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Paediatric sports injuries: providing age-appropriate management

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There are significant differences in the patterns of sports injuries that are sustained by children as opposed to those seen in adults. Appropriate diagnosis, investigation and management are required.

Key points

- Sports participation comes with great physical and psychosocial benefits for children and adolescents but also with an element of risk.
- The patterns of injury in children and adolescents differ to those seen in adults and relate to the unique properties of the developing musculoskeletal system.
- The adolescent growth spurt represents a period of increased vulnerability for injury.
- Imaging modalities should only be used when necessary in the young athlete, to minimise exposure to ionising radiation.
- Assessing and managing paediatric sporting injuries appropriately is important in promoting ongoing participation and minimising attrition rates from organised sport.
- The potential for a missed diagnosis of a more serious condition exists because of the overlap of symptoms with common sports injuries; alternative diagnoses should be considered in patients with atypical signs and symptoms.

Childhood and adolescence encompass a series of physical, emotional and cognitive developmental stages. Participation by children in sports provides benefits across each of these domains and promotes self-esteem, social acceptance and community involvement. In addition, participation in organised sport and regular activity may play a role in preventing obesity, maintaining bone health and improving lipid profile and insulin sensitivity.[1]

In recent decades, the promotion of regular physical activity and increasingly competitive youth sports has resulted in an increased intensity of sport and number of playing hours. This increased exposure to sport also increases the risk of traumatic injury or overuse musculoskeletal injury.[2,3]

An analysis of injuries occurring outside of school in Australian children aged from 5 to 12 years reveals an overall injury rate of 5.7 injuries per 10,000 hours of exposure to physical activity and a medically treated injury rate of 1.7 per 10,000 hours.[4] The highest injury risks per exposure time occurred for tackle-style football (2.18 per 1000 hours), wheeled activities such as cycling (1.72 per 1000 hours) and tennis (1.19 per 1000 hours).[5]

Given the risk of sports- and activity-related injuries, it is important for GPs to have an understanding of the range of sports injuries common in children and adolescents as well

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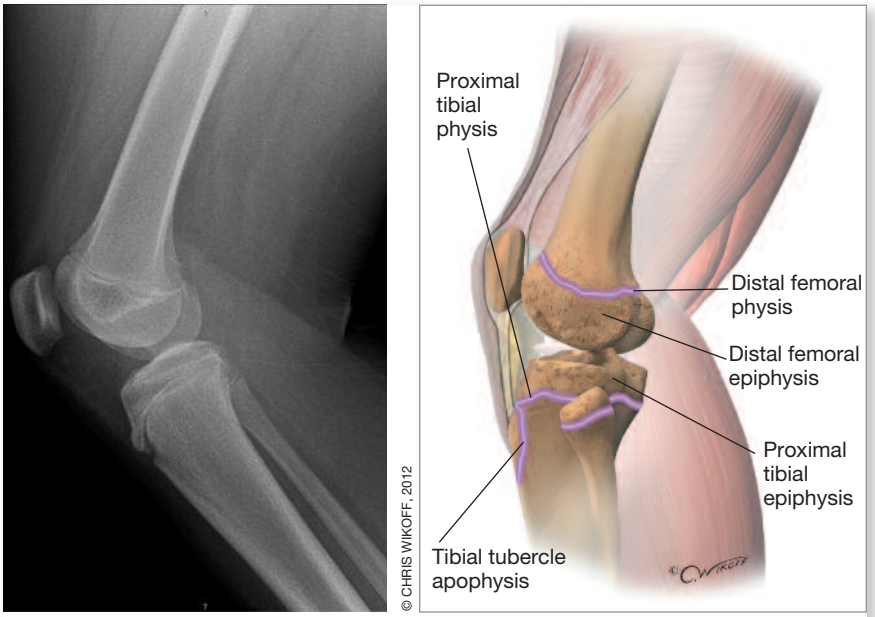


Figures 1a and b. Anatomy of the growing skeleton. X-ray (a, left) and diagrammatic representation (b, right) showing radiographic presence of epiphyses and apophyses in a knee.

as an understanding of the reasons for these unique patterns of injury. The key to diagnosis, as with sports injuries in adults, is a thorough history with particular focus on the mechanism of injury, followed by a targeted clinical examination.

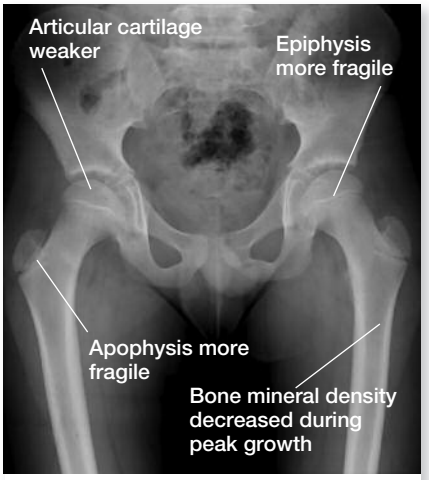


Figure 2. Unique properties of the growing skeleton.

It is important to carefully consider the most appropriate and safest form of imaging when investigating paediatric sports injury presentations. Imaging does not necessarily aid in the diagnosis of many paediatric sports injuries and should be used with discretion given the risk of irradiating the immature skeleton.[6]

THE IMMATURE MUSCULOSKELETAL SYSTEM

Children have unique patterns of musculoskeletal injury, sustaining a distinctly different pattern of injury as compared with adults. Mechanisms of injury that tear ligaments in adults are more likely to cause growth-plate injuries or avulsion fractures in children. Overuse injuries are related to damage to the growth cartilage or immature articular cartilage rather than the degradation of tendons. The reason for the unique pattern of injuries seen in children and adolescents relates primarily to the unique properties of the musculoskeletal system and in particular the presence of cartilaginous growth plates known as the epiphysis and apophysis (Figure 1). These cartilaginous growth plates close at different ages and appear more vulnerable to injury at certain times (depending on times of peak growth and the timing of closure of the growth plate).

The period of early to mid-adolescence in particular is a time of known skeletal vulnerability. The peak incidence of fractures coincides with the adolescent growth spurt in both boys and girls.[7] During periods of rapid growth, the epiphyses and apophyses are thicker, more fragile and susceptible to both acute and chronic compressive, shearing and traction forces.[8,9] Factors influencing this increased risk of injury are outlined in Figure 2.

ACUTE SPORTS INJURIES

Epiphyseal and apophyseal injury

Although weight-bearing activities in childhood may be protective against fractures in adult life, participating in sports at higher levels is associated with an increased risk of fracture in prepubertal children. Of particular clinical importance in children is the occurrence of fractures involving either the epiphysis or apophysis.

Epiphyseal fractures are classified via the Salter-Harris Method (Figure 3) and patients should be managed in consultation with an orthopaedic surgeon due to the potential risk of complications with these types of fracture.

Apophyseal injury or avulsion fractures of the apophysis are a common acute presentation of injury in the adolescent athlete. These injuries are seen in adolescents taking part in explosive activities such as sprinting, kicking or jumping, and are particularly common around the hip and pelvis where large muscle groups pull upon the relatively weak apophysis. Common examples include avulsion fractures of the anterior superior iliac spine

(at the origin of the sartorius muscle), the anterior inferior iliac spine (at the origin of the rectus femoris muscle) and the ischial tuberosity (at the origin of the hamstrings).

Apophyseal injuries present with an acute onset of localised pain and swelling at the apophysis with associated weakness and decreased range of motion. The diagnosis is made by the combination of physical findings, symptoms and history detailing a typical mechanism of injury. Plain radiographs are used to assess for displacement of the avulsed apophysis (Figure 4); however, if the avulsion is nondisplaced or the apophysis is not yet ossified, plain radiographs may appear normal. MRI scans may be useful if the diagnosis is unclear based on history and clinical findings or to further assess the degree of an avulsed and displaced apophysis.[10] Patients with avulsions displaced more than 2 cm need to be referred to an orthopaedic surgeon for consideration of surgical fixation.

Patients with nondisplaced and minimally displaced avulsion injuries may be treated conservatively with rest, ice and a period of six to eight weeks of restricted activity. A stretching, strengthening and proprioception program supervised by a physiotherapist, prior to a graded return to full activity once the young patient is pain free, is advised.

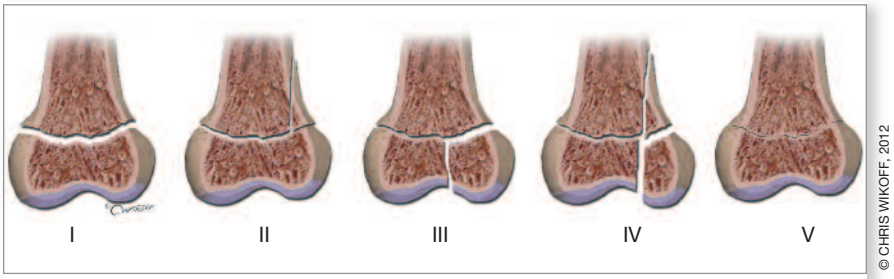


Figure 3. The Salter-Harris classification of growth plate injuries. I, a complete physeal fracture with or without displacement; II, a physeal fracture with a portion of the metaphysis attached; III, a physeal fracture that extends through the epiphysis; IV, a physeal fracture plus epiphyseal and metaphyseal fractures; V, a compression fracture of the physis.

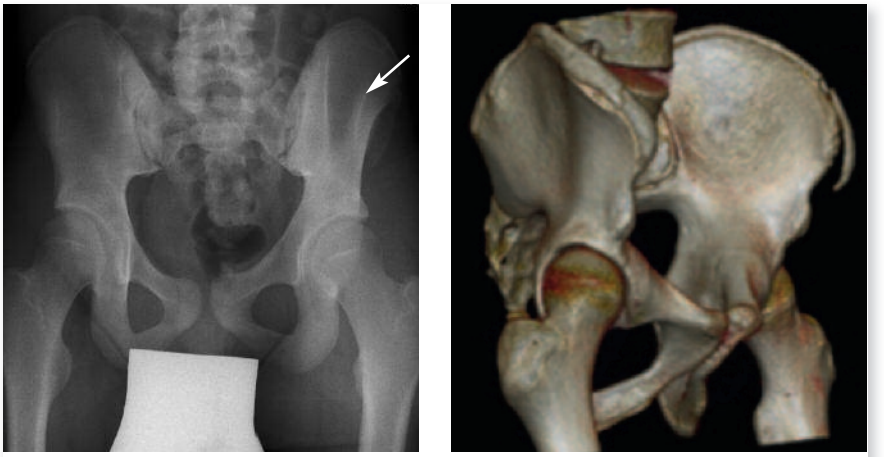
Acute soft tissue injury

Although contusions are common in the young athlete, the proportion of acute soft tissue injuries such as muscle strains and ligament tears seen in children and adolescents is relatively lower than that seen in adult populations. One important ligamentous injury not to miss in the adolescent athlete is a mid-substance anterior cruciate ligament (ACL) tear. Rates of this type of injury in active adolescents are rising together with increases in sports participation.[11] Interestingly, a gender difference appears to occur in this specific injury. The incidence of ACL injuries among prepubescent children is similar in boys and girls;[12] however, at puberty the incidence of ACL injury is higher in girls than in boys.[13,14]

The mechanism of injury is often indirect or noncontact. This usually involves the athlete pivoting or changing direction resulting in a torsional force being applied to the knee, which exceeds the tensile strength of the ACL. Children and adolescents may describe a 'pop' at the time and site of the injury and marked instability is often present.

A physical examination usually reveals a large knee joint effusion with markedly decreased range of motion secondary to pain and swelling. Positive Lachman and pivot shift tests, which are specific clinical tests of ACL integrity, are highly suggestive of the diagnosis.

Immediate treatment is RICE (Rest, Ice, Compression, Elevation), which serves to minimise inflammation and swelling. A range of motion brace may also be indicated to minimise the risk of instability. MRI scanning assists with confirmation of the injury and also helps in assessing for meniscal and articular cartilage damage.



Figures 4a and b. a, left. x-ray image of an avulsion injury (arrow) of the anterior superior iliac spine in a 14-year-old soccer player who had his kick blocked. The patient was referred to an orthopaedic surgeon for fixation of the avulsed fragment. b, right. A 3D CT scan was ordered to assist with operative planning and demonstrates the avulsed apophysis.

TABLE. COMMON OSTEOCHONDROSES

Disorder	Site	Age (years)	Mechanism
Physeal			
Scheuermann's disease	Vertebral end plate	13 to 17	Repetitive micro-trauma
Distal radial physeal injury	Distal radial physis	8 to 15	Repetitive micro-trauma
Intra-articular			
Perthes' disease	Femoral head	4 to 8	Osteonecrosis possibly secondary to trauma
Freiberg's disease	Metatarsal head	13 to 18	Osteonecrosis possibly secondary to trauma
Osteochondritis dissecans	Capitellum Knee Ankle (talus)	12 to 15	Osteonecrosis possibly secondary to trauma
Extra-articular (traction apophysitis)			
Osgood–Schlatter's disease	Tibial tuberosity	11 to 15	Repetitive trauma
Sever's disease	Calcaneus	9 to 11	Repetitive trauma

Once the diagnosis is suspected or confirmed, children and adolescents with this type of injury should be referred to a specialist orthopaedic knee surgeon who has experience and expertise in surgical repair of ACL injuries. Children and adolescents are much less likely to appropriately limit their activities and adapt to ACL insufficiency, and as such surgical repair is usually warranted. Surgical repair at a young age aims to prevent secondary meniscal injuries, degenerative joint disease and symptomatic instability when playing sport or during activities of daily living.[15,16]

OVERUSE SPORTS INJURIES

Osteochondroses

The osteochondroses represent the most common overuse type of sports- or activity-related injuries seen in children and adolescents. They are a large group of heterogeneous conditions that affect the developing skeleton at growth plates and articular cartilage. In a young person with a growing skeleton, the osteochondroses may occur at the apophysis, epiphysis or the articular cartilage. The location of symptoms generally relates to repeated mechanical loading at a specific anatomical site that is undergoing rapid growth and as such is more vulnerable to injury. The osteochondroses differ in their treatment and prognosis, with some conditions resolving spontaneously and others being associated with complications requiring surgical intervention. This group of conditions can be best classified as either intra-articular, physeal or extra-articular. Some of the more common anatomical sites of each of these three types of osteochondroses are described in the Table.

Physeal osteochondroses

Physeal osteochondroses are characterised by primary involvement of the epiphyseal growth plate responsible for longitudinal growth. The mechanism is thought to be caused by repetitive micro-trauma as a result of compressive or shear forces across the open growth plate.

A typical example of a physeal osteochondrosis is a slipped femoral capital epiphysis. In this condition, the femoral head is displaced due to slipping on the open proximal femoral epiphyseal plate. The presentation can be acute and associated with a specific incident; however, it is frequently chronic, presenting as discomfort in the hip, groin or medial thigh or as referred pain at the knee. In chronic slips, symptoms may be relatively mild, with the child able to walk and the initial concern being that of altered gait.

Examination of the child's range of motion of the hip shows limitation of hip abduction, flexion and internal rotation with additional external rotation. There may be mild to moderate shortening of the affected leg. Plain radiographs with anteroposterior and 'frogleg lateral' views show widening of the epiphyseal line or displacement of the femoral head.

Management of young patients with acute and chronic slips involves immediate orthopaedic referral for surgical stabilisation using percutaneous screws. Potential complications include chondrolysis (degeneration of the articular cartilage) or avascular necrosis of the femoral head leading to permanent alteration of femoral head anatomy thus emphasising the need for appropriate diagnosis and immediate referral.

Figure 5. Bilateral osteochondritis dissecans of the knee in an 11-year-old girl.

Other common examples of physeal osteochondroses include Scheuermann's disease (vertebral end plate), Little Leaguer's shoulder (proximal humeral physeal injury in the throwing athlete) and distal radial physeal injury (in the adolescent gymnast).

Intra-articular osteochondroses

The intra-articular class of osteochondroses pose a significant risk for disability due to the potential for residual articular incongruity. These conditions result from either generalised or focal areas of avascular necrosis affecting the subchondral bone. A typical example of an intra-articular osteochondrosis is osteochondritis dissecans (OCD) of the knee, which is characterised by focal areas of avascular necrosis. The lesion occurs in the lateral aspect of the medial femoral condyle in about 75% of cases, with most of the remainder affecting the lateral femur condyle.

Children and adolescents with OCD typically present with poorly localised pain and swelling and, on occasion, catching and locking due to the presence of an intra-articular loose body. This condition frequently presents late, with months of vague poorly localised knee ache and dysfunction.

Examination of the knee usually reveals an effusion and quadriceps wasting. Plain radiography confirms the presence of the OCD lesion (Figure 5) with MRI used primarily to stage the lesion and assist with planning appropriate management. The goal of treatment is to achieve intra-articular congruity with normal viable subchondral bone. Stable lesions can be managed nonoperatively with six to eight weeks of restricted activity and physiotherapy, whereas unstable lesions should be referred to an orthopaedic surgeon. In general, the younger the patient with OCD, the better the prognosis.

Other examples of intra-articular osteochondroses include OCD of the elbow (see case study 1 on this page), Kohler's disease (navicular bone of the foot), Freiberg's disease (metatarsal head, usually the second) and Perthes' disease, which affects the femoral head in younger children.

Extra-articular osteochondroses

The extra-articular osteochondroses, also known as traction apophysitis, are the most common of the osteochondroses seen in children and adolescents. The condition results from excessive traction of tendon or ligament on an unfused apophysis and the degree of symptoms seen in these conditions appears to closely mirror training and playing loads in young athletes. These osteochondroses are benign and self-limiting without risk of significant complications; however, they can cause significant distress to the young athlete and their family through missed sport and activity. Traction apophysitis is a clinical diagnosis and imaging is not mandatory and should be reserved for when symptoms are atypical, ongoing or increasing without explanation.

A typical example of this type of osteochondrosis is Sever's disease or traction apophysitis of the calcaneal apophysis. The clinical picture is that of heel pain in a growing active child, which worsens with activity (see case study 2 on page 39). Symptoms may be unilateral or bilateral and the condition is seen most commonly in boys between the ages of

CASE STUDY 1: ELBOW PAIN IN A BOY WHO PLAYS BASEBALL

A 12-year-old boy presented with right elbow pain. He was a baseball pitcher who initially noticed intermittent pain on the medial aspect of his elbow after training and games. He was then selected for the state baseball team in his age group and with an increase in his training load his medial elbow pain worsened and he developed lateral elbow pain.

On clinical examination, the boy had tenderness of both the medial and lateral aspects of the elbow. A diagnosis of traction apophysitis of the medial epicondyle was made and a plain radiograph was arranged due to the presence of lateral elbow pain. The x-ray demonstrated flattening, sclerosis and fragmentation of the capitellum consistent with osteochondritis dissecans of the elbow.

The boy was referred to an orthopaedic surgeon, who arranged an MRI to further assess the injury. A decision to treat conservatively was made. He was initially restricted from all throwing until his pain settled entirely. He was referred to a physiotherapist for a stretching and strengthening program and his coaches were contacted to ensure excessive training loads were limited. An analysis of his pitching technique was also arranged to correct any technique errors in an effort to minimise re-injury upon his return. Following these measures, the boy was able to make a successful graded return to full activity.

10 and 13 years, the time at which the calcaneal apophysis begins to ossify. The onset of heel pain is usually gradual with a clear history of being aggravated by activity.

Examination reveals reproduction of pain with ankle dorsiflexion and tenderness on palpation of the heel. Swelling of the heel and calcaneal enlargement may be present.

Other examples of this group of osteochondroses are Osgood–Schlatter's disease (affecting the apophysis of the tibial tubercle at the insertion of the patellar tendon), Sinding–Larsen–Johansson disease (affecting the inferior pole of the patella) and Iselin's disease (affecting the base of the fifth metatarsal).

Principles of management of osteochondroses

The osteochondroses are very different in their characteristics and presenting

CASE STUDY 2: HEEL PAIN IN A 13-YEAR-OLD BOY

A 13-year-old boy presented with activity-related heel pain, noted to be worse towards the end of the day and aggravated by running. He gave no history of a specific injury. He had recently started two additional training sessions per week after being selected for his regional junior rugby league team in addition to his usual club and school-based rugby league competitions.

On examination he had tenderness of the heel at the insertion of the tendo Achilles. Forced dorsiflexion of the ankle reproduced his pain. He was also noted to have bilateral flat feet. A diagnosis of Sever's disease (traction apophysitis of the calcaneus) was made based on his history and clinical findings.

The boy was given advice to apply ice to his heels after exercise. Orthotics were prescribed to provide a heel raise to unload the apophysis as well as to provide some medial arch support to prevent excessive pronation of his foot. He was also given a calf-stretching program.

The boy's overall training load was reduced until his symptoms came under control. Swimming and cycling were substituted for running sports until the pain had settled. A graduated return to training and competition was made so that symptoms did not return immediately due to high training and playing loads.

The child and parents were reassured that Sever's disease is a self-limiting condition without significant complication. They were made aware that his symptoms could potentially recur intermittently with excessive training volume or load.

symptoms, thus making generalisations regarding management of all osteochondroses difficult. Management of patients with extra-articular osteochondroses (traction apophysitis) can be made easier if common principles are followed. Simply telling a child to give up his or her chosen sport is never satisfactory and usually not necessary in most cases. A more appropriate approach is explaining to the child and parents the reason for the injury, and the benign and self-limiting nature of the condition, inviting a proactive approach to the management by the young person and his/her respective carers. Such advice may include:

- reducing pain with local application of ice following activity
- using simple analgesics or NSAIDs
- reducing load on the apophysis by resting from aggravating activities such as running, jumping, kicking or throwing
- offering biomechanical support with appropriate footwear, a heel raise or orthotics.

In many cases referral to a physiotherapist, sports physician or paediatrician with a special interest in paediatric sports medicine is beneficial because this allows for analysis and correction of poor biomechanics, as well as advice on an appropriate stretching and or strengthening program of involved or related muscle groups. This is essential not only in treating the pain in the first instance, but also in ensuring a timely return to sport without immediate exacerbation of symptoms with increased levels of activity.

ALTERNATIVE PATHOLOGIES

A number of potentially important diagnoses have their symptoms attributed to musculoskeletal injury in active children and adolescents. Night pain and significant pain despite rest are red flags to alert the clinician to serious pathologies such as leukaemia, which can present initially as musculoskeletal pain or swelling alone, or malignant bone tumours, which have an increased prevalence during adolescence.

Juvenile idiopathic arthritis is another condition where unrelated minor falls or high training loads are often blamed as the cause for musculoskeletal symptoms. Persistent joint swelling and the presence of morning stiffness are useful keys in differentiating between arthritis and chronic sports- and exercise-related conditions such as the osteochondroses. It should be noted, however, that there is the potential for overlap of symptoms with one subtype of juvenile idiopathic arthritis called enthesitis-related arthritis manifesting with the presence of not only arthritis but also inflammation of the enthesis (the structure that attaches tendons and ligaments to bone). These children will present with pain and tenderness over the same location as those with a traction apophysitis, making the differentiation between the two conditions potentially difficult on clinical examination alone.

CONCLUSION

The assessment and management of musculoskeletal sporting injuries in children requires an understanding of the biological differences between children and adults and the age-specific injuries children may sustain. With this knowledge, the clinician will gain great satisfaction from caring for these patients and their families through facilitating their return to sport and physical activity. MT

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References are included in the pdf version of this article available at www.medicinetoday.com.au.

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