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Sport injuries: a review of outcomes

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Injuries can counter the beneficial aspects related to sports activities if an athlete is unable to continue to participate because of residual effects of injury. We provide an updated synthesis of existing clinical evidence of long-term follow-up outcome of sports injuries. A systematic computerized literature search was conducted on following databases were accessed: PubMed, Medline, Cochrane, CINAHL and Embase databases. At a young age, injury to the physis can result in limb deformities and leg-length discrepancy. Weight-bearing joints including the hip, knee and ankle are at risk of developing osteoarthritis (OA) in former athletes, after injury or in the presence of malalignment, especially in association with high impact sport. Knee injury is a risk factor for OA. Ankle ligament injuries in athletes result in incomplete recovery (up to 40% at 6 months), and OA in the long term (latency period more than 25 years). Spine pathologies are associated more commonly with certain sports (e.g. wresting, heavy-weight lifting, gymnastics, tennis, soccer). Evolution in arthroscopy allows more accurate assessment of hip, ankle, shoulder, elbow and wrist intra-articular post-traumatic pathologies, and possibly more successful management. Few well-conducted studies are available to establish the long-term follow-up of former athletes. To assess whether benefits from sports participation outweigh the risks, future research should involve questionnaires regarding the health-related quality of life in former athletes, to be compared with the general population.

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Introduction

Participation in sports is widespread all over the world,[1] with well-described physical, psychological and social consequences for involved athletes.[2–5] The benefits associated with physical activity in both youth and elderly are well documented.[2,6–8] Regular participation in sports is associated with a better quality of life and reduced risk of several diseases,[1,9] allowing people involved to improve cardiovascular health.[10,11] Both individual and team sports are associated with favourable physical and physiological changes consisting of decreased percentage of body fat[12] and increased muscular strength, endurance and power.[13,14] Moreover, regular participation in high-volume impact-loading and running-based sports (such as basketball, gymnastics, tennis, soccer and distance running) is associated with enhanced whole-body and regional bone mineral content and density,[14,15] whereas physical inactivity is associated with obesity and coronary heart disease.[16] Sports are associated with several psychological and emotional benefits.[7,17,18] First of all, there is a strong relationship between the development of positive self-esteem, due to testing of self in a context of sport competition,[19] reduced stress, anxiety and depression.[20] Physical activities also contribute to social development of athletes, prosocial behaviour, fair play and sportspersonship[21] and personal responsibility.[22]

Engaging in sports activities has numerous health benefits, but also carries the risk of injury.[7,23,24] At every age, competitive and recreational athletes sustain a wide variety of soft tissue, bone, ligament, tendon and nerve injuries, caused by direct trauma or repetitive stress.[25–35] Different sports are associated with different patterns and types of injuries, whereas age, gender and type of activity (e.g. competitive versus practice) influence the prevalence of injuries.[7,36,37]

Injuries in children and adolescents, who often tend to focus on high performance in certain disciplines and sports,[24] include susceptibility to growth plate injury, nonlinearity of growth, limited thermoregulatory capacity and maturity-associated variation.[9] In the immature skeleton, growth plate injury is possible[38] and apophysitis is common. The most common sites are at the knee (Osgood-Schlatter lesion), the heel (Sever's lesion) and the elbow.[39] Certain contact sports, such as rugby, for example, are associated with 5.2 injuries per 1000 total athletic exposures in high school children (usually boys). These were more common during competition compared with training and fractures accounted for 16% of these injuries, whereas concussions (15.8%) and ligament sprains (15.7%) were almost as common.[40]

Sports trauma commonly affects joints of the extremities (knee, ankle, hip, shoulder, elbow, wrist) or the spine. Knee injuries are among the most common. Knee trauma can result in meniscal and chondral lesions, sometimes in combination with cruciate ligament injuries.[37] Ankle injuries constitute 21% of all sports injuries.[41] Ankle ligament injuries are more commonly (83%) diagnosed as ligament sprains (incomplete tears), and are common in sports such as basketball and volleyball. Ankle injuries occur usually during competition and in the majority of cases, athletes can return to sports within a week.[42] Hip labral injuries have drawn attention in recent years with the advent of hip arthroscopy.[43,44] Upper extremity syndromes caused by a single stress or by repetitive microtrauma occur in a variety of sports. Overhead throwing, long-distance swimming, bowling, golf, gymnastics, basketball, volleyball and field events can repetitively stress the hand, wrist, elbow and shoulder. Shoulder and elbow problems are common in the overhead throwing athlete whereas elbow injuries remain often unrecognized in certain sports.[45] Hand and wrist trauma accounts for 3–9% of all athletic injuries.[46] Wrist trauma can affect the triangular fibrocartilage complex[47] or cause scaphoid fractures,[48] whereas overuse problems (e.g. tenosynovitis) are not uncommon.[49] Spinal problems can range from lumbar disc herniation,[39–42] to fatigue fractures of the pars interarticularis,[50] and 'catastrophic' cervical spine injuries.[51]

Thus, in addition to the beneficial aspects related to sports activities, injuries can counter these if an athlete is unable to continue to participate because of residual effects of injury. Do injuries in children, adolescents and young adults have long-term consequences? What are the outcomes of the most commonly performed surgical procedures? The aim of this review is to provide an updated synthesis of existing clinical evidence of long-term follow-up outcome of sports injuries.

Literature search

An initial pilot Pubmed search using the keywords 'sports', 'injury', 'injuries', 'athletes', 'outcome', 'long term', was performed. From 1467 abstracts that were retrieved and scanned we identified the thematic topics (types of injury, management, area of the body involved) of the current review, listed below:

(i) Physeal injuries and growth disturbance

(ii) Residual problems after injury in athletes
   (a) Osteoarthritis (OA) in former athletes
   (b) Spine problems in former athletes
   (c) Knee injury and OA

   (d) Ankle ligament injury and OA
   (e) Residual upper limb symptoms in the ‘overhead’ athlete

(iii) Outcomes of operative management of common sports injuries
   (a) Meniscectomy and OA
   (b) Meniscal repair in athletes
   (c) Anterior cruciate ligament (ACL) reconstruction and OA
   (d) ACL reconstruction in children
   (e) Ankle arthroscopy in athletes
   (f) Hip arthroscopy in athletes
   (g) Operative management of shoulder injuries in athletes (focusing on surgery for instability and labral tears)
   (h) Operative management of wrist injuries in athletes (focusing on triquetral fibrocartilage complex, TFCC, injuries and scaphoid fractures)

Then a more detailed search of PubMed, Medline, Cochrane, CINAHL and Embase databases followed. We used combinations of the keywords: ‘sport’, ‘sports’, ‘youth sports’, ‘young athletes’, ‘former athletes’, ‘children’, ‘skeletally immature’, ‘adolescent’, ‘paediatric’, ‘pediatric’, ‘physeal’, ‘epiphysis’, ‘epiphyseal injuries’, ‘hip’, ‘knee’, ‘ankle’, ‘spine’, ‘spinal’, ‘shoulder’, ‘elbow’, ‘wrist’, ‘football players’, ‘football’, ‘soccer’, ‘tennis’, ‘swimmers’, ‘swimming’, ‘divers’, ‘wrestlers’, ‘wrestling’, ‘cricket’, ‘gymnastics’, ‘skiers’, ‘baseball’, ‘basketball’, ‘osteoarthritis’, ‘former athletes’, ‘strain’, ‘contusion’, ‘distortion’, ‘injury’, ‘injuries’, ‘trauma’, ‘drop out’, ‘dropping out’, ‘attrition’, ‘young’, ‘ youth’, ‘sprain’, ‘ligament’, ‘ACL’, ‘cruciate ligament’, ‘meniscus’, ‘meniscal’, ‘chondral’, ‘labrum’, ‘labral’, ‘reconstruction’, ‘arthroscopy’, ‘throwing’, ‘overhead’, ‘rotator cuff’, ‘TFCC’, ‘scaphoid’, ‘osteoarthritis’, ‘arthritis’, ‘long term’, ‘follow-up’ and ‘athlete’. The most recent search was performed during the second week of November 2009.

Given the different types of sports injuries in terms of location in the body, several searches were carried out. The search was limited to articles published in peer-reviewed journals.

From a total of 2596 abstracts that were scanned, 1247 studies were irrelevant to the subject and were excluded. The remaining studies were categorized in the topics identified earlier. We excluded from our investigation case reports, letter to editors and articles not specifically reporting outcomes, as well as ‘kin’ studies (studies reporting on the same patients’ population). The most recent study or the study with the longest follow-up was included. In some topics of particular importance, such as the effect of knee injuries (given their frequency), we included long-term studies reporting not only on athletes, but also on the general population (usually in these studies a very high proportion on sports injuries is included). Regarding knee injuries in adults, we included articles with follow-up more than 10 years.

Given the linguistic capabilities of the research team, we considered publications in English, Italian, French, German, Spanish and Portuguese.

Physeal injuries and growth disturbance

A concern regarding children's participation in sports is that the tolerance limits of the physis may be exceeded by the mechanical stresses of sports such as football and hockey or by the repetitive physical loading required in sports such as baseball, gymnastics and distance running.[52] Unfortunately, what is known about the frequency of acute sport-related physeal injuries is derived primarily from case reports and case series data. In a previous systematic review on the frequency and characteristics of sports-related growth plate injuries affecting children and youth, we found that 38.3% of 2157 acute cases were sport related and among these 14.9% were associated with growth disturbance.[24] These injuries were incurred in a variety of sports, although football is the sport most often reported.[53]

There are accumulating reports of stress-related physeal injuries affecting young athletes in a variety of sports, including baseball, basketball, climbing, cricket, distance running, American football, soccer, gymnastics, rugby, swimming, tennis.[24] Although most of these stress-related conditions resolved without growth complication during short-term follow-up, there are several reports of stress-related premature partial or complete distal radius physeal closure of young gymnasts.[25–29] These data indicate that sport training, if of sufficient duration and intensity, may precipitate pathological changes of the growth plate and, in extreme cases, produce growth disturbance.[24,32]

Disturbed physeal growth as a result of injury can result in length discrepancy, angular deformity or altered joint mechanics and may cause significant long-term disability.[33] However, the incidence of long-term health outcome of physeal injuries in children's and youth sports is largely unknown.

Based on the previously selection criteria, 20 studies[54–73] were retained for analysis (Table 1). Injury to the physis can result in limb deformities and leg-length discrepancy, the latter being more common after motor vehicle accidents, rather than sports participation.

Table 1 Evidence on acute physeal injury with subsequent adverse affects on growth.

Study	Injury	Patients	Residual deformities
Stephens *et al*.[58] (retrospective case series)	Struck by car; automobile accident; football; gymnastics; baseball; fall;	20	Varus/valgus deformity of knee (4/20); femoral shortening (9/18); limitation knee motion (4/20); ligament laxity (5/20)
Criswell *et al*.[59] (retrospective case series)	Football	15	Varus/valgus deformity of distal femur (5/15); shortening of injured leg (2/15)
Lombardo and Harvey[60] (retrospective case series)	Motor-vehicle accident; fall; football; bicycle accident	34	Limb-length discrepancy (>1 cm) (13/28); varus/valgus deformity of distal femur (11/33); limitation of knee motion (11/31); ligament laxity (8/33); quadriceps atrophy (5/30)
Goldberg and Aadalen[56] (retrospective case series)	Football; basketball; skateboard; skiing; gymnastics; ice skating	53	Ankle varus deformity (2/53); shortening of injured leg (12/53)
Burkhart and Peterson[61] (retrospective case series)	Motor-vehicle accident; sledding; bicycling; gymnastics football; basketball; hurdling; high jump; twist	26	Varus/valgus deformity of knee (7/26); limb-length discrepancy (4/26)
Cass and Peterson[62] (retrospective case series)	Automobile/motorcycle accident; lawnmower accident; fall; jumping; gymnastics; roller skating; skiing; inversion	32	Varus/valgus deformity of knee (5/18); limb-length discrepancy (10/18)
Ogden[63] (retrospective case series)	Birth trauma; child abuse; fall; vehicular accident	14	None
Landin *et al*.[64] (retrospective case series)	Sports injury; fall; traffic accident	65	Anterior angulation (5/65); dorsal angulation (1/65); valgus ankle deformity (1/65); varus ankle deformity (1/65); tibial shortening (1/65)
Hynes and O'Brien[65] (retrospective case series)		26	Medial physeal arrest of distal tibia with varus deformity (3/26); central physeal arrest of distal tibia without deformity (2/26)
Krueger-Franke *et al*.[66] (retrospective case series)	Soccer; skiing; track and field; gymnastics; volleyball; basketball; horseback riding; skate boarding; field hockey; ice hockey; judo; wrestling	85	Valgus deformity of knee (2/49); leg-length discrepancy (4/49); femoral rotational deformity (1/49); varus ankle deformity (1/49)
Berson *et al*.[67] (retrospective case series)	Sports injury; fall; vehicular accident	24	Varus/valgus deformity (18/24); leg-length discrepancy (5/24); physeal bar without deformity (6/24)

Continued

Table 1 *Continued*

Study	Injury	Patients	Residual deformities
Eid and Hafez[68] (retrospective case series)	Sport-related activities; road traffic accidents; falls	151	Femoral shortening (58/151); premature growth arrest (28/151); varus deformity (21/151); valgus deformity (14/151); recurvatum (2/151); flexion deformity (19/151); varus/valgus with flexion deformity (21/151); loss of knee motion (43/151); ligamentous laxity (21/151); thigh atrophy (42/151)
Cannata *et al*.[57] (retrospective case series)		163	Radial shortening (8/157); ulnar shortening (5/157); radial growth arrest/ulnar overgrowth (2/157); radioulnar length discrepancy (38/157); ulnar styloid non-union (53/157); atrophy of forearm muscles (10/157)
Barmada *et al*.[69] (retrospective case series)	Fall; skateboard accidents; motor vehicle accidents; football; soccer; biking; baseball	92	Premature physeal closure of distal tibia with shortening and/or angular deformity (25/92)
Nietosvaara *et al*.[70] (retrospective case series)	Fall; ballgames or playground equipment; motor-vehicle accidents	109	Growth arrest (2/20); persistent symptomatic apex volar angulation exceeded 10° (2/20)
Lalonde and Letts[71] (retrospective case series)	Motor-vehicle accident; fall; sports activities	12	Leg-length discrepancy (>1 cm) (3/12); varus deformity (>5°) (4/12); physeal bar without deformity (6/12)
Nenopoulos *et al*.[55] (retrospective case series)	Falling down stairs; tripping over a step, or slipping or falling while roller skating or skateboarding; sports injury; traffic accident; direct violence	83	Varus deformity of ankle (7/83); overgrowth of medial malleolus (2/83); external rotation (3/83); angulation of distal fibula (1/83); growth disturbance (3/83)
Kawamoto *et al*.[72] (retrospective case series)	Sports injury; fall; traffic accident	297	Leg-length discrepancy (1/297); varus deformity (1/297); toe angulation (1/297); toe shortening (1/297); finger dorsal angulation (2/297); extention lag (1/297); metacarpal dorsal angulation (1/297)
Ilharreborde *et al*.[54] (retrospective case series)	Struck by cars; sports-related accidents (ski, soccer, judo); fall	20	Leg-length discrepancy (>1 cm) (5/20); varus/valgus deformity of knee (13/20); motion restriction (5/20)
Arkader *et al*.[73] (retrospective case series)	Motor vehicle accidents (including pedestrian versus motor vehicle) and sports-related injuries (most predominately football)	83	Physeal bar without deformity (7/73); leg-length discrepancy (9/73); angular deformity (8/73); loss of reduction (3/73); loss of range of motion (3/73); malunion (1/73)

Residual problems after injury in athletes

OA in former athletes

Two studies investigated former top-level female gymnasts for residual symptoms (back pain) and radiographical changes.[74,75] Both studies reported no significant differences in back pain between gymnast and control groups; however, the prevalence of radiographical abnormalities was greater in gymnasts than controls in one study.[74]

Lower limb weight-bearing joints such as the hip and the knee are at risk of developing OA after injury or in the presence of malalignment, especially in association with high impact sport.[76] Varus alignment was present in 65 knees (81%) in 81 former professional footballers (age 44–70 years), whereas radiographic OA in 45 (56%).[77] Others showed that prevalence of knee OA in soccer players and weight lifters was 26% (eight athletes) and 31% (nine athletes), respectively, whereas it was only 14% in runners (four athletes).[78] By stepwise logistic regression analysis, the increased risk is explained by knee injuries in soccer players and by high body mass in weight lifters. A survey in English former professional soccer players revealed that 47% retired because of an injury. The knee was most commonly involved (46%), followed by the ankle (21%). Of all respondents, 32% had OA in at least one lower limb joint and 80% reported joint pain.[79] Another study examined the incidence of knee and ankle arthritis in injured and uninjured elite football players. The mean time from injury was 25 years.[80] Arthritis was present in 63% of the injured knees and in 33% of the injured ankles, whereas the incidence of arthritis in uninjured players was 26% in the knee and 18% in the ankle. Obviously, it should be kept in mind that radiographic studies can only ascertain the presence of degenerative joint disease, which is just one of the features of OA. Clinical examination is always necessary to clarify the diagnosis, and formulate a management plan.

Ex-footballers also had high prevalence of hip OA (odds ratio: 10.2),[81] whereas in another study the incidence of hip arthritis was 5.6% among former soccer players (mean age: 55 years) compared with 2.8% in an age-matched control group. In 71 elite players it was higher (14%). Female ex-elite athletes (runners, tennis players) were compared with an age-matched population of women, and were found to have higher rates (2–3 fold increase) of radiographic OA (particularly the presence of osteophytes) of the hip and knee.[82] The risk was similar in ex-elite athletes and in a subgroup from the general population who reported long-term sports activity, suggesting that duration rather than frequency of training is important. An older study[83] is runners associated degenerative changes with genu varum and history of injury. A cohort of 27 Swiss long-distance runners was at increased risk of developing ankle arthritis compared with a control group.[84] Similarly elite tennis players were at risk of developing glenohumeral OA,[85] whereas handball players of developing premature hip OA,[86] and former elite volleyball players had marginally increased risk for ankle OA.[87] Interestingly a study that investigated the health-related quality of life (HRQL) in 284 former professional players in the UK found that medical treatment for football-related injuries was a common feature, as was arthritis, with the knee being most commonly affected. Respondents with arthritis reported poorer outcomes in all aspects of HRQL.[88]

In summary, OA is more common among former athletes, compared with the general population. The lower limb joints are commonly affected, in association with high impact and injury.

Evidence from follow-up studies on spine of former athletes

Heavy physical work and activity lead to degenerative changes in the spine. Studies on different athletic disciplines and heavy workers have given variable degenerative changes and abnormalities in the lumbar spine. Even though sporting activity is regarded as an important predisposing factor in the development of spinal pathologies,[89–99] there are few studies on the late spinal sequelae of competitive youth sport. Any comparison in terms of back pain between top athletes and the general population is difficult. Experience of pain may be influenced by factors such as susceptibility, motivation and physical activity. Minor pain may be provoked by vigorous body movements that hamper athletic performance, thereby ascribing the pain a greater impact than in the general population. On the other hand, a well-motivated athlete may ignore even severe pain to maintain or improve his/her athletic performance. Also, varying rate/prevalence of osteophytosis has been reported in players associated with various disciplines of sports.

Efforts should be made to understand the aetiology of injuries to the intervertebral discs during athletic performance and thereby prevent them.[74]

Based on the previously selection criteria, seven studies[74,89,98,100–103] were retained for analysis (Table 2). In summary, spine pathologies are associated more commonly with certain sports (e.g. wresting, heavy-weight lifting, gymnastics, tennis, soccer). Degenerative changes in the athlete's spine can occur, but they are not necessarily associated with clinically relevant symptoms of OA. Therefore, it cannot be determined whether it threatens the athlete's career, or whether it has a worse impact on athletes compared with the general population.

Table 2 Evidence from follow-up studies on spine of former athletes.

Study	Sport	Joint(s)	Patients	Spine alterations
McCarroll *et al*.[98] (retrospective case series)	Football	Lumbar spine	145	Spondylolysis (3/126)
Granhed and Morelli[101] (retrospective case series)	Wrestling; heavyweight liftering	–	45 (wrestlers, 32; heavyweight lifters, 13)	Disk height reduced (9/32 of wrestlers; 8/13 of lifters); spondylolysis (4/32 of wrestlers; 2/13 of lifters)
Burnett *et al*.[89] (retrospective case series)	Cricket	Thoraco-lumbar spine	19 (fast bowlers)	Disc degeneration (11 of 19)
Lundin *et al*.[74] (retrospective case series)	Wrestling; gymnastics; soccer; tennis	Thoraco-lumbar spine	134 (wrestlers, 28; gymnasts, 48); soccer players, 30; tennis players, 28)	Spondylolysis, disc height reduction, apophyseal abnormalities, abnormal configuration of the vertebral bodies and osteophytes
Schmitt *et al*.[102] (retrospective case series)	Jawelin throwing	Lumbar spine	21	Spondylolisthesis (10/21); spondylolysis without spondylolisthesis (3/21); early ankylosis (1/21)
Baranto *et al*.[100] (retrospective case series)	Divers	Thoraco-lumbar spine	18	Reduced disc height (12/17); disc bulging (8/17); injury to the ring apophyses (1/17); Schmorl's nodes (7/17); abnormal configuration of vertebral body (3/17)
Ozturk *et al*.[103] (retrospective case series)	Football	Lumbar spine	70	Disc height reduction; osteophytosis

Knee injury and OA in athletes

A population-based case-control study investigated the risk of knee OA with respect to sports activity and previous knee injuries of 825 athletes competing in different sports. They were matched with 825 controls. After confounding factors were adjusted, the sports-related increase risk of OA was explained by knee injuries.[104] Another study leads to the same conclusion: 23 American football high-school players were compared with 11 age-matched controls, 20 years after high-school competition. No significant increase in OA could be demonstrated clinically or radiographically. However, a significant increase in knee joint OA was found in the subgroup of football players who had sustained a knee injury.[105]

A cohort of 286 former soccer players (71 elite, 215 non-elite) with a mean age of 55 years was compared with 572 age-matched controls, regarding the prevalence of radiographic features of knee arthritis. Arthritis in elite players, non-elite players and controls was 15%, 4.2% and 1.6%, respectively. In non-elite players, absence of history of knee injury was associated with arthritis prevalence similar to the controls.[106]

An interesting study involved a cohort of 19 high-level athletes of the Olympic program of former East Germany. They sustained an ACL tear between 1963 and 1965. None were reconstructed, and all were able to return to sports within 14 weeks. Subsequent meniscectomies were necessary in 15/19 (79%) athletes at 10 years and 18/19 (95%) at 20 years, when in 18 of the 19 knees, arthroscopy was performed, 13 patients (68%) had a grade four chondral lesion. By year 2000 (more than 35 years after ACL rupture), 10/19 knees required a joint replacement.[107]

The incidence of radiographic advanced degeneration (Kellgren–Lawrence grade 2 or higher) was 41% in a cohort of 122 Swedish male soccer players (from a total of 154) who consented to radiographic follow-up, 14 years after an ACL rupture. No difference was found between players treated with or without surgery for their ACL rupture. The prevalence of Kellgren–Lawrence grade 2 or higher knee OA was 4% in the uninjured knees.[108]

Similar results were evident among Swedish female soccer players who were injured before the age of 20. The prevalence of radiographic OA was 51%, compared with 8% only in the uninjured knee, 12 years later. The presence of symptoms was documented in 63 of 84 (75%) athletes who answered the questionnaire, and was similar ($P = 0.2$) in the two management groups (operative versus non-operative). The presence of symptoms did not necessarily correlate with radiographic OA ($P = 0.4$).[109]

In summary, knee injury is a recognized risk factor for OA. Injured athletes develop OA more commonly than the general population in the long term. Approximately half of the injured knees could have radiographic changes 10–15 years later. It is not clear whether radiographic changes correspond to presence of symptoms.

Ankle ligament injuries and OA in athletes

Ankle sprains are common sporting injuries generally believed to be benign and self-limiting. However, some studies report a significant proportion of patients with ankle sprains having persistent symptoms for months or even years. Nineteen patients with a mean age of 20 years (range: 13–28), who were referred to a sports medicine clinic after an ankle inversion injury, were followed for 29 months (average), and compared with matched controls. Only five (26%) injured patients had recovered fully, whereas 74% had symptoms 1.5–4 years after the injury. Assessments of quality of life using the short form-36 questionnaires revealed a difference in the general health subscale between the two groups, favouring the controls ($P < 0.05$).[110]

Similar conclusions were drawn from another study, regarding ankle injuries in a young (age range: 17–24 years) athletic population.[111] There were 104 ankle injuries (96 sprains, 7 fractures and 1 contusion), accounting for 23% of all injuries seen. Of the 96 sprains, 4 were predominately medial injuries, 76 lateral and 16 syndesmosis sprains. Although 95% had returned to sports at 6 weeks, 55% reported pain or loss of function. At 6 months, 40% had not fully recovered, reporting residual symptoms. Syndesmosis injuries were associated with prolonged recovery.

The association between ligamentous ankle injuries has been highlighted in a study that, retrospectively, reviewed data from 30 patients (mean age: 59 years, 33 ankles) with ankle osteoarthritis.[112] They found that 55% had a history of sports injuries (33% from soccer), and 85% had a lateral ankle ligament injury. The mean latency time between injury and OA was 34.3 years. The latency period for acute severe injuries was significantly lower (25.7 years), compared with chronic instability (38 years). Varus malalignment and persistent instability were present in 52% of those patients.

In summary, ankle ligamentous injuries in athletes can result in considerable morbidity, residual symptoms and arthritis 25–30 years later.

Residual upper limb symptoms in the 'overhead' athlete

Shoulder injuries account for 7% of sports injuries and often limit the athlete in his or her ability to continue with their chosen sport.[113] Repetitive overhead throwing imparts high valgus and extension loads to the athlete's shoulder and elbow, often leading to either acute or chronic injury or progressive structural change and long-term problems in the overhead athlete.[45]

Schmitt *et al*.[102] examined 21 elite javelin throwing athletes at an average of 19 years after the end of their high-performance phase (mean age at follow-up was 50 years). Five athletes (24%) complained about transient shoulder pain and three (16%) about elbow pain in their throwing arm affecting activities of daily living. All dominant elbows had advanced degeneration (osteophytes).

Elbow intra-articular lesions are recognized as consequences of repetitive stress and overuse. Shanmugam and Maffulli[9] reported follow-up (mean 3.6 years) of lesions of the articular surface of the elbow joint in a group of 12 gymnasts (six females and six males). This group showed a high frequency of osteochondritic lesions, intra-articular loose bodies and precocious signs of joint ageing. Residual mild pain in the elbow at full extension occurring after activity was present in 10 patients and all patients showed marked loss of elbow extension compared with their first visit.

Glenoid labral tears require repair, and shoulder instability is currently approached operatively more often. A review article found that conservative management of traumatic shoulder dislocations in adolescents was associated with high rates of recurrent instability (up to 100%). Therefore, surgical shoulder stabilization is recommended. The outcomes of surgical management are presented in the next section.

A distinct clinical entity is the 'little league shoulder', which is characterized by progressive upper arm pain with throwing and is more commonly seen in male baseball pitchers between ages 11 and 14 years. It is thought to be Salter-Harris type I stress fracture. Activity modification, education to improve throwing mechanics and core muscle training are recommended. It is not known how this condition behaves in the long term, regarding structural damage and development of degenerative changes.

Overhead athletes are plagued by shoulder and elbow injuries or overuse syndromes that can affect their performance and cause degeneration and pain in the long term.

Outcomes of operative management of common sports injuries

Meniscectomy and OA

The association between knee OA and meniscectomy has been well documented. In former athletes[114–116] it is associated with OA

Table 3 Menicectomy and osteoarthritis in athletes.

Study	Patients	Follow-up	Operation	Outcome
Muckle[114] (retrospective case series)	91 soccer players (50 professional)	7–12 years	Meniscectomy	All had arthritic changes
Jørgensen *et al*.[115] (prospective case series)	147 athletes	At median of 4.5 years; 14.5 years	Meniscectomy	Residual symptoms, 53% at 4.5 years; 67% at 14.5 years; radiographic arthritic changes, 40% at 4.5 years; 89% at 14.5 years; 46% had given up or reduced their sporting activity; 6.5% had changed their occupation
Bonneux and Vandekerckhove[116] (prospective case series)	31 athletes	8 years (mean)	Partial arthroscopic lateral meniscectomy	Tegner score dropped from 7.2 to 5.7; Lysholm score: 65% good/excellent; radiographic changes: 93%

(Table 3). Meniscectomy in children and adolescents[117–123] has been associated with unfavourable results and radiographic arthritic changes in the long term (Table 4). However, radiographic criteria were not always clearly defined. To assess the long-term outcomes of meniscectomy, we also evaluated studies with a minimum follow-up of 10 years in the adult general population[106,124–129] (Table 5). Many of the 'older' studies providing the long-term outcomes represent results of open total meniscectomies. The overall message is that radiographic degeneration is common in meniscectomized knees, and patients are at risk of developing OA. The condition of the articular cartilage is a prognostic factor. However, clinical and radiographic findings do not always correlate. Resection should be limited to the torn part of the meniscus.

Meniscal repair in athletes

Given the long-term problems associated with meniscectomies, preservation of the substance of the meniscus after injury is currently advocated. Based on this concept, arthroscopic meniscal repair techniques have been developed.[125] In the general population, encouraging clinical results with failure rates of 27–30% at 6–7 years follow-up have been reported.[130–132] One study[133] evaluated 45 meniscal repairs in 42 elite athletes followed for an average of 8.5 years. In 83% of them an ACL

Table 4 Menicectomy in children and adolescents.

Study	Patients	Follow-up	Operation	Outcome
Medlar *et al.*[119] (prospective case series)	26 skeletally immature	8.3 years (mean)	Total meniscectomy	Radiographic arthritis: 22/26 (75%)
Zaman and Leonard[121] (prospective case series)	59 children	7.5 years (mean)	Total meniscectomy	Radiographic early arthritic changes in 11/59 (19%)
Manzione *et al.*[122] (prospective case series)	20 children	5.5 years (mean)	Total meniscectomy	Radiographic degeneration: 16/20 (75%)
Wroble *et al.*[120] (retrospective case series)	39 patients <16 years	21 years (mean)	Total meniscectomy	Asymptomatic: 10/39 (27%); pain: 27/39 (71%); limitations in sports: 24/39 (62%); limitations at work: 4/39 (10%); radiographic degeneration: 35/39 (90%)
Dai *et al.*[123] (prospective case series)	24 children (7–16 years)	16.1 years (mean)	Total meniscectomy	Good/excellent results: 15/24 (63%); radiographic degeneration: 21/24 (87%)
McNicholas *et al.*[117] (retrospective case series)	Cohort of 100 adolescents (10–18 years); 63 were reviewed at last follow-up	30 years (mean)	Total meniscectomy	Patients' satisfaction: 45/63 (71%); radiographic findings (53 of 63 patients) in the operated versus contralateral knee: Osteophytes: 41/53 (79%) versus 13/53 (25%) Joint space narrowing: 19/53 (36%) versus 6/53 (11%) One patient underwent knee arthroplasty at age 42; compared with patients follow-up at 17 years,[118] satisfaction rate had increased, ROM had decreased and joint narrowing had increased at 30 years

reconstruction was performed as well. Return to their sport was possible in 81% at an average of 10 months after surgery. They identified 11 failures (24%), seven of which were associated with a new injury. The medial meniscus re-ruptured more frequently compared with the lateral (36.4 versus 5.6%, respectively).

Table 5 Meniscectomy in adults / general popaltion—long-term outcomes.

Study	Patients	Follow-up	Operation	Outcome
Neyret *et al*.[182] (retrospective case series)	195 knees (93 ACL ruptures)	20–35 years	'Rim preserving' meniscectomy	Radiographic OA; ACL deficient: 61% at 20–24 years and 86% if >30 years of follow-up; ACL intact: respective values were 40 and 50%
Rockborn and Gillquist[124] (retrospective case series)	33 patients, 43 knees	12–15 years	Total meniscectomy	Radiographic early OA: 62%; joint space narrowing: 42%; active in sports: 70%, compared with 90% preoperatively
Maletius and Messner[126] (prospective case series)	40 knees	12–15 years	Partial meniscectomy	Good/excellent results: If articular cartilage damaged: 50% If articular cartilage intact: 85% Radiographic joint space narrowing: If articular cartilage damaged: 80% If articular cartilage intact: 30% Activity levels decreased equally in the two groups
Roos *et al*.[106] (prospective case series)	107 knees	21 years (mean)	Total meniscectomy	Mild radiographic changes: 71%; OA changes Kellgren–Lawrence grade >2: 48%; relative risk of 14.0 for developing OA, compared with age-matched controls
Schimmer *et al*.[127] (prospective case series)	119 patients	12 years (mean)	Arthroscopic partial meniscectomy	Good/excellent results: At 4 years: 92% At 12 years: 78% At 12 years if articular cartilage damaged: 62% At 12 years if articular cartilage intact: 95%
Rockborn and Messner[125] (comparative study, non-randomized)	60 patients	13 years (mean)	Arthroscopic partial meniscectomy ($n = 30$) versus repair ($n = 30$)	No difference between in radiographic findings, knee function, subjective complaints, or examination findings; re-operation was needed in 20% of meniscectomies versus 23% of repairs

Continued

Table 5 *Continued*

Study	Patients	Follow-up	Operation	Outcome
Anderson-Molina *et al.*[128] (comparative study, non-randomized)	36 patients	14 years (mean)	Total ($n = 18$) versus partial ($n = 18$) meniscectomy	Radiographic degeneration rate higher after total meniscectomy (72 versus 33%); little influence on activity and knee function; Lysholm score >94 (normal) in 70%
Englund *et al.*[129] (prospective case series)	155 patients	16 years (mean)	'Limited' meniscectomy	OA changes Kellgren–Lawrence grade >2: 43%; only 59% of knees with radiographic OA were symptomatic; in total 50% of knees were symptomatic; the relative risk for combined radiographic and symptomatic OA after post-traumatic meniscal tear was 7.0

Mintzer *et al.*[134] retrospectively reviewed the outcome of meniscal repair in 26 young athletes involved in several sports at an average follow-up of 5 years (range: 2–13.5). No failures were reported, with 85% of patients performing high level of sports activities.

In general, the results of meniscal repairs in the general population, as well as in athletes, are encouraging.

ACL reconstruction and OA

Knee injuries can result in ligament ruptures and/or meniscal tears and are recognized as a risk factor of OA. A systematic review on studies published until 2006[135] reported on the prognosis of conservatively managed ACL injuries showed that there was an average reduction of 21% at the level of activities (Tegner score evaluation). ACL reconstruction is therefore a procedure frequently performed in athletic individuals, as they desire to maintain a high level of activities. However, does ACL reconstruction affect the incidence of knee degeneration and symptoms in the long term? We identified three studies[108,109,136] comparing operative versus non-operative management of ACL ruptures specifically in athletes, in regard to OA.

Two studies from Sweden investigating the prevalence of OA after ACL rupture in male[108] and female[109] soccer players were discussed earlier. Both found no difference in the incidence of radiographic arthritis between surgically and conservatively treated players, more than 10 years after their injury.

A comparative study[136] on high-level athletes with ACL injury showed no statistical difference between the patients treated conservatively or operatively (patella tendon graft) with respect to OA or meniscal lesions of the knee, as well as activity level, objective and subjective functional outcome. The patients who were treated operatively had a significantly better stability of the knee at examination.

Several studies present outcomes of ACL injuries in the general population. A recent systematic review included 31 studies (seven were prospective) reporting radiographic outcomes regarding OA, with more than 10 years follow-up after ACL injury.[137] The prevalence of OA in the injured knee varied from 1 to 100%, whereas in the contralateral knee it was 0–38%. Isolated ACL tears were associated with low OA incidence between 0 and 13%, whereas in the presence of additional meniscal injury, it was 21–48%. Meniscal injury and meniscectomy were the most frequently reported risk factors for OA. The authors scored the quality of the studies and found that studies scoring high reported low incidence of OA. Data extraction indicated that ACL reconstruction as a single factor did not prevent the development of knee OA.[137]

There is lack of evidence to support a protective role of reconstructive surgery of the ACL against OA, both in athletes as well as in the general population.

ACL reconstruction in children

ACL reconstruction in skeletally immature patients is a relatively new trend.[138] The concern is intra-operative epiphysis damage and growth disturbance, a complication which has been avoided in several studies.[139–143]

The earliest published study[144] compared non-operative versus operative management of ACL ruptures in 42 skeletally immature athletes (age range: 4–17 years) followed for a mean of 5.3 years. They used a composite knee score based on clinical examination and a patient questionnaire and found superior results in the operatively treated patients. Age and growth plate maturity did not influence results. They recommended ACL reconstruction for active athletic children.

One of the early reports showed that there were no growth disturbances at a mean of 3.3 years after surgery in 9 children, however, with two re-ruptures. Those children could not return to athletic activities.[139]

In a series of 57 ACL reconstructions, 15 patients had reached completion of growth when examined at follow-up, none had signs of growth disturbance, whereas clinical scoring was good or excellent in all patients.[142]

Another study compared the outcomes of two management strategies in 56 children with ACL ruptures, namely ligament reconstruction in the presence of open physis, or delayed reconstruction after skeletal maturity. The 'early' reconstruction group had evidence of less medial meniscal tears (16 versus 41%), and no evidence of growth disturbances, at 27 months mean follow-up.[140]

After 1.5–7.5 years follow-up of 19 ACL reconstructions in 20 athletic teenagers (age range: 11.8–15.6 years), all but one had returned to sports, none had tibiofemoral malalignment or a leg-length discrepancy of more than 1 cm, and the modified Lysholm score was 93 out of 95.[143]

Finally, 55 children (ages 8 to 16 years, mean 13 years) were followed for a mean of 3.2 years (range: 1–7.5 years) after ACL reconstruction, with no evidence of growth disturbances. Clinical scores showed normal or almost normal values (higher than 90 out of 100 possible points) and 88% of the patients went back to normal or almost normal sports according to the Tegner score.[141]

Overall, the clinical results are encouraging and iatrogenic epiphysis damage does not seem to be a problem, possibly because physeal sparing procedures were used. The study designs, however, are inadequate to answer the question of whether early or delayed ACL reconstruction results in the best possible outcome in skeletally immature patients.

Ankle arthroscopy in athletes

Anterior impingement syndrome is a generally accepted diagnosis for a condition characterized by anterior ankle pain with limited and painful dorsiflexion. The cause can be either soft tissue or bony obstruction. Arthroscopic debridement is currently considered a routine procedure, and chondral lesions are now more frequently identified as causes of ankle pain. Few reports specifically in athletes are available[145–149] (Table 6). Short-term outcomes only are available. It is not known whether arthritis is a long-term consequence.

Hip arthroscopy in athletes

Only recently has the hip received attention as a recognized site of sports injuries, possibly as a result of the evolution of hip arthroscopy which allowed recognition of intra-articular pathology.[150] Acetabular

Table 6 Ankle arthroscopy in athletes.

Study	Patients	Follow-up	Problem	Operation	Outcome
Saxena and Eakin[145] (comparative study, non-randomized)	46 athletes	2–8 years	Cartilage lesions of talar dome	Arthroscopy and microfractures ($n = 26$) or arthrotomy and bone grafting ($n = 20$)	Return to sports: 100%; excellent/good AOFAS score: 96%; no difference between the two methods
Rolf *et al*.[146] (prospective case series)	61 athletes (26 professional, 35 semi-professional), soccer, 49%, rugby, 14%	2 years (mean) for 51/61 patients	Cartilage lesions	Arthroscopic debridement	Returned to sports at 16 weeks (range 3–32); pre-injury level: 73% (37/51); reduced level: 24% (12/51); ended career: 4% (2/51); residual symptoms: 43% (22/51)
Baums *et al*.[147] (prospective case series)	26 athletes	2–4 years (mean 2.6 years)	Anterior ankle pain and limited dorsiflexion (soft tissue $n = 12$, bony $n = 14$)	Arthroscopic debridement	Athletes' satisfaction: 25/26 (96%); return to competitive sport: 100%; Tegner score improved from 3 to 8 (average); Karlsson ankle score improved from 66 to 92 (average)
DeBerardino *et al*.[148] (prospective case series)	61 athletes	0.5–6 years (mean 2.3 years)	Anterolateral soft tissue impingement	Arthroscopic debridement	Excellent/good clinical results: 95% (58/61)
Jerosch *et al*.[149] (prospective case series)	35 athletes	2.7 years (mean)	Anterior synovitis	Arthroscopic debridement	Not significant change in clinical scoring; same athletic activity: 26% (9/35); reduced athletic activity: 54% (19/35); stopped athletic activity: 20% (7/35); iatrogenic nerve damage: 17% (6/35)

labrum and chondral lesions can be addressed arthroscopically, and patients' satisfaction rates up to 75% have been reported.[44] One study evaluated the outcome of hip arthroscopy in 15 athletes (mean age: 32 years, range: 14–70) followed for 10 years. Nine were recreational athletes, four high school and two intercollegiate athletes. Diagnoses included cartilage lesion (8), labral tear (7), arthritis (5), avascular necrosis (1), loose body (1) and synovitis (1). The median improvement in the modified Harris hip score was 45 points (from 51 preoperatively to 96, on the 100-point scale), with 13 patients (87%) returning to their sport. All five athletes with arthritis eventually underwent total hip arthroplasty at an average of 6 years.[43] Long-term outcomes regarding progression of joint degeneration after traumatic chondral or labral damage are not available.

Operative management of shoulder injuries in athletes

Labral tears require repair, whereas shoulder instability is currently approached operatively more often. Conservative management of traumatic shoulder dislocations in adolescents is associated with high rates of recurrent instability (up to 100%), whereas recurrent dislocations were reported in up to 12%, at an average of 3 years after arthroscopic stabilization. Shoulder dislocations are particularly common in rugby, the characteristic mechanism of injury being tackling, whereas labral tears are common in the 'overhead' athlete'. Published results in athletes[151–162] (Table 7) show that operative stabilization of the shoulder is initially successful, but instability and pain can recur in the long term. Results of arthroscopic techniques in the management of intra-articular pathologies are promising, but long-term outcomes are unknown (Table 7).

Operative management of elbow injuries in athletes

Elbow ulnar collateral ligament (UCL) insufficiency is one of the frequently recognized injuries in the overhead athlete, as a result of excessive valgus stress. It constitutes a potentially career threatening injury and requires surgical repair.[163] The use of a muscle-splitting approach, avoiding handling of the ulnar nerve, and the use of the docking technique for stabilization is recommended[164,165] (Table 8). Recent advantages in arthroscopic surgical techniques and ligament reconstruction in the elbow have improved the prognosis for return to competition for highly motivated athletes. The results of arthroscopic debridement[150,166] (Table 7) need to be evaluated in the long term.

Table 7 Operative management of shoulder injuries in athletes

Study	Patients	Follow-up	Problem	Operation	Outcome
Owens *et al.*[153] (prospective case series)	39 athletes (40 shoulders)	9–14 years (mean 11.7 years)	First-time traumatic anterior shoulder dislocations	Acute arthroscopic Bankart repair	Re-dislocations: 14% (6/40); subluxation: 21% (9/40); revision stabilization surgery: 14% (6/40); SF-36 (mean): 94.4 of 100; Tegner score (mean): 6.5 (3–10); patients' rating of shoulder function compared with pre-injury: 93%; would they recommend the surgery? VAS=9.1 of 10 (only three patients <7)
Baker *et al.*[152] (prospective case series)	40 athletes (43 shoulders)	>2 years (mean 2.8)	Multidirectional instability	Arthroscopic capsulorrhaphy	Clinical scores: mean >91 points out of 100; strength: 98% normal or slightly decreased; range of motion: 91% full or satisfactory; return to sport: 86%
Kartus *et al.*[154] (prospective case series)	71 patients (73% involved in 'overhead' sports)	Median 9 years	Anterior labrum (Bankart) lesion	Arthroscopic capsulorrhaphy	Shoulder instability: 37/71 (38%); re-dislocation: 16/71 (23%); Overhead sports participation: 45% (compared to 73% before the injury)
Radkowski *et al.*[155] (prospective case series)	98 athletes (107 shoulders)	Mean 2.3 years	Unidirectional (posterior) instability	Arthroscopic capsulorrhaphy	Good/excellent clinical score in 89% of 'throwers' and 93% of 'non-throwers'; return to pre-injury level: 'throwers' 55%; 'non-throwers' 71%
Bonnevialle *et al.*[156] (prospective case series)	31 Rugby players	>5 years	Shoulder instability	Open stabilization	Return to rugby: 97%; recurrence after trauma: 17%; patients' satisfaction: 88%; radiographic arthritis: 32%

Meller *et al*.[157] (prospective case series)	19 athletes	>2 years	Shoulder instability	Open stabilization	Several clinical scores: good/excellent in all athletes; quality of life (SF-12): reduced by 9.2%; participation in sports: reduced ($P < 0.05$)
Mazzocca *et al*.[158] (prospective case series)	18 athletes, <20 years, 13 collision sports (football), 5 contact sports (wrestling, soccer)	>2 years (mean 3.1 years)	Anterior labrum (Bankart) lesion	Arthroscopic capsulorrhaphy	All returned to organized high school or college sports; re-dislocation: 2/18 (11%), both collision athletes
Hubbel *et al*.[159] (comparative study, non-randomized)	50 athletes	>5 years	Shoulder instability	Open stabilization ($n = 20$); Arthroscopic ($n = 30$)	Re-dislocations 'open' group: none; 'arthroscopic' group: 5/30 (17%); instability in collision sports athletes treated arthroscopically: 6/9 (75%)
Bottoni (RCT) *et al*.[160]	24 athletes	>2 years (mean 3 years)	Acute traumatic dislocation	Non-operative ($n = 14$); arthroscopic repair ($n = 10$)	'Non-operative' group: 2 lost to follow-up, recurrence 9/12 (75%); 'arthroscopic repair group': 1 lost to follow-up, recurrence 1/0 (11%)
Martin and Garth[161]	24 athletes (throwing sports)	>3 years (mean 4 years)	Glenoid labral tear, no ligamentous detachment	Arthroscopic debridement without repair	Good/excellent results: 21/24 (85%); competing at pre-injury level: 16/24 (67%)
Tomlinson and Glousman[162] (prospective case series)	46 'overhead' athletes (30 baseball players)	>1.5 year (mean 2.7)	Glenoid labral tear	Arthroscopic debridement without repair	Good/excellent results, all athletes: 25/46 (54%); professional baseball players: 12/16 (75%); non-professionals: 13/30 (43%)
Altchek *et al*.[151] (prospective case series)	40 patients involved in 'overhead' sports	>2 years (mean 3.6)	Glenoid labral tear	Arthroscopic debridement without repair	Pain relief at 1 year: 72%; pain relief at last follow-up: 7%

RCT, randomized controlled trial; VAS, visual analogue scale.

Table 8 Operative management of elbow injuries in athletes.

Study	Patients	Follow-up	Problem	Operation(s)	Outcome
Vitale and Ahmad[164] (systematic review of 8 retrospective studies)	'Overhead' athletes	>1 year	UCL injury	UCL repair Muscle-splitting approach versus Detachment of flexor-pronator mass Unlar nerve transposition versus no transposition Docking versus figure of eight technique	Overall: good/excellent results: 83%; complication rate: 10%; ulnar neuropathy: 6%; muscle, splitting approach: better results and less complications; ulnar nerve transposition: less favourable results, higher neuropathy rate (9% versus 4%); docking technique: better outcomes
Savoie *et al.*[165] (prospective case series)	60 high school, college athletes	Mean 5 years	UCL injury	Direct repair (suture placation with repair to bone)	Good/excellent results: 93%; return to sports (pre-injury level) within 6 months: 97%; transient ulnar neuropathy: 5%; failures:
Rahusen *et al.*[166] (prospective case series)	16 athletes	>2.5 years (mean 3.2)	Posterior elbow impingement	Arthroscopic debridement	Extension deficit: reduced from 8° to 2°; VAS in rest: reduced from 3 to 0; VAS during sports: reduced from 7 to 2 (all differences were significant, $P < 0.05$)
Byrd and Jones[150] (prospective case series)	10 baseball players	Mean 4 years	Osteochondritis dissecans of the capitellum	Arthroscopic debridement	Excellent clinical results; radiographs: Primary lesion evident in 2/10 athletes Degenerative changes in 2/10 athletes Return to baseball: 4/10 athletes

UCL, ulnar collateral ligament.

Operative management of wrist injuries in athletes

A review of the literature shows that 3–9% of all athletic injuries occur in the hand or wrist, and are more common in adolescent athletes than adults.[46] In this article, we focused on TFCC injuries and acute scaphoid fractures in athletes.

TFCC injuries are an increasingly recognized cause of ulnar-sided wrist pain, and can be particularly disabling in the competitive athlete. Advances in wrist arthroscopy made endoscopic debridement and repair of the TFCC possible. McAdams *et al.*[47] treated arthroscopically TFCC tears in 16 competitive athletes (mean age: 23.4 years). Repair of unstable tears was performed in 11 (69%) and debridement only in 5 (31%). Return to play averaged 3.3 months (range: 3–7 months). The mean duration of follow-up was 2.8 years (range: 2–4.2 years). Clinical scores (mini-DASH and mini-DASH sports module) improved significantly. No long-term outcomes are available.

Operative management of scaphoid fractures in athletes, even if undisplaced, is recommended if early return to sports is desired. One study followed 12 athletes treated operatively for a scaphoid fracture. They were able to return to sports at 6 weeks. At an average follow-up of 2.9 years, 9 of 12 athletes had range of motion equal to the uninjured side, and grip strength was equal to the unaffected side in 10 of 12 athletes.[49]

Discussion

Participation in sports offers potential benefits for individuals of all ages, such as combating obesity and enhancing cardiovascular fitness.[1] On the other hand, negative consequences of musculoskeletal injuries sustained during sports may compromise function in later life, limiting the ability to experience pain-free mobility and engage in fitness-enhancing activity.[167] Increasingly, successful management of sports-related injuries has allowed more athletes to return to participation. The knee is the joint most commonly associated with sports injuries, and therefore is most at risk of developing degenerative changes. It is not clear whether radiographic OA always correlates with symptoms and reduced quality of life. Furthermore, even effective management of meniscal or ACL injury does not reduce the risk of developing subsequent OA.[137,168] OA in an injured joint is caused by intra-articular pathogenic processes initiated at the time of injury, combined with long-term changes in dynamic joint loading. Variation in outcomes involves not only the exact type of injury (e.g. ACL rupture with or without meniscal damage),[137] but also additional variables associated with the individual such as age, sex, genetics, obesity, muscle strength, activity and reinjury. A better understanding of these variables may improve future prevention and treatment strategies.[169]

In many of the long-term studies (the majority being retrospective case series), several methodological flaws have to be highlighted. A recent systematic review on OA after ACL injuries[137] suggested that some studies may overestimate the prevalence of long-term OA. The authors in several studies mention that a proportion of the index group of injured athletes were available for follow-up or consented for radiographic examination. One can argue that these patients were the ones with symptoms, therefore the prevalence of OA (after ACL rupture for example) may appear higher than it really is. Presentation of outcomes was not always based on robust criteria. Different clinical scores and radiographic classifications have been used, and therefore results between studies are not directly comparable. In the majority of the studies, it was not clarified whether radiographic appearance correlated with symptoms, and how important these were for the quality of life of the patients. Disabling arthritis requiring intervention may actually be delayed for more than 20–30 years.[107,112] Furthermore, long-term studies present outcomes of older techniques, not used any more in clinical practice (e.g. primary ACL repair or total meniscectomy). Evolution in surgical or rehabilitation techniques might have improved outcomes of certain injuries. Therefore, currently known 'long-term outcomes' may only reflect the results of techniques used in the past and not what we should expect in the future. Increasing awareness of athletes and trainers, new diagnostic and musculoskeletal imaging modalities, improved surgical and rehabilitation methods, but also analysis of injury patterns in different sports and development of injury prevention strategies might be beneficial to minimize the effects of sports injuries in the years to come.

What is the true incidence of arthritis in the long term? Will it be a disabling condition for the former athlete, in the coming decades? Currently, joint preserving procedures (e.g. microfractures,[145] mosaicplaty,[170] autologous chondrocyte implantation,[171,172] realignment osteotomies[173] and implant arthroplasties[174]) have evolved and allow middle aged or older patients to live without pain and maintain an active life style. Meniscal transplantation shows encouraging results.[175] Should therefore an increased risk for developing musculoskeletal problems prevent children and adults from being active in sports?[176] Do the benefits of participating in sports outweigh the risks?

A survey in Sweden showed that 80% of former track and field athletes with an age range of 50–80 years felt they were in good health, compared with 61% of the referents, despite higher prevalence of hip arthritis in former athletes. Low back disorders were similar in the two groups, shoulder and neck problems were lower in former athletes, and knee arthritis was similar in the two groups.[177]

No definite answer can be given to the previously addressed questions, based on available evidence. Future research should involve questionnaires assessing the HRQL in former athletes, to be compared with the general population.[27,178–181]

Conclusions

Physical injury is an inherent risk in sports participation and, to a certain extent, must be considered an inevitable cost of athletic training and competition. Injury may lead to incomplete recovery and residual symptoms, drop out from sports, and can cause joint degeneration in the long term. Few well-conducted studies are available on the long-term follow-up of former athletes, and, in general, we lack studies reporting on the HRQL to be compared with the general population. Advances in arthroscopic techniques allow operative management of most intra-articular post-traumatic pathologies in the lower and upper limb joints, but long-term outcomes are not available yet. It is important to balance the negative effects of sports injuries with the many social, psychological and health benefits that a serious commitment to sport brings.[9]

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