Treatment of overuse injuries in children

Richard Gouron

Chief of Department of Pediatric Surgery. Department of Pediatric Orthopaedic Surgery Amiens University Hospital. SSPC Laboratory (Simplification des Soins des Patients Chirurgicaux Complexes) Picarde Jules Verne University.
Institut Fédératif GRECO (Groupe de Recherche En Chirurgie rObotique) Picarde Jules University.

Introduction

The intensity of physical exercise in children is constantly increasing [1,2] and many of these children practice multiple types of sports with decreasing periods of rest at the end of the sporting season. This leads to permanent overuse of the musculoskeletal system [3]. Moreover, children have a tendency to specialize in one type of sport precociously, with a constant premature increase in intensity, thereby leading to an overt risk of overuse injuries [4].

Repeatedly stressing the bones, muscles and tendons without appropriate recuperation and healing times leads to mictrotrauma of these structures. The growth plate is physiologically vulnerable, especially at the level of the apophyses where the strained tendons attach, leading to specific injuries. The physis and the epiphysis might also be stressed which could lead to intraarticular lesions. Finally, repetitive compression and traction of a bone may lead to bone marrow edema and stress fractures of the diaphysis, metaphysis, or the spine (spondylolysis).

The treatment of these injuries must be aimed at the entire pathophysiological process of the overuse injury and, of course, at the specific lesions and local consequences cause by this increased load.

General principles

Rest is the basis of the treatment of overuse injuries and should be absolute, unless severe intra-articular injuries have occurred. Depending on the severity of the lesion and pain, training may be simply adapted to the patient's injury or the specific movement that is overloading a certain joint modified [5].

Immobilization is sometimes useful in alleviating pain or in facilitating the healing of a bony fragment.

Conventional painkillers or NSAIDs are rarely prescribed since artificial pain relief might encourage the child to return to sports prematurely, thereby leading to further overuse and exacerbation of the injury. Furthermore, peritendinous or peri-apophyseal injections must be avoided [5].

Surgery may be indicated in some cases in order to facilitate healing, remove or repair an loose osteochondral fragment, or treat sequelae of a previous injury.

Patience is key in overuse injuries since a significant proportion of these injuries (of the physes or apophyses) will spontaneously heal during puberty as the growth plates begin to fuse and the pelvis reaches Risser grade 1. Overuse injuries are diverse, and every anatomical site and type of injury (apophysis, epiphysis, physis or stress fracture) has its own characteristics.

Treatment of apophyseal injuries

General principles [6]

The first step in the management of apophyseal injuries is relative rest. The presence of residual pain will guide management to either need for further rest or return to sports. If pain is experienced at the level of the apophysis during physical exercise, sports should be restricted for a period of days to weeks. Return to sports may be achieved progressively with, at first, restricted training times, until the patient's previous level of intensity is reached. If symptoms reoccur, activity is once again either reduced or withheld.

The family, school and trainer must be informed that adjusting the training volume depending on the child's pain may be considered. For high-performance athletes, a sporting activity that spares the injured joint may be authorized in order to maintain cardiovascular conditioning.

Extremely painful episodes may be managed by temporarily immobilizing the limb. This immobilization must not be too prolonged in order to avoid muscular atrophy.

Painkillers may be prescribed, although local treatments such as icing are preferable. Finally, physical therapy is sometimes useful in increasing the tightened muscle's flexibility and length – an integral part of the pathophysiology of apophysitis – and should be initiated as soon as the apophyseal pain has subsided. In fact, continued strain on the apophysis during rehabilitation may maintain the microlesion that is at the source of the symptoms that the physical therapist is attempting to treat. Daily stretching programs may therefore be simpler and more useful than formal physical therapy.

Return to normal sporting activity is allowed depending on the non-recurrence of the injury by maintaining adequate flexibility and proper muscular length.

Elbow [3]

Medial epicondyle apophysitis, secondary to valgus loading in patients with open medial epicondylar growth plates (between 9 and 12 years), is frequently encountered in tennis and baseball players. The initial treatment is limiting the activity causing the increased load (e.g. pitching) along with local treatments such as icing. Adequate joint range of motion should be maintained as soon as symptoms decrease in order to avoid stiffness. Furthermore, young athletes should maintain some sort of physical activity in order to preserve their cardiovascular conditioning. Return to sports is achieved progressively while limiting the number of pitches or serves in tennis players. In addition, premature return to sports may

lead to recurrence of the injury, medial epicondylar hypertrophy, or an apophyseal avulsion fracture requiring surgical fixation.

Pelvis and hip

Apophyseal injuries of the iliac spine, ischium, or lesser trochanter are essentially avulsion fractures secondary to the attachments of the tendons [7]. The treatment is very frequently symptomatic. Rest with unloading of the limb and bed rest for a period of 7 to 10 days is recommended. The patient's position during this time should reduce the strain of the tendon in question (e.g. flex hip for injuries of the anteroinferior iliac spine caused by traction of the rectus femoris).

Weight bearing is returned progressively. Potential muscle tightness must be assessed and treated by stretching as soon as the pain subsides. Return to sporting activities is generally allowed after the second month. Repositioning and surgical fixation should be discussed but does not allow a faster return to sports. Nevertheless, a recent meta-analysis showed a return to sports at a higher level after surgery compared to conservative treatment and recommends that fragments with a displacement superior to 15mm be treated with surgical fixation, especially in high-level athletes [8].

Knee

Apophyseal injuries of the knees are essentially chronic injuries, such as Osgood-Schlatter disease of the tibial tuberosity and Sinding-Larsen-Johansson syndrome of the tip of the patella. Treatment consists primarily of relative rest. Cessation of all sports that are at the origin of the increased strain on the apophysis will lead to progressive pain relief. Return to sports is achieved progressively with an adjustment of the volume and intensity of the training and is primarily guided by the persistent symptoms. Painkillers and local treatments such as icing are also useful.

Immobilization with a knee brace may considered if symptoms are severe or resistant to symptomatic treatment. Once a pain-free return to sports has been achieved, patients with Osgood-Schlatter disease or Sinding-Larsen-Johansson syndrome must maintain adequate flexibility of the quadriceps and hamstrings in order to limit strain and traction on the apophysis and decrease the risk of injury recurrence [7,9]. In fact, a direct link has been found between symptomatic Osgood-Schlatter disease and muscle tightness [10].

Intratendinous heterotopic ossifications may be a potential complication of apophysitis and require surgical excision if pain is experienced on the long term despite physeal closure [3,7,11].

Ankle and foot

Apophysitis of the greater tuberosity of the calcaneus (Sever disease) is frequently encountered in children between 8 and 12 years of age [7] and treatment is always symptomatic. Initially, physical exercise must be limited until the pain subsides. A triceps surae stretching program must then be initiated since posterior chain tightness is a fundamental element of Sever disease [9,11]. Commercial elastomer insoles may be

prescribed decreasing ground reaction forces during gait. Nevertheless, these insoles must reduce the shock all the while avoiding concealing any equinus that may be due to a tight heel cord. In fact, such equinus would only exacerbate the traction forces on the calcaneal apophysis.

More severe pain may require offloading the affected limb with crutches or a wheelchair. Immobilization with a short leg cast or a walking boot for a period of 3 to 4 weeks may sometimes also be useful in more severely painful episodes [9].

Other osteochondrites of the foot are rarely encountered. Navicular injuries are managed with symptomatic treatment. The bone is physiologically reconstructed over a period of months, during which intense sporting activities must be suspended and plantar orthoses supporting the medial arch, or even short periods of immobilization, may be utilized depending on the severity of the pain [7].

The treatment of Iselin disease (base of the 5th metatarsal), Renander disease (sesamoid of the greater toe), and Freiberg disease (head of 2nd metatarsal) is identical to Sever disease. Rarely, in some patients with Freiberg's disease, an osteotomy of the head of the 2nd metatarsal may be necessary [7].

Treatment of epiphyseal injuries

Elbow

Osteochondritis of the lateral condyle of the elbow, or Panner disease, occurs in very young children and presents primarily as painful and limited elbow extension without locking sensations or intra-articular loose bodies. The natural history of the disease always progresses toward healing.

Treatment is therefore only symptomatic with painkillers, restriction of sporting activities, and exceptionally immobilization until symptomatic relief over 12 to 18 months [7,12]. Osteochondritis dissecans of the capitellum, occurring essentially in adolescents, presents a similar clinical scenario with sometimes locking and clicking due to loosening of an osteochondral fragment within the joint.

Treatment depends on the stability of the osteochondral fragment. Stability is generally evaluated using MRI: instability is evidenced by an increased signal intensity surrounding the osteochondral fragment on T2-weighted images [12].

In patients with stable lesions, rest and restriction of all physical exercise causing excessive valgus load on the elbow, such as gymnastics, for a period of at least 6 months is recommended. Patients with persistent signs of instability or with an intra-articular loose body after a period of conservative management may benefit from surgery [11,12], preferably by arthroscopy. Arthroscopic management consists of debridement of the osteochondral area and removal of the loose osteochondral fragment from the joint space. Perforating the lesion area may relieve the pain and facilitate healing, especially in skeletally mature patients [13]. For lesions larger than 10mm, osseocartilaginous grafts are generally used [14].

Knee

Juvenile osteochondritis dissecans of the knee often only requires symptomatic treatment [9]. The lesions are generally stable with an intact joint line. Load from physical exercise should be reduced for a minimum of 6 months, although weight bearing is authorized. A short non-weight-bearing period may be indicated if pain is the primary complaint [7]. MRI determines the presence of associated cartilaginous lesions and guides management. Unlike in adults, an increased signal intensity on T2 images in children does not indicate instability of the osteochondral fragment [15]. If the osteochondral fragment is smaller than 2.5 cm^2, half of patients achieve healing over a period of 6 months, with the rest almost always within 18 months [7]. In patients in whom healing is delayed, extra-articular perforations of the osteochondral area through the epiphysis may be considered in order to increase vascularization and facilitate consolidation, all the while preserving the articular surface [9,16]. If the cartilage is injured, arthroscopy may be used to assess and then perforate the damaged area through the joint line in order to accelerate healing. Loose osteochondral fragments within the joint may also be removed via arthroscopy. If the fragment is large enough, fixation must be attempted even though healing is not guaranteed. However, if the same fragment is on a weight-bearing portion, then osteochondral mosaicplasty may be attempted [17].

Talus

Osteochondral lesions of the talus may be either anteromedial (primarily as a complication of a sprain) or posteromedial, with the latter being the most frequent location of osteochondrosis [7]. Treatment consists primarily of complete sporting restriction. Radiographic and MRI surveillance are used to guide the remainder of the treatment. These lesions may heal spontaneously over several months, although chondral lesions may require perforation either by arthroscopy or arthrotomy with sometimes a trans-malleolar approach to better expose the injured area.

Treatment of physeal injuries

General principles

Physeal injuries may be due to acute trauma, the treatment of which is within the realm of general trauma and will not be detailed in this chapter. Overuse injuries of the growth plate may occur in young athletes and at different anatomical locations, and be due to different types of sports. The majority of these lesions heal without complications by simply limiting physical exercise. However, epiphysiodesis has been described in rare instances sometimes resulting in a varus deformity of the knee secondary to injury to the distal femoral or proximal tibial growth plate in rugby and tennis players [18].

These injuries can be prevented; Training intensity and load on the physes during growth spurts should be limited. Exercise should be varied during training in order to avoid overly straining a single joint. Proper physical preparation with appropriate warm-ups, proprioception training and stretching must be compulsory. Trainers must further be educated on the actuality of these pathologies. Finally, in order to properly rest the physes,

the periodic nature of training sessions must be respected, and resting periods, particularly summer breaks, must be imposed [18].

Shoulder

At the level of the shoulder, overuse of the proximal humeral physis (leading to widening of the physis and epiphysiolysis of the humerus) is treated by suspension of sporting activities for a period of 3 months (often baseball pitchers, gymnasts, tennis players, volleyball players, or swimmers) [7,11]. A program based on strengthening, better pitching mechanics, and physiotherapy is suggested for high-level athletes [6]. A preexisting deficit in internal rotation of the glenohumeral joint is a predisposing factor for these sorts of injuries in children. Recurrence of injury is common (7% at 7 months) and 3 times more frequent in children with a preexisting deficit in internal rotation [19].

Wrist

At the level of the wrist, physeal injuries are frequently encountered in gymnasts, especially in patients in whom the ulna is shorter than the radius [7,20]. Treatment is based on interruption of sporting activities and immobilization in an attempt to avoid premature closure of the physis [7]. Cast immobilization is preferred over splinting in order discourage premature mobilization by children who may be pressured by their trainers or parents. More severe injuries found on imaging may require longer recuperation periods. As a result, some authors prefer early screening of radial physis injuries in gymnasts [20]. The complete fusion of the distal radius is one complication of these types of sports injuries and may require distal ulnar epiphysiodesis or an ulnar shortening osteotomy [21].

Knee

Overuse injuries of the physes of the distal femur may be visualized on conventional radiographs as a widening of the physis, although a more adequate diagnosis may be made on MRI. Healing is always achieved with a return to normal growth by simply limiting physical exercise, and the use of a knee brace may accelerate recuperation. Return to normal activity in over 3 months is determined both clinically and after normalization of imaging. Rest is an essential component of treatment since non-compliance may lead to axial deformities of the knee [9,22].

Treatment of stress fractures

Overuse leading to stress fractures are common and may be seen in 13 to 50% of young athletes, depending on the practiced sport [6]. Conventional radiographs have a sensitivity of only 10% in the acute setting. The diagnosis is usually made on MRI. Findings in the acute setting may be limited to simple periosteal edema without a clear fracture line, whereas more advanced stages tend to show a complete fracture line [23].

Management is preferentially undertaken on an individual basis depending on the site of injury, age of the child, and practiced sport. Nevertheless, the general principles of treatment include reduction of the load to allow proper healing. Immobilization, protected weight-

bearing (e.g. using a walking boot or a long pneumatic splint) or full-weight-bearing using crutches may further reduce the load and control the pain. It is recommended to alternate training with activities sparing the injured limb, such as biking or swimming, in order to maintaining cardiovascular conditioning [6]. Return to sports must be done progressively after complete resolution of the pain and radiographic signs of healing are evident, A process requiring around 3 to 4 months in periosteal forms, and 6 months in patients with an actual fracture [6,23]. Management is exceptionally surgical but may be indicated in certain rare cases, such as stress fractures of the femoral neck with progressive displacement or a non-union. These patients are generally treated by osteosynthesis similar to conventional fractures [24].

Prevention

The best treatment of overuse injuries is prevention by acting early and addressing the multiple pathophysiological elements that are at the origin of these injuries.

Early specialization

Early sports specialization is one of the primary causes of overuse injuries [25,26]. This generally entails intense training throughout the year for a single type of sport while excluding other types of physical exercise [27]. In fact, there has been an increase in training intensity in young children, the majority of which are already specialized before the age of 7 years. Participating in multiple types of activities allows skill transfer from one sport to another and a better overall development of young athletes [28]. This variety in sporting activities also allows a more balanced neuromuscular development and a decrease of the repetitive stresses over the same joints [27]. As a result, preventing overuse injuries must imperatively include a varied approach to the volume and quality of physical exercise in these young athletes.

Lifestyle

Similar to adults, high-level athletic children must maintain a healthy lifestyle. This allows the proper conditioning for the body to endure the repetitive load it is subjected to during physical exercise. An adapted diet, proper hydration, and sufficient sleep (more than 8 hours per night) all play a major role in limiting these overuse injuries [7,27,29]. Finally, the equipment must be adapted to the type of strain caused during exercise (proper socks, softer balls in children…) [7].

Adapting training frequency

The volume and quality of training must be evaluated. There is a broad consensus on the rule of 10%, which states that the work done must not increase more than 10% per week in order to allow better recuperation. Depending on the type of sport, this signifies that training time, weight, distance, and speed must not increase by more than 10% [7]. Trainers must also be included while adapting the quality of the training program. This allows for a better analysis of the child's athletic techniques and performance errors. The total weekly time spent training is also important: if this time is superior to 16 hours per week, the risks of sustaining an injury

increase significantly [6]. Moreover, a minimum of 1 day per week and 3 months per year must be afforded for adequate rest and recuperation.

Flexibility

Musculotendinous tightness is an essential element of overuse injuries [10]. Flexibility both improves the child's performance and avoids increased strain on the apophyses. Regular stretching sessions (quadriceps, hamstrings, triceps surae) should be mandatory. However, these stretching sessions should preferentially take place at a distance from the training session, since they can aggravate the muscular microlesions that have been sustained during exercise. These sessions are preferentially held during dedicated periods after apophyseal pain has subsided and follow a thorough program [7].

Adapting training during puberty

Trainers and parents must be continually aware of the child's pubertal stage. In children younger than 12 years old, growth plate fragility makes the occurrence of an overuse injury more likely if both training intensity and volume are not adapted.

The pubertal status must be favoured over chronological age, since, in a similar age group, there are evidently differences in stages of pubertal development between children. In some children, certain movements risk placing too much stress on certain joints, and training must be adapted on an individual basis [7].

Conclusion

The majority of overuse injuries are benign, and their treatment is often simple and solely symptomatic, relying primarily on common sense and adaptation of the sporting activity based on the athlete's age. The means of prevention must be well known by children, parents, and trainers.

Cessation of sports is always the initial management strategy, and after returning to sports, children must be aware or early signs of recurrence.

Even though immobilization, or even surgery, may sometimes be necessary, adapting the activity based on the child's age and pubertal status is the primary element in management and dictates treatment outcomes.

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