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MINISYMPOSIUM

Basketball injuries in children

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Abstract Basketball is a popular, worldwide sport played outdoors and indoors year-round. Patterns of injury are related to abrupt changes in the athlete's direction, jumping, contact between athletes, the hard playing surface and paucity of protective equipment. Intensity of play and training in the quest of scholarships and professional careers is believed to contribute to an increasing occurrence of injury. Radiologists' appreciation of the breadth of injury and its relation to imaging and clinical findings should enhance the care of these children. Some of the patterns of injury are well known to radiologists but vary due to age- and size-related changes; the growing skeleton is affected by differing susceptibilities from biomechanical stresses at different sizes. Beyond screening radiographs, the accuracy of MRI and CT has improved diagnosis and treatment plans in this realm. Investigations to detect symptoms and signs in an attempt to prevent the tragedy of sudden cardiac death in basketball players may lead to MRI and CTA studies that compel radiologists to evaluate cardiac function along with myocardial and coronary artery anatomy. Worthy of mention also is the female athlete triad of disordered eating, amenorrhea, and osteoporosis that is observed in some young women participating in this and other sports.

Keywords Sports · Imaging · Children · Injuries · Basketball

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Introduction

Benefits associated with childhood athletics include improved physical fitness and coordination, self-discipline, teamwork and a sense of personal satisfaction and accomplishment. Some children specialize in a sport at a young age, practicing year-round and competing at an elite level. The lure of a college scholarship or a potential professional career may partly explain this [1]. One result is that more sports-related injuries in children are now seen that, in the past, were noted only in elite and adult professional athletes.

Some characteristics of child athletes, however, make them vulnerable to injuries unseen in adults. The presence of open physes can result in fractures as opposed to the strains and sprains seen in adults. The pull of a strong tendon near a growth center can result in repetitive traction injury, as occurs in the Osgood Schlatter lesion. For reasons that are unclear, the growth cartilage of a developing physis is susceptible to repetitive injury, particularly in the elbow, knee, and ankle. Additionally, in a rapidly growing child, differences in growth rates of bones and soft tissues can result in a loss of flexibility and coordination owing to dynamic muscle imbalances [2–4].

According to the Sporting Goods Manufacturing Association, an estimated 26 million Americans play basketball, with participation peaking at the age of 13 years [5]. In 2002, more than 207,000 children between the ages of 5 and 14 years were treated in hospital emergency rooms for basketball-related injuries, and a recent survey found that 15% of children between the ages of 5 and 14 years have been injured while playing basketball [6].

Each sport has a specific injury profile and degree of risk. While football and basketball players tend to suffer knee injuries, wrestlers have a higher risk for shoulder injuries. The degree of risk depends on skill level, activity at time of injury (more injuries occur during games than during practice) [7, 8], playing surface and the use of protective equipment. Risk factors particular to basketball include the rapid start-and-stop nature of the game, the relatively slick playing surface, the risk of player-to-player and player-to-object contact [9], and the relative lack of protective equipment. The positions played by an athlete also influence the degree of risk. Studies have shown that a center, who spends more time under the basket in a high player density area, is more at risk for injury than a player at the periphery, such as a point guard or forward [10].

Sudden cardiac death

Sudden cardiac death, also known as sudden arrest, is death from an unexpected, abrupt loss of cardiac function in which there is no history of trauma. Death typically occurs within a few hours; the athlete was otherwise in a previously normal state of health. The fact that it typically occurs during or after practice or a competition suggests that exertion is a precipitating factor [11]. The first documented case of sudden death in an athlete occurred in 490 BC when Phidippides, a Greek soldier, ran from Marathon to Athens to announce a military victory. Upon arrival in Athens, he delivered his message, collapsed and died. There have been numerous other cases of sudden cardiac death within the popular press, including Hank Gathers, an all-American basketball player at Loyola Marymount University in 1990, and Reggie Lewis, a professional basketball player, in 1993 [12]. Sudden cardiac death is rare, with less than 100 cases reported in the US annually. According to the US National Registry of Sudden Death in Athletes, the majority of sudden death cases (65%) occur in athletes less than 17 years of age; 89% occurred in male athletes, and the most common athletic activity at the time of sudden cardiac death is basketball [13].

Sudden cardiac death is attributed to a number of causes. Coronary artery disease is the most common cause of sudden cardiac death in patients 30 to 40 years old [14, 15]. Among younger patients, sudden cardiac death is more commonly caused by structural abnormalities including hypertrophic and dilated cardiomyopathy and anomalous coronary arteries [16, 17]. Arrhythmias may also play a role.

Hypertrophic cardiomyopathy (HCM) is the most common cause of sudden cardiac death among young competitive athletes [17]. It is autosomal dominant with variable penetrance. The incidence is approximately 1 in 500 in the general United States population, but is higher in African-American populations [18]. Most patients with HCM are asymptomatic until the time of death. Symptoms may include dyspnea or chest pain with exertion, light-headedness or syncope. Death from HCM is more likely to result from ventricular arrhythmias than from limited cardiac output caused by the obstructing left ventricular hypertrophy [19]. Imaging with echocardiography and MRI may demonstrate asymmetric left ventricular hypertrophy, most commonly involving the ventricular septum. The left ventricle is not dilated. Approximately one-third of patients demonstrate myocardial bridging (also known as intramural tunneling) when a segment of coronary arteries is completely surrounded by myocardium [20].

Anomalous coronary arteries are the second most common cause of sudden cardiac death in young athletes, most commonly when the left coronary artery arises from the right sinus of Valsalva [21]. The majority of these patients are asymptomatic [21]. Possible mechanisms for ischemia include a slit-like osteum that narrows with aortic dilation during exercise, an acutely angled take-off of the coronary arteries, or impingement of the artery as it passes between the aorta and the pulmonary trunk [22]. Imaging for diagnosis may include echocardiography, angiography, MRA and CTA.

Although valvular disease is common in the general population, it is an uncommon cause of sudden cardiac death. Additional causes of sudden cardiac death include conduction abnormalities, myocarditis and drug-induced coronary artery vasospasm (cocaine) [23]. Commotio cordis is an uncommon but particularly dramatic form of sudden cardiac death. In this situation, the athlete receives an innocuous-appearing, nonpenetrating blow to the chest. The blow results in immediate cardiovascular collapse from ventricular fibrillation [24]. There is no structural damage to the sternum, ribs or heart from the blow, and no underlying cardiovascular abnormality [25]. Only 15% of individuals experiencing commotio cordis survive because of a general lack of early recognition of the situation and failure to initiate resuscitation. Survival is more likely when resuscitation, including defibrillation, begins within 3 min of the event [24].

The American Heart Association (AHA) recommends cardiovascular screening by qualified health professions for high school athletes before participating in sports at 2- to 4-year intervals. The AHA recommends similar screening for college-level athletes prior to participating in sports, followed by interim history and blood pressure checks annually. Screenings should include a personal and family history and physical examination focused on detecting cardiovascular abnormalities associated with sudden cardiac death. The AHA does not recommend routine screening with electrocardiography or echocardiography [26, 27].

Wrist

Injuries to the wrist most typically involve a fall on an outstretched hand. The location of a fracture following this type of fall depends on the angle of the wrist upon hitting the ground as well as the age of the patient at the time of injury. If the wrist is more flexed, the athlete is more likely to sustain a scaphoid fracture. If the wrist is more extended, he or she is more likely to suffer a distal radial or ulnar fracture [28]. Also, the risk of scaphoid fracture in children increases as the bone matures [29]. Findings on physical examination include tenderness in the "anatomic snuffbox" as well as decreased range of motion, swelling and pain with dorsiflexion [28]. Imaging for these fractures typically begins with radiographs. If radiographs are negative, but there is high clinical suspicion for a fracture, the athlete may be further evaluated with CT or MRI to search for an occult fracture [30]. MRI has a sensitivity and specificity for scaphoid fracture approaching 100%, and is considered by some as the next best imaging modality to evaluate a potential fracture. With a lower sensitivity for scaphoid fracture, some reserve CT for presurgical planning in patients with a known scaphoid fracture [31]. Arthrography is typically not necessary for the diagnosis of a scaphoid fracture by MRI or CT, but occult fractures can be incidentally diagnosed during these examinations [32].

Ligamentous wrist injuries can include injuries to the triangular fibrocartilage complex (TFCC). This type of injury may occur due to acute trauma or repetitive injury. When acutely injured, the mechanism is often related to axial load bearing with rotational stress, often during a fall on an outstretched hand. Patients typically present with ulnar-sided wrist pain [28]. Injuries to the TFCC are more common in patients with positive ulnar variance [28]. Imaging is typically performed with an MRI scanner using fat-suppressed, fluid-bright sequences such as GRE or T2-weighted (T2-W) sequences. Also, T1-weighted (T1-W) sequences after gadolinium injection into the radiocarpal joint can be used to search for a TFCC tear and abnormal filling of the distal radioulnar joint. CT with arthrography has also been described [32] (Fig. 1).

Fingers

A mallet finger, also known as a hammer finger or baseball finger, is a very common basketball injury that disrupts the extensor mechanism at the distal interphalangeal joint. The mechanism is typically an axial load on a partially flexed finger, usually a ball striking the tip of the finger. Radiographically, the athlete is unable to fully extend his finger, and there may be a small avulsion fracture along the dorsal surface of the distal phalanx (Fig. 2). In a young athlete, an avulsion fracture of the epiphysis is more likely than a rupture of the extensor tendon [33]. While surgical fixation may be deemed necessary, some of these injuries are treated with splinting in extension [34].

Finger injuries may also include a tear of the volar plate at the proximal interphalangeal joint along the palmar surface, sometimes associated with an avulsion fracture (Fig. 3). If an avulsion fracture is present, the injury is considered unstable if the fragment represents more than 30–40% of the articular surface as there is a greater likelihood that the collateral ligaments of the proximal interphalangeal joint have also been injured [34].

Hand injuries may also include injury to the ulnar collateral ligament (UCL), also known as a gamekeeper's thumb. This injury usually results from radially directed force on an abducted thumb, and is an injury commonly seen in basketball. When the UCL tears, the adductor aponeurosis may become interposed between the torn ends of the UCL, or between the UCL and bone, interfering with proper healing (Stener lesion). This injury requires surgical correction. Radiographic images may demonstrate an associated avulsion fracture. Stress radiographs may also demonstrate angulation of the joint that is greater than that of the contralateral side. MRI will demonstrate discontinuity of the UCL [34–38] (Figs. 4 and 5).

Physes and apophyses

Because tendons, ligaments and capsules are stronger than physeal cartilage, forces that may produce a ligamentous or tendinous injury or dislocation in an adult may result in physeal injury in a child. The physis is particularly vulnerable during times of rapid growth [39]. Widening, irregularity and sclerosis of growth plates has been described in athletes in various anatomic locations, including the wrist in gymnasts and the elbow and shoulder in little league baseball players; this is related to chronic overuse and repetitive trauma [35–38]. These same changes can be seen in weight-bearing bones of basketball players, including the distal femur and proximal tibia [37]. When a history of chronic overuse is not provided, an alternate differential consideration would include rickets.

Knee injuries

Fractures about the knee are uncommon in basketball. Avulsion of the tibial tubercle in a young athlete has been well described among basketball players and may occur bilaterally. The mechanism involves violent knee flexion against a tightly contracted quadriceps muscle, or violent quadriceps contraction with a fixed foot [40, 41] (Fig. 6). In order to achieve bony union and restore function, these injuries are typically treated with open reduction and internal fixation [42].

Anterior cruciate ligament (ACL) injury is the most frequent internal derangement sequela of knee trauma, and the incidence among young athletes has increased dramati-

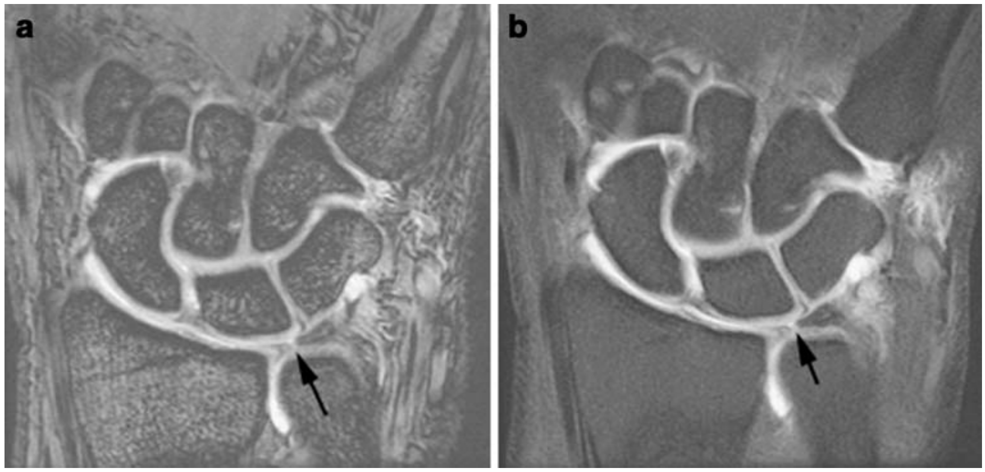

Fig. 1 Triangular fibrocartilage complex (TFCC) tear. Coronal MR images of the wrist in a patient with ulnar side pain. GRE image (**a**) and T1-W image following wrist arthrography with gadolinium administration (**b**) demonstrate high signal within the central aspect of the disrupted TFCC (*arrow*) (*Image courtesy of Emily Vinson, MD, Duke University Medical Center*)

Fig. 2 Mallet finger. Lateral view of the right third digit demonstrates a small fracture fragment arising off the proximal aspect of the distal phalangeal base. The 14-year-old boy was tender in this region and was unable to fully extend his finger following an axial load injury to the finger while playing basketball

cally in recent years [43]. In basketball, the majority of ACL injuries do not involve contact with other players [44]. The classic mechanism is deceleration or change in direction, with either hyperextension or a twisting of the knee. The athlete often hears an audible pop and has a rapid onset of pain, soft tissue swelling and disability [43].

Studies published in the late 1990s have shown that female athletes in jumping and cutting sports have a significantly higher incidence of knee injuries than male athletes participating in the same sports [45–47]. A number

Fig. 3 Volar plate injury. Lateral view of the second-digit finger in a 13-year-old boy following a hyperextension injury demonstrates an avulsed bone fragment arising from the volar surface of the middle phalangeal base typical of a volar plate injury (*arrow*). There is adjacent soft tissue swelling

Fig. 4 UCL injury. Oblique radiograph of the thumb demonstrates an avulsed bone fragment arising from the proximal phalanx of the first digit characteristic of gamekeeper’s thumb

of theories in the literature attempt to explain this gender difference, including the relative smaller femoral notch size [48] and smaller cross-sectional diameter of the ACL in female athletes compared to those in their male counterparts [49, 50]. Hormones may play a role, not only in the ligamentous laxity associated with estrogen, but also in the effects of estrogen on neuromuscular function and tendon/ligament strength [51]. Studies have also shown differences

Fig. 5 UCL injury, MRI. Pain and bruising along the ulnar aspect of the thumb in a 13-year-old female basketball player. Coronal T1-W MR image of the thumb demonstrates discontinuity of the UCL (*arrow*)

Fig. 6 Bilateral tibial fractures. **a**, **b** Lateral images of the right and left knee in a 12-year-old boy who fell with knees flexed beneath him while playing basketball. Image of the right knee demonstrates a fracture of the proximal tibial epiphysis. Image of the left knee demonstrates a fracture of the tibial tuberosity

in muscle firing patterns in female versus male athletes, which, when decelerating, may place more stress on the ligaments and tendons about the knee of a female athlete [51, 52]. Another theory for increased risk of ACL injuries involves the relatively wider pelvis and more valgus alignment of the knee in female versus male athletes [53–55].

A common pattern of ACL injury for a skeletally immature athlete is an avulsion fracture of the tibia, or less commonly the femur, at the site of ACL attachment, as the chondro-osseous junction is the weakest part of the ACL complex [56, 57]. Injuries to the ACL may also involve ligament tears, which are more commonly partial tears if the athlete is skeletally immature and complete tears as the athlete ages [57]. The pattern of injury is also related to the width of the intercondylar notch. Athletes with a narrower intercondylar notch are more likely to tear the substance of the ACL, while those with a wider intercondylar notch are more likely to avulse the tibial spine [58].

Radiographic findings of ACL injury may include a Segond fracture. This is an avulsion fracture at the site of insertion of a lateral capsular ligament. Injury to the ACL is seen in 75–100% of patients with a Segond fracture [59]. MRI may demonstrate disruption or attenuation of the ACL fibers with abnormal signal, and marrow edema in the midportion of the lateral femoral condyle and posterior lateral tibial plateau with a pivot shift contusion [60]. Findings associated with an avulsion of the ACL insertion will include visualization of the tibial spine avulsion fracture with associated bony edema and possibly a hemarthrosis [57] (Fig. 7).

Injuries of the posterior cruciate ligament (PCL) are less common than injuries to the ACL, and these injuries require greater force [60]. The mechanism in an athlete typically involves a fall on the shin, or a hyperextension injury [61]. Signs and symptoms include pain, swelling, and hemarthrosis, and a positive posterior drawer sign is seen on physical examination [60]. Although often noncontributory, radiographic findings of a PCL injury may include a joint effusion or more rarely an avulsion fracture at the tibial insertion site [60]. MRI findings will include abnormal signal on T1- and T2-W sequences as well as discontinuity of the PCL (Fig. 8). Approximately 30% of PCL injuries are isolated and may not require repair. PCL tears are usually repaired when associated with other ligamentous injury [60].

Traction apophysitis develops when the attachment of tendon to bone is repetitively strained. Sinding-Larsen-Johansson lesion occurs at the junction of the inferior patella and the patellar tendon, and most commonly occurs in athletes between the ages of 10 and 14 years. These patients demonstrate tenderness and soft tissue swelling of the lower pole of the patella [60]. The Osgood-Schlatter lesion occurs at the insertion of the patella tendon to the tibial tuberosity. This typically occurs in boys, usually between 11 and 15 years of age. Often found is a history in sports participation during a rapid growth spurt [60]. Radiographic findings in both the Sinding-Larsen-Johansson lesion (Fig. 9) and the Osgood-Schlatter lesion

Fig. 8 PCL tear. Sagittal T2-W fat-suppressed MR image of the knee in a patient with acute knee pain following a fall on a flexed knee demonstrates increased signal and discontinuity of the PCL

(Fig. 10) include soft tissue swelling and indistinct profile of the tendon at the site of tenderness. Fragmentation of the adjacent bone may also be seen, but the soft tissue swelling is fundamental to the diagnosis of both the Osgood-Schlatter and the Sinding-Larsen-Johansson lesions and must be emphasized.

The Sinding-Larsen-Johansson lesion must be differentiated from an interior patellar sleeve avulsion injury. Patellar sleeve avulsion injury, an acute avulsion rather than the chronic injury of a Sinding-Larsen-Johansson lesion, is only seen in children, typically between the ages of 8 and 12 years. On physical examination, the child is

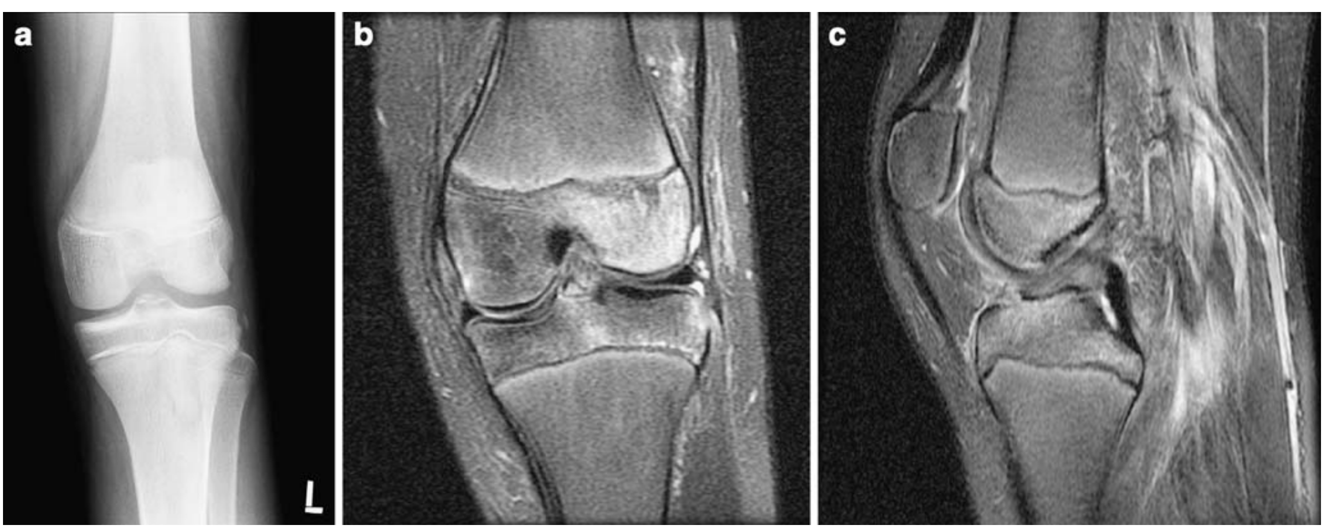

Fig. 7 Knee pain after a twisting injury while playing basketball. **a** AP radiograph of the knee in a 15-year-old boy who developed knee pain after a twisting injury while playing basketball demonstrates a small fracture fragment adjacent to the proximal tibia consistent with a Segond fracture. A small fracture fragment is also visualized adjacent to the tibial spine. **b**, **c** Coronal and sagittal T2-W fat-suppressed MR image of the knee in the same patient demonstrates findings of the Segond and tibial spine fractures (marrow edema and cortical discontinuity). While the ACL is intact, it is no longer functional due to the tibial spine avulsion fracture. Edema of the lateral femoral condyle is consistent with the kissing contusion pattern commonly seen with ACL injury

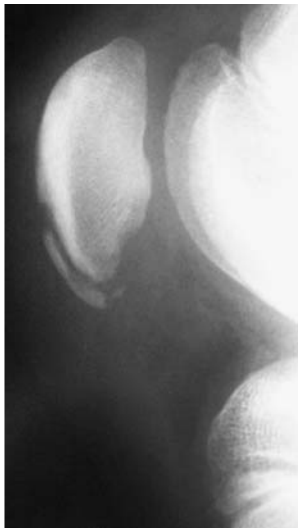

Fig. 9 Sinding-Larsen-Johansson lesion. A close-up lateral view of the knee in a 12-year-old boy with chronic knee pain demonstrates fragmentation of the inferior pole of the patella. The patient was tender to palpation in this area

unable to stand, there is patella alta and there may be a palpable gap in the patellar tendon. Radiographically, in addition to patella alta, there is often a small bony avulsion fragment distal to the inferior pole of the patella. Radiographs, however, may underestimate the extent of cartilaginous injury. Although a patellar sleeve avulsion injury is rare, it is important to differentiate it from a Sinding-Larsen-Johansson lesion as it is treated surgically, while Sinding-Larsen-Johansson lesions are managed conservatively [62].

Jumper's knee is a term for a group of conditions that commonly cause extraarticular knee pain. This is commonly seen in athletes whose activities include frequent and vigorous use of the knee extensor mechanism (repetitive jumping, running or kicking) [60]. Abnormal size of the patellar tendon is critical to the diagnosis on MRI because just abnormal signal may be due to the magic angle phenomenon in the patellar tendon (Fig. 11).

Stress fractures in adolescents involved in running and cutting sports commonly occur in the tibial diaphysis [63]. Tibial stress fractures most commonly involve the posteromedial cortex, a pattern of injury most commonly seen in athletes participating in running sports. Athletes involved in jumping sports such as basketball, ballet and track and field can develop a more specific stress fracture involving the anterior tibial cortex [64, 65]. For stress fractures of the posteromedial surface, the prognosis is generally good with conservative management. The prognosis is worse if the fracture involves the anterior tibia, as these have a higher rate of nonunion or progression to complete fracture [66]. Radiographic findings are influenced by the site and timing of injury. Radiographs are typically normal for 2–3 weeks following the onset of symptoms, and may be normal for several months [66]. In diaphyseal stress fractures, findings may include periosteal and endosteal cortical thickening, possibly associated with a linear cortical lucency. In the epiphysis, metaphysis, or in a cancellous area, sclerosis is frequent, and periosteal reaction is not as prominent [64].

Fig. 10 Osgood-Schlatter lesion (patellar tendinitis). Lateral view of the knee in an athlete with anterior proximal tibial pain demonstrates thickening of the patellar tendon and adjacent swelling proximal to the insertion into a fragmented tibial tuberosity

Fig. 11 Jumper's knee. Sagittal, T2-W fat-suppressed MR image of the knee in a child with anterior knee pain demonstrates thickening of the proximal patellar tendon, with increased signal in both the tendon and the distal patella

Radionuclide and MRI examinations are more sensitive than radiography for detection of stress injuries [64]. MRI may be reserved for those athletes with confusing symptoms; however, it has been shown that early diagnosis of stress reaction/fracture results in shorter time to return to play, which may be important to elite athletes [67, 68].

Ankle and foot

Ankle sprains, which involve injury to the ligaments and joint capsule, make up between 10% and 28% of all athletic injuries. A syndesmosis sprain or "high ankle sprain" typically occurs with dorsiflexion and external rotation and involves the interosseous membrane and the anterior and posterior inferior tibiofibular ligaments [43]. A Maisonneuve fracture results in injuries above the ankle (either fracture or ligamentous injury) accompanied by a fracture of the proximal fibula [69]. Radiographic findings of a syndesmosis injury may include lateral talar displacement or distal tibiotalar widening without a distal tibial fracture on the AP ankle radiograph [69]. The type of syndesmosis injury is based on the degree of widening, which is best evaluated with MRI. However, as stated earlier, ankle fractures must be considered in the child athlete due to the presence of open growth physes [70]. Care must be taken to exclude a Salter I fracture of the distal fibula, which may only be suggested on radiographs by soft tissue swelling adjacent to the injured growth plate (Fig. 12).

In children, rupture of the Achilles tendon is uncommon. Achilles tendinopathy is more common, and may be seen in athletes with a sudden increase in training frequency or intensity. Patients present acutely with Achilles tendon pain, swelling and impaired performance. When more chronic, the Achilles tendon may become nodular on palpation. MRI will demonstrate a thickened tendon. The presence of high signal on a T2-W image suggests a tear of the tendon. Treatment is initially conservative with rest, ice and antiinflammatory medication. Surgery is reserved for those in whom conservative management has failed [71].

Fig. 12 Salter I fracture – distal fibula. Oblique view of the ankle in a 15-year-old girl with acute ankle pain demonstrates a prominent, widened distal fibular physis when compared with the nearly closed tibial physis

Plantar fasciitis is seen in young athletes involved in jumping, hill running or speed work, and is a degenerative rather than an inflammatory process. These athletes present with inferior heel pain and stiffness early in the morning or after long periods of immobility [70]. History may include a new or increased activity, a change in floor surface or new shoes. Plantar fasciitis is diagnosed clinically. MRI may demonstrate thickening of the plantar fascia with abnormal high signal on T2-W images immediately adjacent to the calcaneus, possibly also with increased signal within the calcaneus [72].

In children, 61% of all fractures of the foot involve the metatarsals, most commonly the fifth metatarsal (41%) [73]. Injuries to the head and shaft of the metatarsals are usually the result of direct trauma. Injuries to the proximal metatarsals may result from an acute injury, such as an acute transverse fracture (Jones or dancer's fracture) or avulsion. The metatarsals are the most common site of stress fractures, typically involving the second, third and fifth proximal metatarsals [73].

Fractures of the proximal fifth metatarsal may be divided by location. Avulsion injuries typically occur at the tuberosity. Acute transverse fractures (also known as a Jones fracture) and fifth metatarsal stress fractures occur more distally, in the proximal portion of the diaphysis [74].

An avulsion fracture of the proximal fifth metatarsal is an indirect injury that results from a sudden inversion injury. The bony avulsion fragment contains the insertion site of the peroneus brevis and the lateral band of the plantar aponeurosis [75]. This fracture is usually extra-articular [76]. Treatment involves weight bearing as tolerated, and the athlete may return to play whenever he or she is comfortable (Fig. 13).

An acute transverse fracture of the proximal fifth metatarsal is also known as a Jones fracture. This fracture was first reported by Sir Robert Jones [77] in 1902 when he described an injury that he sustained in his own fifth metatarsal, which he suffered while dancing around a Maypole at a military garden party. This fracture occurs at the proximal metadiaphyseal region of the fifth metatarsal. Because this fracture occurs at a watershed area, these fractures are associated with poor healing, nonhealing and refracture [64]. Surgical fixation is the treatment of choice

Fig. 13 Fifth metatarsal avulsion fracture. Close-up oblique view of the foot in a patient with acute lateral foot pain demonstrates a transverse avulsion fracture of the tuberosity of the proximal fifth metatarsal

Fig. 14 Fifth metatarsal stress fracture. A 20-year-old male basketball player with pain along the lateral foot. Magnified oblique view of the foot demonstrates cortical thickening and transverse linear lucency along the diaphysis consistent with a stress fracture (*Image courtesy of Christopher Gaskin, MD, University of Virginia*)

for Jones fractures in athletes, and has been suggested for nonathletes as well. Fixation allows faster healing and return to play [78].

Stress fractures of the fifth metatarsal are commonly seen in basketball players [79, 80]. History is helpful for diagnosing these injuries. Radiographic findings will include sclerosis and cortical thickening of the proximal metadiaphyseal portion of the fifth metatarsal, and may include transverse linear lucency [79] (Fig. 14). These injuries may be treated with immobilization, particularly when acute or in a nonathlete. However, because the time of immobilization may be prolonged and as there is a risk for nonunion and refracture, this injury is commonly treated by surgical fixation in the elite athlete [74, 79].

Miscellaneous

Since the passage of Title IX in 1972, a substantial growth has occurred in participation in organized sports, with study by the National Federation of State High School Associations demonstrating a more than tenfold increase in girls participating in high school sports [81]. Unfortunately, increasing numbers of girls and young women have been diagnosed with the female athlete triad, which is composed of disordered eating, amenorrhea, and osteoporosis. These three components are interrelated in cause and consequence. Coupled with strenuous exercise, disordered eating may result in decreasing body mass and body fat, which may result in prolonged secondary amenorrhea. This prolonged amenorrhea results in decreased ovarian hormone production, which is associated with osteoporosis similar to that seen in menopause. This diminished bone mass increases the risk of stress fractures and the potential for osteoporosis in adulthood [82]. Unfortunately, these findings may persist long beyond the formative years into adulthood.

Conclusion

Injuries associated with sports, including those that in the past were seen in elite and older athletes are, for various reasons, becoming more common in younger athletes. Although some of the injuries described above are very common in basketball players, including ACL and finger injuries, none is specific to the sport. It is important, however, to keep the history of a sport in mind when evaluating an athlete with pain, as common injury patterns can be seen. Taking into account that the patient is an elite athlete may change differential considerations and treatment. The female athlete triad is something to also keep in mind, as the radiologist may be the first to notice a pattern of repeated stress injuries and poor bone density in an otherwise healthy-appearing young female athlete.

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