28 Hip and Groin Injuries in Basketball

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28.1 Introduction

Basketball is a physically demanding, high-speed pivoting sport in which injury risk, especially to the lower limbs, is high, including injuries to and around the hip [1–5]. Basketball players perform repetitive activities that require wide ranges of motion of the hip such as jumping, pivoting, sprinting, and direction changes. These repetitive activities over time may contribute to the development of various injuries in and around the hip. Pathology around the hip is present in both genders and at all ages and levels of play in basketball [1–4]. Hip injuries were found to account for up to 14.6% of all injuries and 4.3% of games missed in National Basketball Association (NBA) players, with the majority being muscle sprains/strains and contusions [2, 3], and among high school basketball players, hip/thigh injuries were found to represent 8.2% and 8.7% of all injuries for male and female athletes, respectively [1]. While the last two decades have introduced a better understanding of intra-articular hip pathology, the majority of injuries to the hip in basketball are still extra-articular [3, 5]. However, as the understanding and diagnosis of femoro-acetabular impingement syndrome (FAIS) has increased in recent years, it is likely that a number of athletes might have been misdiagnosed as having a "strain" over the years when pain etiology was actually FAIS.

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Limited data exists on the prevalence of surgery due to basketball-related hip injuries. Jackson et al. reported that only 22 of 2852 injuries (0.8%) required surgery over a period of 24 years in the NBA; however, their data excluded offseason surgery and, thus, probably does not provide a true representation of the total burden of hip injuries requiring surgery in basketball.

This chapter addresses the spectrum of the common hip and groin injuries in basketball, diagnosis and management, from soft tissue injuries to extra- and intra-articular impingement, with a focus on FAIS.

28.2 Soft Tissue Hip and Groin Injuries

Despite the increasing focus in recent years on intra-articular hip pathology and FAIS in basketball, the majority of hip and groin injuries in the sport are soft tissue injuries [2, 3]. While at the high-school level, ligament sprains were the most common injury type with 44% [1], the vast majority of soft tissue injuries at the professional level (up to 90%) are strains and contusions, with a higher incidence of hamstrings and adductor strains compared to NFL players in the NBA [2, 3].

Hip and groin pain in athletes have suffered for years from lack of consensus in terms of terminology, definitions, and classification [6]. The Doha agreement, published in 2015 provided uniform definitions for classical groin injuries, including adductor related, iliopsoas related, inguinal related, and pubic related groin pain (Table 1) [7].

Fact Box 1

Hip and groin injuries are common in basketball, accounting for up to 14.6% of all injuries at the professional level. Soft tissue injuries such as muscle strains and contusions represent the most common type of injuries around the hip, with higher incidence of adductor and hamstrings strains at the professional level.

28.2.1 Risk Factors for Groin Injuries

There is very limited data on how acute groin injuries occur in basketball; however, sudden change of direction and lateral acceleration-deceleration movements where the muscles are stretched during forceful contraction have been shown to be common causes in other sports and are common movement patterns in basketball [6].

A systematic review focusing on level 1 and 2 studies highlighted a number of factors associated with increased risk of groin injury in athletes. The most common factor found was previous groin injury, while higher level of play, decreased hip adduction strength (both by itself and relative to abduction), and lower levels of sport specific training were also recognized [8]. Another systematic review and meta-analysis investigating cross-sectional factors differentiating athletes with and without hip and groin pain revealed pain, lower strength on adductor squeeze test, reduced hip internal rotation, and bent knee fall out were frequent findings in athletes with hip and groin pain [9].

In a 24-year epidemiologic overview of hip injuries in the NBA, Jackson et al. highlighted that the majority of hip soft tissue strains occur during the preseason and the first month of the season, with the majority of strains involving the hamstrings and adductors (Fig. 28.1) [3]. This could be explained by the acute surge in loads during this period in comparison to the preceding off-season period [10].

28.2.2 Adductor Muscle Strains

Musculotendinous injuries around the groin are by far the most common type of injuries related to the hip and groin in athletes. For both acute and long-standing groin pain, adductor-related injuries are the most frequent, accounting for up to 64% of all hip and groin injuries [11]. The hip adductor muscles, consisting of six muscles—the adductor longus (AL), magnus, and brevis, gracilis, obturator externus, and pectineus—originate on the pubis and attach on the medial aspect of the femur. The occurrence of adductor injuries

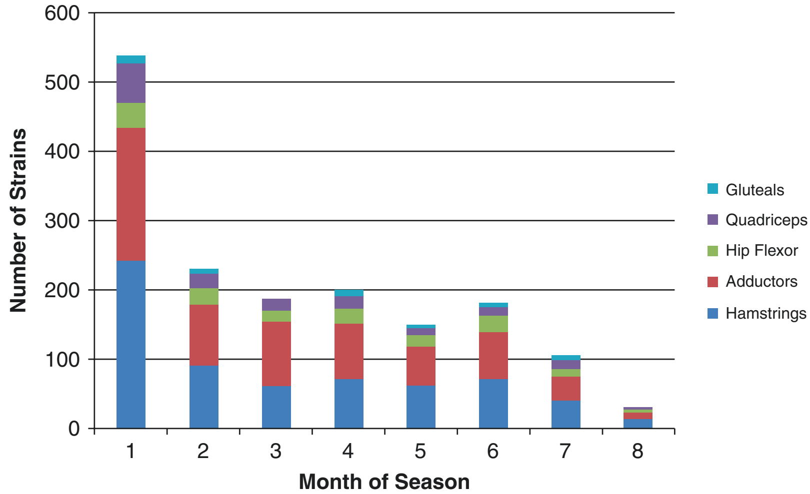

Fig. 28.1 Frequency of hip soft tissue strains in the NBA by month of the season over 24 seasons in the NBA. Month 1 represents the preseason. From: Jackson TJ, Starkey C, McElhiney D, Domb BG. Epidemiology of Hip Injuries in the National Basketball Association: A 24-Year Overview. Orthop J Sports Med. 2013;1(3):2325967113499130

can be acute, with a clear associated mechanism of injury, or chronic, with gradual symptom development. Injuries to the adductor muscles most commonly occur during eccentric contraction, when the muscle contracts while being lengthened or during passive stretch. The adductor longus is most commonly injured during sport activity [12]. It is not surprising that adductor injuries are not uncommon in basketball as sudden direction changes are common in the game both in offense and defense situations, constantly contesting the adductor-abductor muscle groups during play [3].

Mismatch in the abductor and adductor muscle group strength has been identified as a risk factor for adductor strains in athletes [13]. Tyler et al. found that adduction strength was found to be just 78% of abduction strength in those players who sustained an adductor injury and that players were 17 times more likely to sustain an adductor muscle strain if their adductor strength was less than 80% of their abductor strength [13]. Furthermore, they found that preseason hip adduction strength was 18% lower in players who went on to sustain an adductor muscle strain compared to uninjured players.

Clinical signs of adductor-related groin pain include tenderness at the adductor longus and/or gracilis origin at the inferior ramus pubis as well as groin pain at the same site with palpation or resisted adduction [11]. Other common signs include decreased adductor muscle strength and groin pain on full passive abduction [9]. Magnetic resonance imaging (MRI) and ultrasound are the preferred modalities for evaluating and assessing the location and severity of adductor strains. MRI findings may include avulsion of the adductor muscle from the pubic ramus, edema, or hemorrhage.

Treatment of adductor strains is primarily conservative and depends on the onset (acute or chronic). In the acute setting, management consists of rest, protected weight bearing, and initiation of a strengthening and rehabilitation program. In the chronic setting, muscle weakness and imbalance may be more pronounced and may require a more gradual strengthening strategy. While most protocols begin with passive modalities such as stretching and local treatment, there is evidence that attention to active strengthening consisting of progressive resistive abduction/adduction, core strengthening, balance training, and sports-specific movements can be more effective in treating chronic adductor strains [3]. In the event an athlete fails conservative treatment, surgical management is an appropriate option, particularly in the chronic setting, however may also be an option in selected acute cases involving fibro-cartilaginous avulsion. Surgical treatment consists of adductor tendon debridement/release [14, 15] and/or repair [16]. If chronic changes are present at the insertion site on the pubis, debridement of the insertion site may be warranted.

Return-to-play following adductor injuries has been previously evaluated in collegiate and professional basketball players. In an epidemiologic study of 621 hip adductor strains among National Collegiate Athletic Association (NCAA) athletes between the 2009–2010 and 2014–2015 academic years, [17] found that among male collegiate basketball players with adductor injuries, 22.9% were restricted from practice or gameplay for 1–6 days, 8.6% for 7–21 days, and 5.7% for >21 days [17]. A similar study of 967 NBA players sustaining hip injuries between the 1988–1989 and 2011–2012 seasons found that an injury to the adductor group resulted in 6.45 ± 7.4 missed practices and/or games [3]. Interestingly, suggesting adductor strains may be more debilitating at the professional level, which could be explained by a more stringent return-to-play protocol in the NBA.

The majority of athletes with adductor-related injuries return to sport within 4–6 weeks. There is, however, evidence that if an elite athlete sustains a groin re-injury, the recovery period for the re-injury is almost twice as long compared to the index injury, emphasizing the importance of managing the injury properly the first time around [18].

Fact Box 2

Adductor injuries represent the most common site of soft tissue injuries around the hip.

The majority of athletes with adductor-related injuries return to sport within 4–6 weeks. It is important to manage these injuries properly and achieve full recovery as the recovery period for a re-injury, if one occurs, is almost twice as long compared to the index injury.

28.2.3 Hip Flexor Muscle Injury/ Iliopsoas Tendinitis

Hip flexor muscle injuries and iliopsoas tendinitis can be a common source of injury and irritation in professional basketball players. The iliopsoas muscle is involved in spinopelvic control and hip flexion and is frequently recruited in basketball players leading to increased risk of injuries. Jackson et al. reported an overall incidence of 13.2% for hip flexor muscle or Iliopsoas injury, resulting in 7.7 ± 11.3 days out of sports in a cohort of 967 NBA players over 24 years [3].

Athletes with iliopsoas-related pain may complain of groin pain with hip flexion, tenderness palpating the muscle through the lower abdominal wall and/or just distal to the inguinal ligament medial to the sartorius, and pain on passive stretching during the Thomas test [11]. The iliopsoas may be tight as well as weak and sore when tested isometrically with 90° of hip flexion and may also present as an internal snapping sensation from rubbing over the iliopectineal eminence (“internal snapping hip”). Hip flexor tendinopathy diagnosis is largely clinical; however, ultrasound and MRI may assist in the diagnosis with findings of iliopsoas tissue disruption, edema, neo-vascularization or calcified tissue in the iliopsoas and any findings suggestive of muscle-tendon complex disruption. An ultrasound-guided lidocaine injection into the psoas tendon sheath can aid for diagnostic purposes. Application of steroid should be used with caution.

Conservative measures are the mainstay of treatment for iliopsoas tendonitis, consisting of NSAIDs, physical therapy, rest, massage, and activity modification. These treatments yield symptomatic relief in the majority of athletes. Rehabilitation programs should focus on core musculature and hip flexor strengthening with gradual progression according to clinical milestones. If insufficient symptomatic relief is achieved, ultrasound-guided corticosteroid injection can be considered as a final treatment step [19], however should be used with caution, while other injection options such as platelet-rich plasma (PRP) have gained more popularity in recent years and are considred a safer option.

Although arthroscopic tendon lengthening or release has been shown to have success in athletes [20], this modality should be applied sparingly as there is risk for altering spinopelvic dynamics and sacrificing a secondary stabilizer of the hip, thereby potentially contributing to micro-instability.

28.2.4 Sports Hernia/Athletic Pubalgia/Core Muscle Injury

Although adductor and hip flexor injuries are common soft tissue injuries in professional athletes, lower abdominal musculature and inguinal region dysfunction can be an important cause for pelvic disability. These injuries, often referred to as "sports hernia" or "athletic pubalgia", have many names including "Gilmore's groin" and "osteitis pubis," and more recently, the term "core muscle injury" (CMI) has been coined. While less common than adductor and hip flexor injuries, the extent of this pathology has yet to be described in basketball players. In elite male football, almost 50% of players suffering from inguinal-related groin injury miss more than 4 weeks of training and match play, and injury time is almost double that of adductor injuries [18, 21]. The pathology is thought to involve an injury to the abdominal wall at the fascial attachments of the rectus and adductors onto the pubic symphysis. Some authors have described CMI as an actual tear in the part of the transversalis fascia that forms a portion of the posterior inguinal wall, thereby leading to an incipient posteriorly protruding hernia [22]. CMI is thought to occur from abdominal hyperextension and hip abduction [23], motions such as in abrupt direction changes which are common in basketball. Other reported mechanisms include acute trauma or repetitive microtrauma from overuse.

Presentation often includes proximal adductor pain as well as inguinal canal pain near the rectus abdominis muscle insertion on the pubis [23, 24]. Symptoms typically worsen with activity and resolve with rest. Additionally, these athletes may experience pain with coughing or radiation of pain into the groin and testicular regions, indicating entrapment of surrounding nerves [23]. Symptoms are commonly unilateral, although bilateral symptoms have been reported in up to 43% of athletes [24].

On physical examination, patients may have tenderness on palpation of the pubic tubercle and pubic symphysis. The abdominal obliques and conjoined tendon/rectus abdominis should also be palpated to help differentiate CMI from other etiologies of lower abdominal pain. Resisted hip adduction and palpation of the inferolateral edge of the distal rectus abdominis with resisted sit-up may recreate the patient's symptom.

Imaging should include radiographs as a first line, with AP pelvis and lateral views of the femur (also to investigate for other causes of groin pain), and may show signs of osteitis pubis, thereby clueing towards CMI. As a next step, MRI can be useful in detecting both rectus abdominis and adductor aponeurosis pathology [25] as well as signs of osteitis pubis and may demonstrate tearing/detachment of other structures from the pubis. Additionally, MRI can rule out concomitant ipsilateral intra-articular hip pathology. Dynamic ultrasound examination may detect weakness of the abdominal wall during maneuvers that increase intra-abdominal pressure (i.e., Valsalva).

First-line management for CMI is conservative with physical therapy focusing on core stabilization, postural retraining, and re-stabilizing the hip and pelvis muscle balance. Gradual RTS can be attempted after a period of rest and activity modification. It is important to note though that CMI can be a very troublesome condition, which takes a long time to recover from, and may not resolve by conservative treatment. Surgical treatment may be considered following conservative treatment failure. A number of surgical techniques have been described, including open or laparoscopic use of a mesh to support the area of weakness and excision/ablation of various nerves. The advantage of the laparoscopic technique is that it allows addressing both sides through the same incisions (whether both sides are symptomatic or as a prophylactic measure for the non-symptomatic side). Overall, surgical treatment has been shown to be successful in treating CMI in high-level athletes. To our knowledge, the results of surgical treatment for CMI has yet to be described in professional basketball players; however, in a cohort of 22 professional hockey players undergoing external oblique aponeurosis repair and excision/ablation of surrounding neurovascular bundles, Irshad et al. reported 86% of players were able to return to professional hockey [26].

28.3 The Hypermobile Athlete

The hypermobile athlete is a unique population that is predisposed to a specific subset of hip disorders. While more common in dancers or gymnasts that require extreme ROM to perform their athletic tasks, thus placing them at risk for potential hip pathology, it is still important to rule out the condition in basketball players as well. Excessive hip ROM can cause the labrum to become pinched between the femoral head and acetabulum, leading to labral pathology and symptoms consistent with hip impingement. Completing a simple Beighton hypermobility score can aid in the diagnosis, with scores from 5–6/9 and above suggesting a degree of joint laxity and hypermobility [27]. Additionally, high proportions of hypermobile athletes can present with borderline hip dysplasia that will contribute to hip pathology and presentation.

28.4 Intra-Articular Hip Injuries/Pathologies

Intra-articular hip injuries are the most common source of groin pain in athletes not related to the musculotendinous structures in the groin area. In recent years, intra-articular hip injuries have received increased recognition as an important differential diagnosis in athletes with groin pain with an increasing incidence reported [21]. In elite football, intra-articular hip injuries were found to account for up to 10% of all hip and groin injuries [18]. The most common diagnosis of intra-articular hip pain is femoro-acetabular impingement syndrome (FAIS) representing symptomatic abnormal premature contact between the proximal femur and the acetabulum [28].

28.4.1 Femoro-Acetabular Impingement Syndrome (FAIS)

Recently, a consensus statement, also referred to as the "Warwick agreement," defined uniformly accepted definitions and terminology regarding FAIS [28]. It defined FAIS as a motion-related hip disorder consisting of a triad of symptoms, clinical signs, and imaging findings [28]. The pathology is particularly prevalent in athletes who participate in high-impact sports such as basketball which involve constant pivoting motions [3, 29]. FAIS is comprised of two common bony pathomorphologies. Femoral-sided pathomorphologies are termed CAM deformities and acetabular-sided pathomorphologies are termed PINCER deformities. These abnormalities can be present each in isolation or in combination (referred to as "mixed-type FAIS"), as well as associated labral, cartilage, and soft tissue pathology (Fig. 28.2).

CAM patho-morphology refers to a flattening or convexity at the femoral head neck junction, while PINCER patho-morphology refers to either global or focal overcoverage of the femoral head by the acetabulum [30]. Their presence, however, in the absence of appropriate symptoms and clinical signs, does not constitute a diagnosis of FAIS as a substantial proportion in the general population are thought to have CAM or PINCER morphology [31, 32].

28.4.2 Labral Tears

The labrum is a horseshoe-shaped fibrocartilaginous tissue which attaches to the rim of the acetabulum. At its apex, however, the labrum is triangular and functions to maintain hip stability by increasing the depth of the socket, increasing

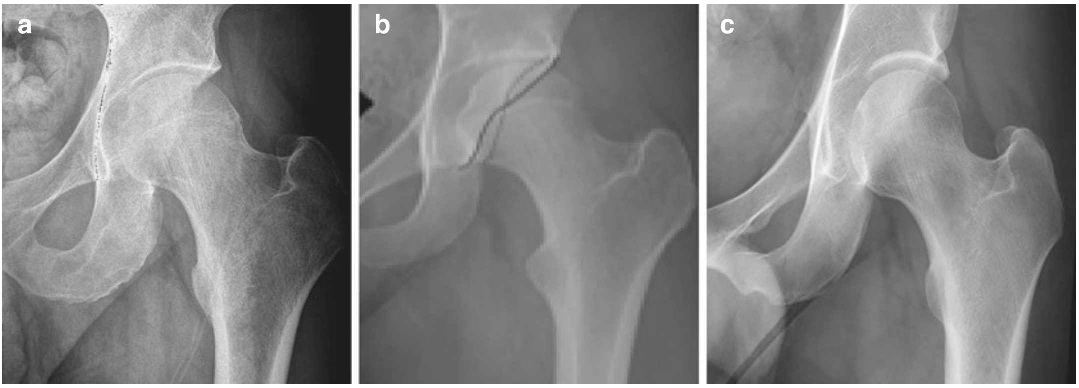

Fig. 28.2 CAM type, Pincer type, and combined type deformities. Anterior-posterior X-ray imaging of the left hip demonstrating isolated CAM-type deformity of the femoral head (**a**), isolated PINCER-type deformity of the acetabulum with acetabular retroversion and over-coverage (**b**), and a combined CAM and PINCER deformity (**c**)

the surface area of the hip and providing a suction seal. As the labrum ends inferiorly at the anterior and posterior edges of the acetabular fossa, it becomes continuous with the transverse ligament which spans the base of the socket. Similar to the meniscus of the knee the acetabular labrum is vascularized from the periphery and contains nerve fibers which can produce pain upon injury to the structure.

In FAIS a variety of abnormalities of the femur and/or acetabulum combined with rigorous and/or terminal hip motion can produce repetitive collisions that can damage the soft tissue structures (labrum/cartilage) around the acetabulum. CAM-type impingement occurs due to the loss of concavity of the femoral neck junction anterolaterally. This prevents this portion of the femoral head from sliding smoothly under the acetabulum during hip range of motion. As a consequence, the femoral head with its abnormal morphology continuously abuts the acetabulum causing lifting of the labrum due to shear stresses and which may disrupt the chondrolabral junction. Alternatively, traumatic injuries of the labrum also exist. These injuries occur when super-physiologic flexion of the hip causes direct abutment of the femoral neck on the acetabulum. This can cause direct damage to the labrum and acetabular cartilage while creating indirect posterior inferior cartilage damage by leverage [33].

While Labral tears typically occur antero-superiorly in association with FAI or dysplasia, less commonly, labral pathology may occur in isolation in a less common direct anterior location, adjacent to the iliopsoas tendon in the absence of bony abnormalities, and are likely the result of iliopsoas impingement [34–36].

28.4.3 Acetabular Dysplasia

Acetabular dysplasia is a developmental disorder reported to be present in 4.3% of males and 3.6% of females [37]. Dysplasia can lead to hip pain in the young adult and has been recognized as a potential precursor for the development of early hip arthrosis if not recognized and treated early. Hip dysplasia is the result of abnormal hip joint development in early infancy and childhood resulting in abnormal morphology of the acetabulum, femoral head, or both [38]. More commonly there is undercoverage of the femoral head anteriorly or laterally resulting in increased focal contact pressures in the posterosuperior acetabular rim. The labrum is often hypertrophic in dysplastic hip as a result of a physiologic attempt to compensate for the lack of bony coverage. The increased contact pressures can lead to labral and cartilage damage, while decreased contact pressures in the undercovered area can lead to premature cartilage and labral degeneration [39, 40]. Decreased femoral head coverage can lead to potential instability with increased femoral head translation in the area of acetabular deficiency. Recurrent subluxation/dislocation events can additionally lead to degeneration and cartilage injury, ultimately leading to an increased rate of early arthritis if not treated early.

28.4.4 Pathogenesis of FAIS

Athletes involved in pivoting sports such as basketball are at increased risk for the development of hip pathology [29, 41]. Particularly high-impact activities that involve flexion and rotation of the hip expose the joint to abnormal joint forces. This abnormal mechanical stresses may present in a variety of hip pathologies including FAIS, labral tears, and cartilage injury. High-intensity sport activity causing physeal stress surrounding adolescence has also been suggested as a risk factor for the development of the CAM morphology, with observations showing higher FAIS incidence in athletes than in age-matched individuals not participating in high-level sports [42, 43]. Alternatively, FAIS may develop secondary to residual deformity from the sequelae of childhood hip disorders, such as Legg–Calvé–Perthes disease, slipped capital femoral epiphysis (SCFE), and hip dysplasia. When athletes place greater demand on the hip than its natural ROM, compensatory stresses and subsequent pain may develop in the lumbar spine, pubic symphysis, sacroiliac joints, and posterior acetabulum. These compensatory stresses can also be transferred to the periarticular musculature and pubis, which may lead to muscle injuries of the hip flexors, proximal hamstrings, adductors, iliopsoas and pubic pain.

28.4.5 Peri-Articular and Extra-Articular Hip Impingement

Although hip impingement is classically described as a mechanical condition due to abnormal contact of the femur (CAM) and the acetabulum (PINCER), other forms of impingement have been recently described. **Anterior inferior iliac spine** (AIIS) or **subspine impingement** occurs when a prominent AIIS or subspine region contacts the inferior/medial femoral neck when the hip is flexed beyond 90° [44]. This form of impingement, referred by some as extra- or peri-articular impingement, may be related to the acetabulum structure (due to acetabular retroversion) or may arise from bony changes related to prior stresses to the AIIS or prior rectus femoris AIIS avulsion injuries which may heal with a prominent AIIS or subspine region causing impingement [45–48]. This injury, caused by avulsion of the anterior or straight head of the rectus femoris, primarily occurs between the ages of 13 and 23 years when the ratio of muscle to physeal strength is the greatest [46, 47].

Ischiofemoral impingement is another form of extra-articular impingement where pain is often associated with hip extension, adduction, and external rotation and commonly presents as lower buttock and inner thigh pain and pain radiating toward the knee [49, 50]. Snapping and clicking are often reported. The pathology stems from reduced distance between the ischial tuberosity and lesser trochanter and injury to the quadratus femoris muscle can be evident on MRI and is the result of repetitive impingement of the muscle between these structures. Ischofemoral impingement is thought to arise from prior injuries at the ischial tuberosity from proximal hamstring injuries, coxa valga, increased femoral neck anteversion, and previous proximal femoral fractures as well as the result of abductor insufficiency leading to increased hip adduction, and should be conservatively managed initially.

28.4.6 Diagnosis

The clinical examination of the hip in basketball players is a comprehensive assessment that includes a detailed history, a structured physical examination, and clinical tests as well as simple and advanced imaging.

28.4.6.1 History

Obtaining a thorough history is key and will help better characterize the injury and symptoms in context. Understanding whether symptoms are the result of an acute or overuse injury, direct or indirect trauma as well as characterizing the pain (location/constant/intermittent/mechanical) can provide important input as well as what provokes or alleviates the pain; whether there is a radiating pain element; identifying activity limitations both in activities of daily living (ADL), work, and sport; and also previous treatment/s and response to such treatment/s.

When history does not provide a clear direction, a systematic approach may be warranted. It is important to remember that even when dealing with an otherwise healthy and often young athletic population, more serious conditions (e.g., infection, malignancy, or systemic disease) are possibilities and should always be considered as the hip and groin region is a common sight of referred pain. It is therefore important to ask about weight loss, fatigue, fever, chills, or a history of recent infection.

In an acute injury setup, a precise description of the injury mechanism can be useful. Characterizing the mechanism (i.e., contact or non-contact related), energy and forces involved, the exact movement and action which generated the injury, as well as whether the player could resume activity soon after the injury and the pain pattern following, may be relevant for an accurate diagnosis. Additional focus should be directed at symptoms correlating with the timing of the injury or with current symptoms, such as an accompanying sound or sensation (i.e., snap, click, or pop) or an instability sensation.

In the non-traumatic/non-acute setting, it is important to investigate into the activities undertaken by the player in the period preceding the injury as well as a description of symptoms development, previous similar symptoms, change in the activity load (intensity, duration, frequency); change of surface, technique or equipment; and if symptoms development correlated to such changes.

A history of systemic, urogenital, abdominal, or low-back symptoms should be taken as well. Childhood hip disorders such as Legg–Calvé–Perthes disease, SCFE, developmental dysplasia of the hip (DDH), and septic arthritis are important to be aware of. Assessing for alcohol or steroid use as well as sickle cell disease is important when avascular necrosis is suspected. Osteoarthritis (OA) can be present in basketball players and is likely to target players toward the end of their career although not only. OA will more likely present with increasing stiffness and a more global pattern of pain localization as opposed to a focal pattern in FAIS and labral tears.

In FAIS, patients often describe a sharp deep groin pain during hip flexion, internal rotation, or adduction movements. Painful clicking is not infrequently reported and may suggest involvement of the hip labrum or an internal snapping hip [51].

Overall, a thorough history taking can help focus the next steps of the diagnostic process, including the clinical examination and requested imaging studies, therefore aiding in a shorter and more effective process.

Fact Box 3
Femoroacetabular impingement syndrome (FAIS) is a motion-related hip disorder consisting of a triad of symptoms, clinical signs, and imaging findings. The actual prevalence of intra-articular hip disorders may have been underestimated over the years. The prevalence of FAIS in basketball has grown with the evolution in understanding and diagnosis of the condition in recent years.

28.4.6.2 Physical Examination

Gait assessment is a key clinical tool for detecting hip pathology or abnormalities in the kinematic chain. Key elements of gait evaluation include foot progression angle (FPA), pelvic rotation, stance phase, and stride length [52]. Abnormal gait patterns associated with hip pathologies include winking gait with excessive pelvic rotation in the axial plane, abductor deficient gait (Trendelenburg gait or abductor lurch), antalgic gait with a shortened stance phase on the painful side, and short leg gait with dropping of the shoulder in the direction of the short leg. Excessive rotation on FPA could raise suspicion of femoral or acetabular ante/retroversion. Abductor weakness can be identified using the single leg stance test (Trendelenburg test), in which a positive test is determined by the observation of a pelvic drop toward the nonbearing side or shift of more than 2 cm toward the bearing (affected) side. Functional tasks such as squatting (two and single leg), single leg dip and a "step down test" may assist in detecting functional weakness and compensatory strategies. Performing deep squats is often difficult in patients with FAIS as well as sudden stopping/starting and cutting movements. It is important to assess functional tasks in both the frontal and sagittal plane in athletes as pathologic patterns may not always present in simple functional tasks and activities of daily living, as symptoms are mainly related to athletic performance in this population. Therefore, more strenuous activities such as running and jumping may need to be investigated for any unloading or compensating strategies and which may provoke or accentuate their symptoms.

The *seated examination* consists of range of motion in the seated position provides a reproduceable and reliable way to assess bilateral internal and external rotation with the ischium square to the examination table. Players with increased femoral anteversion will display increased internal rotation and decreased external rotation, while players with increased femoral retroversion or acetabular retroversion will have decreased internal rotation and increased external rotation (Fig. 28.3).

Supine examination begins with inspection of both legs for any abnormalities or leg length discrepancy. A thorough vascular, lymphatic, and neurologic examination should be performed. Lower back and spinal cord-related symptoms that could present as hip pain should be ruled out. Palpation is performed in key clinical areas that can contribute to hip pain (groin, abdomen, pubic symphysis, adductor tubercle, and greater trochanter). The palpation of the adductor insertion is done with the hip flexed, abducted, and externally rotated, and the knee slightly flexed. Pain on palpation suggests adductor-related groin pain [11]. When adductor-related groin pain is suspected, an adductor squeeze test can be performed (Fig. 28.4).

Hip ROM is recorded for passive flexion, adduction, abduction, and internal and external rotation at 90° of hip flexion. In FAIS, patients often have decreased hip range of motion and hip

Fig. 28.3 Hip range of motion. Internal and external rotation of the hip is checked with the patient supine and the hip flexed to 90°. It can also be checked and compared in the seated and supine positions

Fig. 28.4 The Adductor Squeeze test. There are several adductor squeeze tests however the most sensitive is performed with the patient in the supine position. The examiner stands at the end of the examination table/bed with hands and lower arms between the patient's feet holding them apart. The patient is asked to press the feet together with maximal force with the feet point straight up (**a**). A positive test accounts for pain reproduced from the adductor longus insertion site where the patient also was tender at palpation [11, 55]. Another common version of the test is performed with the hips flexed to 45° (**b**)

muscle strength [54], with flexion and internal rotation mostly affected. The Thomas tests helps assess for hip flexion contractures which can contribute to hip pathology. The hip flexion contracture test or Thomas test is performed by instructing the patient to hold one knee to their chest and passively extend the other knee to the exam table. The inability of the limb to reach the examination table indicates contracture of the hip flexors; however, patients with hyperlaxity or hyper lordosis of the lumber spine may have a false negative. Assessment of hip flexors or psoas strength is performed using the resisted straight leg raise or Stinchfield test (resisted hip flexion from 10–45° with the knee extended). The psoas may place pressure on the labrum during the maneuver which can cause pain in players with intra-articular pathology or psoas impingement/tendinitis.

The diagnostic process of FAIS remains a challenge due to the relative low diagnostic accuracy of specific clinical tests [56, 57]. The *FADDIR* (Flexion Adduction Internal Rotation) test or *Anterior Impingement Test* is commonly abnormal in athletes with FAIS (Fig. 28.5). However, although very sensitive (high sensitivity), it should be noted that this test is not very specific (low specificity), and thus positive in most patients with an intra-articular

Fig. 28.5 The FADDIR or anterior impingement test is performed in the supine position with flexion to 90°, adduction and internal rotation of the hip, bringing the anterior femoral neck in contact with the anterior rim of the acetabulum, trying to reproduce the patients' symptoms thus indicating a positive test

problem [56]. Therefore, a positive test is not diagnostic on its own for an intra-articular hip joint problem however if negative an intra-articular hip joint problem is not likely [56]. Other tests with less sensitivity and specificity include the FABER (Flexion, Abduction External Rotation) test, also known as Patrick's test [56, 58] (Fig. 28.6) and the squat test [59]. Subspine impingement is tested with straight hip flexion past 90° and is positive with reproduction of the characteristic pain.

Fig. 28.6 (**a**, **b**) The FABER (Patrick's) test stands for flexion, abduction, and external rotation. It is considered positive for intra-articular hip pain if it reproduces the patients' typical groin symptoms [58]

28.4.6.3 Imaging

Radiographic abnormalities are not uncommon in basketball [43].

Baseline imaging for a player with hip and groin pain should consist of X-rays. Standard AP pelvis radiographs, preferably with the patient standing [60] with neutral pelvic tilt and leg internal rotation of 15° and a true lateral view are in most cases useful to determine the presence of CAM and/or pincer morphology [61]. Other useful views include the axial cross table view, the modified Dunn view, and the false-profile view and may be preferred by some clinicians in addition to the AP pelvis view and are helpful in identifying femoral head and acetabular abnormalities. CAM morphology is often defined as an alpha angle >55° [28] which is a measure of head–neck sphericity measured in the Dunn view, although in earlier studies it has been defined as >50°. Pincer morphology is often defined as a lateral center edge angle >39° [28] (Fig. 28.7).

However, clinicians should be cautious when interpreting findings of CAM and/or pincer morphology, as their prevalence has been shown to be high in athletes regardless of symptoms [63] and in athletes with adductor-related groin pain [7]. Standard radiographs are also useful to assess for other potential causes of hip and groin pain, such as hip dysplasia, femoral neck stress fractures, or osteoarthritis [28] as well as osseous avulsions femoral neck growth plate injuries in skeletally immature adolescent players when suspected.

Hip dysplasia is defined as a lateral center edge angle <20 while borderline hip dysplasia between 20° and 25°, and these conditions are of relevance

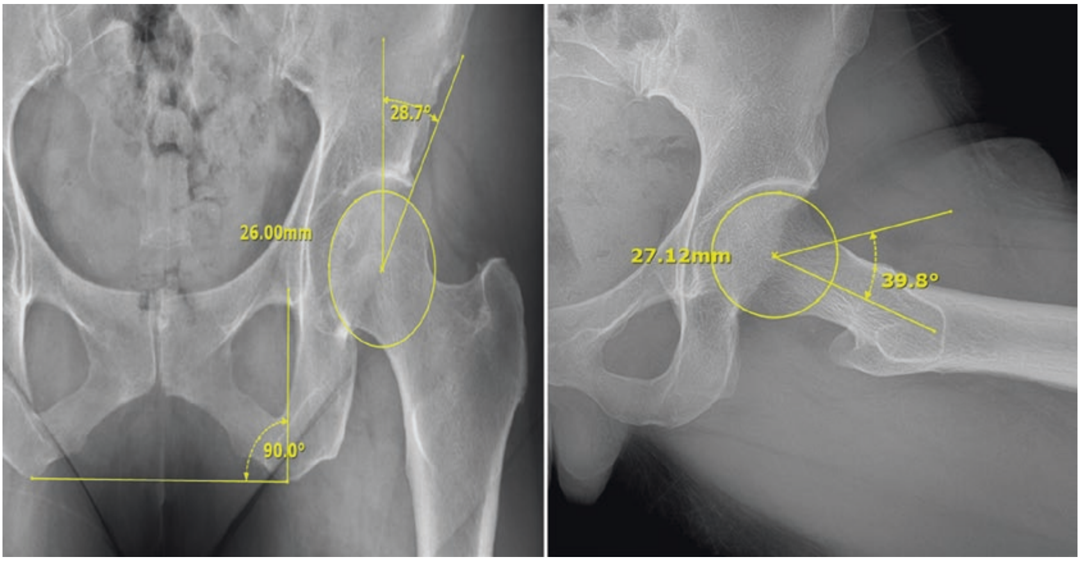

Fig. 28.7 Alpha and lateral center edge angle. The alpha angle is measured in the Dunn view as the angle between (1) a line from the center of the femoral neck to the center of the femoral head and (2) a line from the center of the femoral head to the point where the femoral head–neck junction extends beyond the margin of the circle [62]. The center edge angle is measured as the angle between (1) a vertical line through the femoral head center and (2) a line between the femoral head center and the lateral edge of the acetabulum [62]

as they may lead to labral and/or acetabular cartilage damage [64]. The acetabular index or Tonnis angle is another measure of hip dysplasia and an angle greater than10–14° on AP pelvis X-ray also is diagnostic of hip dysplasia (Fig. 28.8).

Ultrasound is useful to confirm/exclude extra-articular soft tissue pathologies in the groin area such as adductor-related injuries/pathologies as well as a means to accurately deliver diagnostic injections. Its limitations stem from being a performer dependent modality.

Advanced imaging modalities may be required for documentation of soft tissue pathology and when indicated, for surgical planning. A 3.0 T MRI is considered the preferred imaging modality for identifying acetabular labral tears and chondral lesions in the hip [28]. However, when a high-resolution MRI is not available, an MRI with intra-articular contrast (MR arthrogram/MRA) can aid in the detection of labral tears and chondral defects or delamination. Cautious should however be taken in the clinical interpretation of positive findings as acetabular labral tears may be asymptomatic [32].

MRI can also be useful in assessing the symphysis pubis area for osteolytic changes and sclerosis, with pubic bone marrow edema on MRI adjacent to the symphysis joint being diagnostic and may indicate the level of reactivity of this area.

An ultrasound or fluoroscopy guided intra-articular diagnostic injection is an important aid in the examination of athletes with potential intra-articular hip injuries [28]. Pain relief following such an injection has been suggested to support the diagnosis of FAIS [65].

While radiographs, ultrasound, and MRI have all been used to assess abnormal hip pathology, computed tomography (CT) remains the gold standard in assessment of bony morphology and pathology. CT is particularly useful in evaluating acetabular dysplasia, complex FAI, malalignment syndromes, traumatic hip instability, and subspine impingement. CT imaging also enables a full rotational/version profile assessment, and the use of 3D reconstructions on CT allows an accurate understanding of the CAM location, as well as identifying a prominent AIIS.

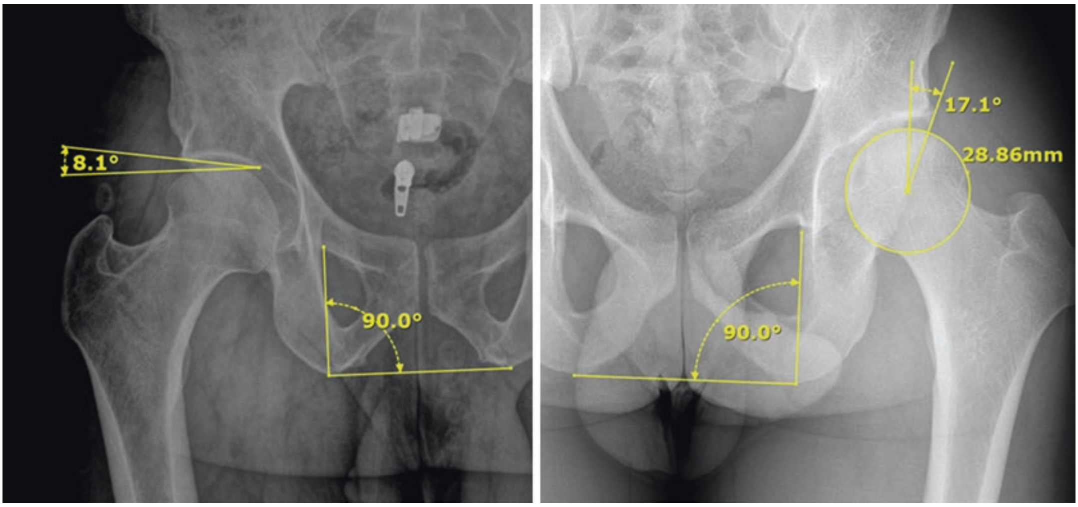

Fig. 28.8 Acetabular index and lateral center edge angle. The acetabular index is formed by a horizontal line connecting both triradiate cartilages (Hilgenreiner line) and a second line which extends along the acetabular roofs. The lateral center edge angle is measured between the line from the center of the femoral head parallel to the longitudinal axis and the line from the center of the femoral head to the most lateral aspect of the acetabulum or the sourcil edge. The Inter-Ischial line (or alternatively, the Inter Teardrop line) is often used as a reference to avoid any pelvic tilt bias

28.4.7 Treatment of FAIS

Treatment of hip-related pain in athletes continues to evolve. Initial management of hip related pain is usually conservative and most patients, particularly recreational or low-demand athletes may benefit from non-operative care. NSAIDs may be beneficial in cases of muscle contusions, tendinitis or inflammatory causes of hip pain. Local anesthetic injections with or without steroids - bursal, intra-articular, or to the symphysis pubis - can be diagnostic for confirming the cause of hip pain as well as therapeutic in certain instances. Many individuals will benefit from physical therapy after sustaining a hip injury [28]. Athletes with extra-articular pathology are more likely to respond than athletes with intra-articular abnormalities. Therapy should focus on reduction of inflammation, managing pain, regaining dynamic stability, strength, and normalizing joint movement.

If conservative management fails, surgery should be considered. Recent evidence suggests that high-level athletes and patients with intra-articular hip pathology seem to benefit more from operative management [66, 67]. Hip arthroscopy is most commonly performed for intra-articular conditions such as FAIS, labral tears, cartilage injuries, capsular or synovial disorders, loose bodies, and extra-articular impingement. Labral tears can be repaired and stabilized whenever applicable using suture anchors. If there is labral fraying or a small tear, debridement is an option. If an extensive debridement has been performed as a result of extensive labral damage where repair is not feasible, labral reconstruction could be considered; however, there is lack of evidence on return to sport following this procedure. Focal pincer morphology can be addressed with an acetabuloplasty to remove the impinging bone or alternatively, with debridement of the reciprocal head–neck junction to avoid impingement. If present, subspine impingement can also be debrided [48]. CAM deformities can be addressed with a re-shaping osteochondroplasty of the femoral head–neck junction. As capsulotomy is routinely performed during hip arthroscopy to allow access and maneuverability, concerns may exist with regard to de-stabilizing the hip. Recent literature has suggested that routine and complete capsular closure following capsulotomy is important to restore the natural biomechanics to the hip and optimize outcomes [68–70]. Rehabilitation following hip surgery can be challenging but is essential in obtaining a positive outcome. The rehab process requires a delicate exercise progression to restore mobility, gait, strength, and neuromuscular control and return to normal activity while preventing excessive anterior hip joint forces that can lead to chronic anterior hip pain. Post-op rehabilitation should focus on addressing muscular and functional hip deficits. The athlete should progress from isolated hip exercises targeting the deep hip stabilizers, into functional activities. Developing hip muscle strength through isolated hip strength exercises such as the Copenhagen Adduction exercise [71], the sliding hip exercise [72], and hip flexion with an elastic band [73] should also be emphasized to increase the load absorption capacity of the hip joint complex. During rehabilitation, the clinician should pay attention to, and address, potential painful competing structures, such as the iliopsoas muscle [74]. Many muscle strengthening exercises and functional exercises can be performed on the court and sport specific tasks which do not involve the lower limb could be performed from very early stages of rehab (i.e., shooting from a seated position). The late phases of rehab should develop toward sport-specific functional tasks with a gradual progression from tasks with no opposition onto full contact. Return to play guidelines should be based on factors such as leg symmetry on hip muscle strength and one-leg jump performance, as well as pain-free capacity to perform complex sport-specific tasks. Clinicians should also be aware that psychological factors such as self-efficacy, motivation and fear of re-injury may be important for successful return to play and should be addressed if indications of such potential barriers exist [75].

28.4.8 Return to Sport

Return to play (RTP) following hip arthroscopy has been previously evaluated [76–83]. Stubbs and colleagues evaluated return to sport and performance outcomes after hip arthroscopy in four pro-level sports, showing an 85.7% RTP rate at an average of 243 days following hip arthroscopy in 28 NBA athletes. No differences in performance were found after RTP [82]. Christian et al. reported an 81% RTP rate in 24 NBA players following hip arthroscopy with a mean RTS time of 175 days [77]. They also found no difference in games played or sport-specific performance scores following return to NBA play after hip arthroscopy. Jack and colleagues evaluated performance and return to sport across four professional sports following hip arthroscopy for FAI [79]. While they reported similar RTP rates for NBA players compared to other sports, they found a decrease in playing time, career longevity, and performance in NHL players following RTP. Ishoi and associates evaluated RTP and sports performance in 189 athletes identified in a Danish Hip Arthroscopy Registry [84]. When more specifically questioning return to sport and performance level, their study found that only 57% of athletes were able to return to their preinjury sport at pre-injury level. Additionally, only 29.6% of athletes reported optimal sports performance including full sports participation. In general, these studies showed a high RTP rate across various professional and amateur sports; however, there is limited data on RTS at pre-injury level [85]. It is likely that in professional sports career longevity and performance following RTP may vary across sports and even playing positions.

Fact Box 4
Initial management of FAIS is conservative and most patients, particularly recreational or low demand athletes, may benefit from non-operative care. However, evidence suggests that high-level players with intra-articular hip pathology seem to benefit more from operative management with good RTS rates.

28.5 Hip Osteoarthritis (OA) in Basketball

While it has been shown that elite athletes are at a higher risk of developing hip and knee OA and undergoing arthroplasty surgery, there is limited data on OA prevalence in basketball [86]. It has been shown that athletes involved in pivoting sports such as basketball are at increased risk for developing hip pathology which can lead to FAIS, labral tears, and cartilage injury [29, 41]. High-intensity sport activity causing physeal stress surrounding adolescence, such as the one encountered in basketball, has also been suggested as a risk factor for the development of the CAM morphology, with observations showing higher FAIS incidence in athletes participating in high-level sports [42, 43]. CAM-type impingement has been highlighted as a risk factor of hip OA [87], and therefore, basketball players with such features could be a population at risk for development of hip OA. A recent survey study by Ekhtiari et al. in 108 retired NBA players showed more than one third (36.3%) of athletes reported current hip and/or groin pain, with 17.6% of athle received injections for hip or groin conditions since retiring from the NBA. Since retiring, 14.7% of the study respondents had undergone total hip arthroplasty. They concluded that retired NBA athletes are at high risk of hip and groin pain after retirement and are more likely to require total hip arthroplasty compared with the general population [88].

28.6 Summary

The hip and groin of basketball players are subjected to high biomechanical loads leading mainly to soft tissue injuries about the hip and pelvis as well as intra-articular injuries which represent a significant burden of injury. The majority of injuries around the hip are soft tissue strains and contusions and are managed primarily with conservative treatment with dedicated rehabilitation protocols and activity modification. For recalcitrant pain and in selected conditions, surgical treatment should be considered. The actual prevalence of intra-articular hip disorders in basketball may have been underestimated over the years. The prevalence of FAIS in basketball has grown with the evolution in understanding and diagnosis of the condition in recent years.

Initial management of FAIS is conservative; however, evidence suggests that high-level players with intra-articular hip pathology seem to benefit more from operative management with good RTS rates.

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