Chapter 15
Sports Medicine in the Adolescent and Young Adult Athlete

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Introduction

Physical activity (PA) in adolescence can optimise musculoskeletal development and help maintain healthy weight. Optimal physical health positively impacts neuromuscular, cardiovascular and cognitive development, as well as benefitting mood, sleep, academic attainment and social behaviour [1].

Despite ultimately increased musculoskeletal and aerobic capacity to undertake physical activity through maturation, many AYA stop sport during adolescence. Reasons are multifactorial including competing social and educational pressures and self-inhibition during puberty. Physical inactivity (PIA) during formative years is increasing: higher adiposity and lower aerobic fitness in AYA map to higher risk of morbidity from non-communicable chronic disease in adulthood [2]. Conversely, higher rates of aerobic fitness and muscular strength are linked to lower morbidity, lifelong [3]. Every healthcare consultation represents an opportunity to promote physical activity for the health of AYAs.

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Sports-Related Injury in Young People

Most musculoskeletal injuries in AYA are minor, relating to muscle, ligament and tendon. Boys are more active than girls at all ages and more likely to participate in high impact and contact sport, sustaining higher injury rates [4]. Contact and jumping sports have the highest injury rates, and early specialisation is linked to overuse injuries (see below). Elite young athletes' training programmes may be protective with relatively lower injury rates seen [5].

Management of minor muscular injury, e.g. a contusion or muscle strain, should follow the principle of rest, ice, elevation and compression. Whilst recovery is usually straightforward, there may be a need to review training, technique or equipment errors.

Bony Sport-Related Injuries

Physeal Fracture

In the older child and adolescent, 30% of acute fractures involve the developing growth plate (*physis*). This is a common site in impact injury, such as a fall following a rugby tackle. The growth plate is vulnerable to injury at the junction between calcified and uncalcified hypertrophying cells, where turnover is rapid.

Investigations

X-rays taken in two planes, with oblique views and with classification made according to the Salter-Harris system.

Management

Cast immobilisation and reduction to reduce the risks of growth disturbance at the affected site.

Spondylolysis and Spondylolisthesis

Spondylosis and spondylolisthesis occur more frequently in the young sporting population repetitively loading into extension, with rotation of the spine (e.g. cricket, gymnastics).

Spondylolysis

Spondylosis is a defect of the vertebral arch at the pars interarticularis. The pars elongates during growth and is susceptible to stress from excessive repetitive loading and torsion. An underlying dysplastic pars is often found, with a genetic link to the condition. Ninety percent of cases occur at L5.

Presentation

Unilateral back pain can be pathognomonic, although symptoms of non-specific persistent back pain in the AYA should raise suspicion. Injury affects may be bilateral.

Investigations

X-ray may demonstrate acute fracture; however, sensitivity is limited, and stress reactions will not usually be seen. Both computed tomography (CT) and magnetic resonance imaging (MRI) can identify signs including deviation of the spinous process and sclerosis of the contralateral pedicle.

MRI and single-photon emission computed tomography (SPECT) scintigraphy can usefully elucidate bony oedema where stress reaction, but not a cortical breach, has occurred.

Management

Rest for 4–6 weeks is guided by pain resolution, with aim for osseous union and to prevent progression to spondylolisthesis.

Spondylolisthesis

Spondylolisthesis refers to displacement of the vertebra in relation to the vertebra below. In the AYA population, this can occur secondary to bilateral pars fractures and usually presents with bilateral, localised back pain with potential nerve root compromise. Full neurological assessment should be performed. Imaging is as for spondylosis.

Management

Spondylolisthesis is graded according to the degree of slippage. Less than 50% displacement is managed conservatively, with rest, analgesia and bracing used in combination with rehabilitation. Once pain settles, a comprehensive approach to posture, strengthening and movement patterns is required before specific return to sport. Less than 5% of patients have more significant slippage and require surgery (e.g. fusion, decompressive laminectomy).

Avulsion Fractures

Sudden muscular force upon immature bone can cause bony avulsion at the tendinous attachment. Presentation is typically sudden pain, difficulty weight bearing and point tenderness after explosive activity. Chronic microtrauma from repetitive overload may lead to avulsion injury. Common bony sites for avulsion fractures are shown in Table 15.1.

Investigations

Radiographs demonstrate the bony injury. Ultrasound is increasingly available and can delineate the muscle insertion, and MRI can evaluate bony oedema. CT is not recommended first line in view of radiation exposure however may be considered if diagnosis is unclear or a surgical approach is considered.

Table 15.1 Common sites of avulsion injury

Bony avulsion	Muscle origin/ insertion	Mechanism	Sporting
Ischial tuberosity	Hamstrings (origin)	Passive hamstring lengthening (gymnastics) Explosive passive lengthening of habitually contracted hamstrings	Gymnastics, running
Anterior-inferior iliac spine	Rectus femoris (origin)	Forceful hip-flexion, knee extension	Football, athletics, tennis
Anterior superior iliac spine	Sartorius (origin)	Forceful hip-flexion, knee extension	Football, athletics, gymnastics
Pubic symphysis	Rectus abdominis (insertion)	High-velocity forces through trunk	Football, fencing
Iliac crest	Abdominal muscles (insertion)	High-velocity rotation through trunk; change of direction	Football, gymnastics, tennis
Lesser trochanter	Iliopsoas (insertion)	Excessive passive stretch of chronically shortened muscles	Athletics

Management

Rest from aggravating activity with appropriate analgesia with rehabilitative physiotherapy.

Recovery can be prolonged. Surgical opinion should be sought for a significantly displaced fragment.

Overload Injury

Chronic Growth Plate Injury

Overuse injury can be sustained in AYA who specialise early in a sport or overtrain, relative to the body's ability to grow and repair.

Presentation

Pain is initially confined to sports practice, becoming pervasive if aggravating activity is continued. On examination, decreased range of active and passive movement at the joint is typical. Pain persisting at rest and reduced range of movement may indicate a stress fracture.

Investigations

Early radiographs may be normal. Widening at the growth plate indicates a failed healing response and repetitive microtrauma to the developing bone. A fracture at the growth plate requires orthopaedic review.

Management

Initial rest from sport is usually required for 3–6 months.

Successful rehabilitation and return to sport should involve a graded programme, modifying excessive training practices.

Traction Apophysitis

The cartilaginous apophysis contributes to circumferential growth. In repetitive sport, repetitive traction forces through tendon, and ligamentous attachments can cause osteochondral stress. Presentations peak between ages 8 and 15, and this injury occurs more frequently in males.

Common sites are summarised in Table 15.2 below.

Presentation

Pain associated with impact, local tenderness over the apophyseal prominence.

Table 15.2 Common sites of traction apophysitis in adolescents

Common traction apophysitis site		Name	Enthesis	Insertion
Upper limb	Elbow	Medial epicondylar apophysitis	Ulnar collateral ligament	Medial epicondyle
Lower limb	Hip region		Gluteus medius minimus Sartorius Rectus femoris Hamstring	Greater trochanter ASIS AIIS Ischial tuberosity
	Knee	Osgood-Schlatters	Patella tendon	Tibial tubercle
	Knee	Sinding-Larsen-Johansson	Patella tendon	Distal pole patella
	Heel	Severs calcaneal apophysitis	Achilles tendon	Calcaneum
	Foot	Iselin's disease	Peroneus brevis and tertius	5th metatarsal

Investigations

Apophysitis can be diagnosed clinically; however, differentials include inflammation, epiphysitis or, rarely, soft-tissue tumour. A thorough history is required, and radiological imaging may be justified to exclude underlying disease.

Management

Conservative management succeeds in 90% cases with rest from aggravating activity and local ice treatment. Topical or systemic non-steroidal anti-inflammatory medication may be useful although lacks evidence for efficacy. Alternative PA (e.g. cycling, swimming) should be encouraged, to maintain cardiorespiratory fitness. In some cases, symptoms persist for 2–3 years until growth plate fusion.

Bone Stress Injury

High-impact, multidirectional loading of bone during adolescence leads to remodeling, strengthening the bone during skeletal maturation. However, excessive bone loading with suboptimal recovery can exceed bone capacity for adaptation. Micro-fractures in the cortex propagate with accelerated osteoclast remodeling. Periosteal oedema, local hypoxia and chemical stimuli can lead to progression of injury (Fig. 15.1) resulting in stress fracture. The tibia is the most frequent site of stress fracture (40%) followed by the metatarsal (25%). Sports-specific stress fracture patterns are seen, such as the rib in rowers and the lower back in cricketers (see above). The young athlete who continues to train through pain can develop a frank cortical fracture. Complete fracture at a high-risk site can be catastrophic, for example, at the neck of femur.

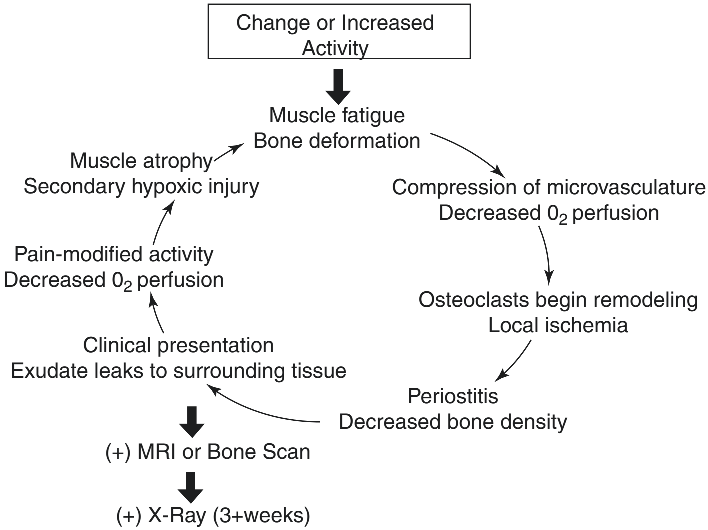

FIGURE 15.1 Cyclic aetiology of stress fracture formation. Changes or increases in activity intensity cause muscle fatigue, bone deformation and compression of the bone's microvasculature. (Reproduced with permission: from Romani et al. [6]

Presentation

Insidious pain during sporting activity becomes more persistent with continued training.

Acute presentation may be with inability to weight bear with localised bony tenderness. There may be increased tone in surrounding musculature.

A history of sudden increment in training load, change in footwear or training surface should raise concerns for bone stress injury.

Investigations

Plain radiographs are frequently negative in a stress reaction, although delayed X-ray may reveal callus formation on long bones. MRI is the gold standard in diagnosis. Classification systems have been developed according to the degree of oedema identified [7]. Bone integrity should be assessed (see Chap. 16). All young athletes presenting with bone stress injuries should be assessed for extrinsic (e.g. training errors) and intrinsic risks (e.g. metabolic bone disease, overtraining or RED-S (see below) should be addressed).

Management

High-risk sites (see Table 15.3) should be referred for orthopaedic opinion. An isolated stress fracture in a young athlete should be treated with offloading with progress from non-weight bearing to weight bearing once pain-free. Rehabilitation can include cross-training and graded return to sport, usually at a minimum of 8 weeks.

Hip Pain in AYA

Femoroacetabular impingement (FAI) describes abnormal contact between the proximal femur and acetabulum and can be a source of pain in the young, non-arthritic hip. It may

Table 15.3 High-risk stress fracture sites

Neck of femur (superolateral-tension side)
5th metatarsal
Patella
Anterior tibia
Talus
Navicular
Sesamoids

predispose to osteoarthritis. FAI subtypes are ‘pincer’ lesions, acetabular overcoverage and ‘cam’ deformity (aspherical change in the femoral head that can lead to chondrolabral damage).

Aetiology is incompletely understood, with both genetic and acquired factors known.

High-impact repetitive loading to the proximal femoral physis during adolescence may predispose to ‘cam’ lesion formation [8].

Investigation

X-ray can measure asphericity, femoral head coverage and the alpha angle (the degree to which the femoral head deviates from spherical).

MR arthrography is most sensitive to diagnose cartilage damage and labral tears closely associated with FAI.

Management

Nonoperative management includes lumbopelvic strength and movement pattern training.

Surgical management may be arthroscopic or open hip surgery.

Adolescent Overtraining Syndrome and Relative Energy Deficiency

The *relative energy deficiency syndrome* (RED-S) describes low energy availability, calculated as energy intake minus the energetic cost of exercise relative to fat-free mass.

Excessive training and disordered eating are leading causes [9].

Presentation

RED-S may present as fatigue, overuse injury (see above), illness or unexplained underperformance. Training history should identify recent increases in volume or training type. The adolescent athlete should have lower training volumes than adult counterparts, and coaching support is advised.

Sensitive enquiry regarding history of disordered eating, pubertal development and female menstrual history should be made.

As shown in Fig. 15.2, RED-S is now known to have multisystem and long-term effects, highlighting the need for early identification in the young athlete.

Mechanism

Low energy availability causes hormonal and metabolic abnormalities and may result in nutritional deficiencies. Suppression of IGF-1, growth hormone and endogenous sex hormones occurs. Hypothalamic hypogonadism can occur in response to the body's attempts at energy conservation. Adolescent female athletes with primary or secondary hypothalamic amenorrhoea during the ages of peak bone mass attainment are at risk for osteoporosis, and low testosterone in males also negatively impacts bone mineral density (see Chap. 16).

Initial Investigations

Screen for other causes of low body weight and hormonal disruption or metabolic bone disease as well as pregnancy. Amenorrhoeic athletes should be referred to gynaecology.

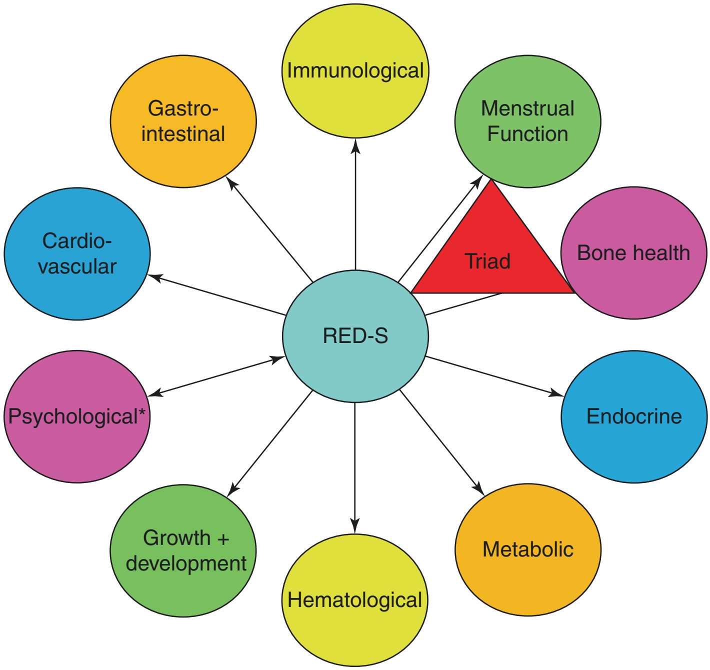

FIGURE 15.2 Health consequences of relative energy deficiency in sport (RED-S) (*Psychological consequences can either precede RED-S or be the result of RED-S). (Reproduced from The IOC consensus statement: Beyond the Female Athlete Triad—Relative Energy Deficiency in Sport (RED-S), Mountjoy et al. (2014), with permission from BMJ Publishing Group Ltd [9])

Management

A multidisciplinary approach is recommended, including medicine, nutrition and psychology. First line management for an athlete with REDS is cessation of sports training until positive energy balance is attained; in females it is best demonstrated by resumption of menses. Consequences of impaired bone health should be managed with metabolic bone and gynaecology input. In some cases, hormone replacement therapy may be instigated, but expert guidance is advised. For females, oral contraceptives may be detrimental to bone health and can mask the absence of periods. Concerns about disordered eating should prompt referral to specialist mental health and nutrition support. The RED-S protocol endorsed by the IOC recognises a 'traffic light' return to training protocol [9].

Summary

This chapter has covered the importance of physical activity in the young person and common patterns of injury presentation and management.

It is recommended that discussing physical activity is part of every consultation, from brief advice to signposting to specialist services. In this way, the healthcare professional can support the young person from the least active to the sportsperson, to attain the optimal benefits from PA which can be sustained into adulthood.

Key Management Points

- Physical activity in adolescence is important for development of a healthy musculoskeletal system and has beneficial effects on physical, cognitive and social development.
- Physical inactivity and obesity are increasing in adolescence and incur lifelong health-risks. The HCP working with adolescents can offer support to promote sustained participation in physical activity.
- Early specialisation in sport is linked to a higher risk of overuse injury with particular vulnerability around the growth centres in bones and joints.

- Whilst musculoskeletal injuries are relatively common in the active adolescent, a thorough work-up is required to recognise less common but serious conditions such as tumours of bone or inflammatory conditions which may present similarly.

Meeting the energy demands of sport can be challenging in the adolescent sporting population and an understanding of the principles of overtraining, overuse injury and the relative energy deficiency can help HCPs identify at-risk individuals.

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