved in a collision or other form of contact during a competition. The athlete may appear to be moving slightly more slowly, may have a loss of focus or comprehension, and may appear to have an unsteady gait. Although grade 2 concussion is characterized by retrograde amnesia, anterograde amnesia can also exist. As previously stated, athletes with grade 3 concussion are unconscious.

The most difficult challenge facing a sideline physician is the recognition of a grade 1 concussion. If, at any time, an athlete appears to be “shaking it off,” the physician should insist that the athlete be removed from the competition for evaluation. This step can prevent second-impact syndrome, which occurs when an athlete sustains a second concussion before recovering from the previous concussive hit.
one; this scenario is even more confounding if the second injury appears insignificant and the athlete appears completely normal. However, instantaneous edema can occur, resulting in brainstem herniation and death.

Treatment of Concussions

Appropriate treatment of concussions sustained by adolescent athletes is based on the grade of the concussion.

**Grade I (mild) concussion.** Athletes who sustain a grade I concussion during an athletic competition must be removed from participation and reevaluated every 5 to 10 minutes. Medical staff should evaluate the athlete for evidence of postconcussive symptoms (eg, amnesia, irritability, hyperexcitability). If any of these symptoms is present or if the athlete is not free of all symptoms after 20 minutes, the concussion should be considered grade 2 and treated accordingly. If there are no symptoms after 20 minutes, the athlete can return to the competition.

**Grade II (moderate) concussion.** Athletes who sustain a grade II concussion during an athletic competition should be removed from participation for the remainder of the competition. Observation is necessary to detect evidence of severe intracranial injury, including vomiting, headache, changes in visual acuity, numbness, weakness, or changes in mental status. Sideline monitoring for changes in neurologic function should occur every 5 to 10 minutes and is best accomplished by comparing serial Glasgow Coma Scale scores. The athlete should then be taken to his or her primary care provider or to a neurologist for further evaluation. Moreover, the athlete’s coach and family members should be instructed to observe the athlete for symptoms suggesting severe intracranial injury (which may not be apparent for several hours or even days after the competition) and to take the athlete to an emergency department immediately if any of these symptoms appears. The athlete should be re-evaluated daily until all symptoms completely resolve and should not return to participation in sports until he or she has been asymptomatic for at least a week.

**Grade III (severe) concussion.** Athletes who sustain a grade III concussion during an athletic competition are, by definition, unconscious and require airway management and neck stabilization (in case there is a fracture of the cervical spine). Smelling salts should not be used in an attempt to arouse the athlete from unconsciousness. Instead, immediate transport to the nearest emergency department for complete neurologic evaluation is required. In this regard, computed tomography scans and magnetic resonance images should be obtained. The Glasgow Coma Scale is also useful in detecting sudden changes in neurologic function.

After being medically cleared, the athlete must remain inactive (ie, refrain from participating in practice or competition) for 1 month and must be asymptomatic—at rest and during exercise—for 2 weeks before returning to competition. Two grade 3 concussions sustained during a single season or year necessitates restriction from contact or collision sports for 1 year.

**SUMMARY POINTS**

- Sports medicine is the multidisciplinary field dealing with the physiologic, biomechanical, psychological, and pathologic variables associated with exercise and sports. As such, it concerns both athletic performance and care of injuries sustained during sports participation.
- The primary goal of the PPE is to help maintain the health and safety of pediatric and adolescent athletes in training and competition.
- Compared with their adult counterparts, pediatric and adolescent athletes have an additional risk for injury because of their more vulnerable growth cartilage at the physeal plate, joint surfaces, and sites of major muscle tendon insertions.
- Most sports injuries (80%) in children involve the musculoskeletal system.
- In pediatric and adolescent athletes, overuse injuries are far more common than are acute injuries.
- The majority of pediatric and adolescent sports-related injuries are relatively benign and easily treated with conservative measures, (eg, protection, rest, application of ice, elevation, compression).
- Approximately 90% of head injuries sustained by children in competitive sports are concussions.
- All pediatric and adolescent athletes who sustain head injuries, other than grade 1 concussions, should be referred for further medical evaluation following their removal from competition.

**BOARD REVIEW QUESTIONS**

Choose the single best answer for each question.

1. Which of the following is the best treatment for overuse injuries such as tendonitis and sprain?
   A) Application of ice only
   B) Continued sports participation only
   C) Rest only
   D) Application of ice and continued sports participation
   E) Application of ice and rest
2. Which of the following is the best screening tool to assess the risk for sudden cardiac death in pediatric and adolescent athletes?
   A) Echocardiography
   B) Electrocardiography
   C) Exercise stress test
   D) Electrophysiologic study
   E) History taking

3. Which of the following disorder(s) is most commonly associated with sudden cardiac death in pediatric and adolescent athletes?
   A) Congenital anomalies only
   B) Heart murmur only
   C) Hypertrophic cardiomyopathy only
   D) Congenital anomalies and hypertrophic cardiomyopathy
   E) Heart murmur and hypertrophic cardiomyopathy

ANSWERS

D  E  E  E  E

REFERENCES

29. Busconi BD, Pappas AM. Chronic, painful ankle instability in skeletally immature athletes. Ununited osteochondral


