18 Hip, Groin, and Abdominal Injuries in Handball

Per Hölmich, Lasse Ishøi, Markus Wurm, Omer Mei-Dan, and Lior Laver

18.1 Introduction

Hip and groin injuries in handball have received less attention compared to other sports such as the football codes and ice hockey. However, a few reports exist on the incidence of hip and groin injuries in handball based on data from major elite tournaments, full handball seasons, and cohorts of athletes diagnosed with hip and groin pain. Hip and groin injury data derived from major elite tournaments, such as the Olympics and the World Championship, report a consistent incidence of 1.5–4%, with a higher incidence in men's handball (3–4%) compared to women's handball (1.5–2%) [1, 2]. A recent study from the Men's Handball World Championship in 2015 distinguishing between groin and hip injuries reported four groin injuries and a single hip injury constituting 3% and 0.8% percent of all injuries reported during the tournament, respectively [3]. As only fit and healthy players are typically included in a squad competing in major tournaments, such data on hip and groin injuries may not reflect the proportion of these injuries during a full handball season.

When deriving injury data from full season studies, hip and groin injury rates seem to be higher compared to major tournaments. In elite senior handball hip and groin injuries constitute up to 12.5% and 11% of all overuse and acute injuries, respectively [4]. However, considerably lower incidence have also been reported in elite senior handball, with hip and groin injuries constituting 0.9% and 7.6% of all acute injuries, respectively, and 1.3% and 0% of all overuse injuries, respectively [5]. Compared to elite handball, the proportion of hip and groin injuries seem to be lower in non-elite [6] and young handball players [4, 7] constituting 5.5% and 2–10% of all injuries, respectively.

The large variation in the proportion of hip and groin injuries observed in the above studies may likely be explained by the varying injury definitions, grouping of injuries, reporting of injuries,

P. Hölmich (✉) · L. Ishøi
Department of Orthopedic Surgery, Sports Orthopedic Research Center—Copenhagen (SORC-C), Arthroscopic Center, Copenhagen University Hospital, Amager-Hvidovre, Denmark
e-mail: per.hoelmich@regionh.dk; lasse.ishoei@regionh.dk

M. Wurm
The Technical University of Munich, Munich, Germany

O. Mei-Dan
Department of Orthopaedics, University of Colorado Hospital, Boulder, CO, USA

L. Laver, M.D.
Department of Trauma and Orthopaedics, University Hospitals Coventry and Warwickshire, Coventry, UK

Department of Arthroscopy, Royal Orthopaedic Hospital, Birmingham, UK

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level of sport, and age. However, nonetheless the data indicate that hip and groin injuries are prevalent in elite, non-elite, and youth handball.

In diagnostic cohort studies investigating the distribution of clinical groin entities in athletes with hip and groin pain, handball players represent up to 5% of athletes diagnosed with long-standing groin pain, primarily categorized as adductor- and iliopsoas-related groin pain [8, 9]. Furthermore, in a prospective cohort study investigating acute groin injuries handball players represented 11% and 3% of athletes with an acute hip adductor or proximal hip flexor injury, respectively [10, 11]. To the authors' knowledge, no such detailed data exist on hip injuries in handball players specifically. However, our experience suggests that intra-articular hip pathology, such as femoroacetabular impingement syndrome (FAIS), is a prevalent issue among handball players.

	Proportion of hip and/or groin injuries
Major elite tournaments	1.5–4%
Full handball season	0.9–12.5%
Diagnostic cohort studies	3–11%[a]

[a]Proportion of handball players diagnosed with hip and/or groin injuries in relation to all athletes included in the studies

18.2 Risk Factors

A systematic review [12] including 29 studies found level 1 and 2 evidence that a number of factors are associated with an increased risk of groin injury in athletes. The most commonly found factor was previous groin injury (Level1), while higher level of play (Level 1), decreased hip adduction strength (both relative to abduction and by itself) (Level 2), and lower levels of sport-specific training were also recognized (Level 2).

Another systematic review examined cross-sectional factors differentiating athletes with and without hip and groin pain [13]. They found 17 cross-sectional studies of which 10 were high quality. In total 62 different measures were investigated. Eight studies were suitable for meta-analysis. A meta-analysis of eight of these studies showed pain and lower strength on adductor squeeze test, and reduced hip internal rotation and bent knee fall out were frequent findings in athletes with hip and groin pain.

18.3 Diagnosis, Entities, and Terminology

Terminology, definitions and classification of hip and groin pain in athletes have been a major problem with lack of consensus. Unspecific and confusing terms like athletic pubalgia, core muscle injury, pubic aponeurosis injury, and osteitis pubis have been used both clinically and in the literature [14]. In 2015 the Doha agreement paper was published in an attempt to change that [15]. A large group of experts from all over the world including general and orthopedic surgeons, physiotherapists, sports physicians, and radiologists agreed to adopt the concept of uniformly recognized entities and defined a number of such entities, based on a clinical classification system, which covered the most common causes of groin pain. Table 18.1 presents the entities as they were defined in the agreement. The primary focus was on the classical groin injuries and included adductor-related, iliopsoas-related, inguinal-related, and pubic-related groin pain [15]. The

Table 18.1 Clinical entities as defined at the Doha agreement meeting 2014

Clinical entities	Clinical symptoms and signs
Adductor-related groin pain	Adductor tenderness and pain on resisted adduction testing
Iliopsoas-related groin pain	Iliopsoas tenderness plus, more likely if pain on resisted hip flexion and/or pain on hip flexor stretching
Inguinal-related groin pain	Pain located in the inguinal canal region and tenderness of the inguinal canal. No palpable inguinal hernia is present. More likely if aggravated by abdominal resistance or valsalva/cough/sneeze
Pubic-related groin pain	Local tenderness of the pubic symphysis and the immediately adjacent bone. No particular resistance tests to test specifically for pubic-related groin pain

idea of these entities is to categorize the problems in order to gain more knowledge and create evidence to support the specific diagnosis that will develop, as the pathology is better understood. The entities are also helpful tools to compare the results of treatment as well as research.

Recently, an agreement paper has also been published regarding FAIS [16]. A similar concept of defining uniformly accepted definitions was applied for FAIS as this entity suffered from the same obstacles related to groin injuries where the terminology, the definitions, and the diagnostic criteria used for FAIS lacked consensus and uniformity. The Warwick agreement defines FAIS as a motion-related hip disorder with a combined triad of symptoms, clinical signs, and imaging findings [16].

These two papers provide a common international language and are extremely important steps to move the clinical understanding and the research of injuries in this region forward for the eventual benefit of the athletes.

18.4 Non-Traumatic and Traumatic Hip and Groin Injuries

18.4.1 Musculotendinous Injuries

Injuries to the musculotendinous structures of 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 most frequent, accounting for up to 64% of all hip and groin injuries [8].

18.4.1.1 Acute Groin Injuries

The most common acute injury in the groin is to the adductors, especially adductor longus, but also the iliopsoas, proximal rectus femoris, and the muscles involved in the inguinal canal/conjoined tendon are not infrequently injured [17]. The hip flexor injuries can be difficult to diagnose with clinical examination alone and imaging with ultrasound or MRI is very helpful [18]. The more common acute adductor injuries can in most cases be diagnosed clinically with no need for imaging [18]. The acute groin injuries are usually located to the musculotendinous junction, but in some cases the tendon itself or the insertion of the tendon into the bone is the site of the injury [10, 11].

There is very limited data how acute groin injuries happen in handball, but sudden change of direction and similar movements where the muscle is stretched during forceful contraction have been shown to be common causes in other sports and are known movement patterns in handball [17].

How many acute injuries develop into long-standing groin injuries is not known. It is however likely that it is important to treat the acute injuries properly and rehabilitate all relevant muscles and synergies related to the pelvis in order to avoid the injury to recur or even develop into a long-standing problem.

18.4.1.2 Adductor-Related Injuries

The clinical signs of adductor-related groin pain are tenderness at the origin of the adductor longus and/or the gracilis at the inferior pubic ramus and groin pain at the same site as with palpation or resisted adduction [8]. Decreased adductor muscle strength and groin pain on full passive abduction are also frequent signs [13]. Most athletes with adductor-related injuries can return to sport within 4–6 weeks. There is evidence that if an elite player sustains a reinjury in the groin, the recovery period for the reinjury is almost twice as long compared to the index injury, emphasizing the importance of getting the injury sorted properly the first time [19].

18.4.1.3 Iliopsoas-Related Injuries

The clinical signs of iliopsoas-related groin pain are tenderness when palpating the muscle through the lower abdominal wall and or just distal to the inguinal ligament in the triangle medial to the sartorius muscle and lateral to the femoral artery and pain on passive stretching of the muscle during the Thomas test [8]. The iliopsoas muscle is sometimes tight, and the muscle can be weak and sore when tested isometrically with 90° of hip flexion.

The iliopsoas also tend to become sensitized in patients with other kinds of hip and groin injuries. Iliopsoas-related groin pain therefore often seems to coexist with intra-articular hip prob-

lems, but is also seen coexisting with adductor-related groin problems as well as being an injury by itself [9, 20]. Whether the coexistence with other injuries represents a protective response, with increased tenderness and pain during palpation and stretching is unknown.

Ultrasound examination has been suggested as the diagnostic imaging modality of choice for determining the existence of tissue disruption in the iliopsoas, oedema, in-growth of blood vessels or calcified tissue in the iliopsoas and any US findings suggestive of specific injury to the muscle-tendon complex.

18.4.1.4 Inguinal-Related Groin Injury (Sports Hernia)

Pain in the inguinal region is sometimes referred to as sports hernia, sportsman's hernia, or likewise. Pain over the inguinal canal and the pubic tubercle often radiating to the medial groin and the scrotum are characteristic complaints. The clinical signs are tenderness at the insertion of the conjoined tendon at the pubic tubercle and pain when palpating the inguinal canal through the scrotum with the patient standing. No hernia can be palpated [8, 15]. Dynamic examination using ultrasonography can be used to visualize the weakness of the abdominal wall during maneuvers that increase intra-abdominal pressure (i.e., Valsalva). Inguinal-related groin injury is not a common injury in the groin region and only accounts for up to 4% of all injuries to the hip and groin in male elite soccer players. The injury incidence is 0.04 per 1000 h of soccer play at the elite level. It can, however, be a very troublesome condition, which takes a long time to recover from, and may not resolve by conservative treatment. The extent of this pathology has yet to be described in handball players. In elite male football almost 50% of players suffering from inguinal-related groin injury are missing more than 4 weeks training and match play, and the injury time is almost double that of the injuries to the adductors [19, 21]. It is not clear whether this is due to operative procedures keeping players out for a longer period or due to the nature of the injury itself.

18.4.2 Intra-Articular Hip Injury

Intra-articular hip injuries are the most frequent sources of groin pain in athletes that are not related to the musculotendinous structures in the groin region. The most common clinical sign of intra-articular hip pain is groin pain [22], and differentiating between intra- and extra-articular sources of groin pain therefore remains a clinical challenge. In recent years, intra-articular hip injuries have received increased recognition as an important differential diagnose in athletes with groin pain. This is reflected in the Australian Football League injury report from 2012, where the incidence of hip-related injuries seems to have gone up during the last 10 years [21]. In elite football, intra-articular hip injuries account for up to 10% of all hip and groin injuries [19]. Due to the similarities in movement patterns between football and handball, such as sudden change of directions and numerous accelerations and decelerations intra-articular hip injuries are expected to be prevalent in handball as well. The most common diagnosis of intra-articular hip pain is femoroacetabular impingement syndrome (FAIS) representing symptomatic premature contact between the proximal femur and the acetabulum [16]. As this condition may lead to associated chondrolabral pathology, synovitis, and early osteoarthritis [23], a proper diagnosis is important. The diagnosis of FAIS is based on a combined triad of subjective symptoms, clinical findings such as a positive impingement test, and imaging findings such as cam and/or pincer morphology [16]. Cam morphology represents convexity at the femoral head-neck junction, while pincer morphology represents global or focal over-coverage of the femoral head by the acetabulum [24]. There is evidence to suggest that hip loading in especially hip flexion and rotation patterns during childhood and early adolescent contribute to the development of cam morphology [25–27]. As such handball may be considered a sport with an inherent risk of developing cam morphology potentially leading to FAIS at a later stage. Especially, handball goalkeepers may be at an increased risk of developing FAIS as they often perform within a wide hip range motion

compared to outfield players. Ice hockey goalkeepers, performing several similar maneuvers as handball goalkeepers, have been suggested as a population at risk [28, 29].

18.4.3 Stress Fractures, Avulsion Injuries, and Apophysis Lesions

Stress fractures in the hip and pelvis are most common in female runners but should not be missed as a possible differential diagnosis, which may present as a groin injury [30]. Stress fracture of the femoral neck, the sacrum, the pubis, and the ischium can be seen. In elite male soccer players, stress fractures constitute less than 5% of all hip and groin injuries [19].

Avulsion fractures from the pelvis are most common in the adolescent patient. The apophyses are prone to overuse or to traumatic overload causing a painful lesion. The most frequent locations in the groin and hip region are at the anterior superior iliac spine (ASIS) caused by the sartorius muscle especially during jumping activities and at anterior inferior iliac spine (AIIS) caused by the rectus femoris muscle during kicking.

18.4.4 Other Sources of Groin Pain

Bursitis either traumatic or inflammatory should also be considered. The bursae are usually localized between tendons and muscles and over bony prominences. The iliopectineal bursa was earlier considered a major contributor to groin pain in athletes. But recent imaging techniques such as ultrasound and MRI have shown that this is not the case.

Peripheral nerves may become entrapped after direct trauma or due to an overuse condition of the neighboring fascia, tendons, or muscles leading to an inflammatory condition. Nerves most commonly affected are the ilioinguinal, genitofemoral, and lateral cutaneous femoral nerves. The diagnosis can be difficult, but localized tenderness at the site of the site of penetration through the fascia is common. The pain is usually experienced with hyperesthesia or hypoesthesia of the skin along the specific nerves innervation area. The characteristics of the pain may vary considerably.

Even in seemingly healthy athletes, neoplasms should be kept in mind as a possible cause of hip and groin pain. Osteosarcomas, chondrosarcomas, and other tumors have been diagnosed often at a late stage, due to both patient's and doctor's delay.

In elite male soccer players which all are examined by clubs doctors and which have a professional sports medicine setup, 5–10% of the investigated hip and groin injuries are classified as non-specific groin pain [19]. This means that in these cases it was not possible to provide a specific diagnosis and that other source of pain needs to be considered.

18.5 Clinical Assessment

18.5.1 Subjective History

Obtaining a thorough history is very important: Acute or overuse injury? Direct or indirect trauma? Previous treatment? The history will often provide a good indication of where to look for the diagnosis. In some cases the history and the present symptoms leave very little doubt, and a direct examination of the relevant region will promptly reveal the diagnosis. But in other cases, a rather comprehensive examination is required. In such cases a systematic approach is imperative. It is also important to realize that even when dealing with otherwise healthy and often young individuals, more serious diseases (e.g., infection, cancer, and systemic disease) are possibilities that should be considered since this region often is hosting pain perceptions from other regions and organs. Accompanying weight loss, fatigue, fever, chills, and a history of recent infection such as diarrhea are important symptoms that could reflect a reactive synovitis in the hip, an infected hip, or a malignant condition.

If an acute episode initiated the injury, a precise description of the injury mechanism can be

very helpful. Understanding if the mechanism was contact or noncontact related, the energy and forces involved in the mechanism, the exact activity and action, which generated the injury, are examples of important information relevant to reaching an accurate diagnosis. Additional focus should be directed at symptoms correlating with the timing of the injury, such as an accompanying sound or sensation (i.e., snap, click or pop), as well as whether the player could resume activity soon after the injury and the pain pattern following.

If no acute incident can be recalled, it is often helpful to look into the activities undertaken by the patient in the period preceding the injury as well as a description of the development of symptoms, such as change in the load of activity (intensity, frequency, duration) and change of equipment, surface, or technique, and if the development of problems correlated to such changes. Furthermore, information on similar previous symptoms should be noted.

A history of systemic, urogenital, abdominal, or low back symptoms should be taken as well. Childhood hip disorders such as Legg-Calvé-Perthes disease, slipped capital femoral epiphysis, developmental dysplasia of the hip and septic arthritis are important diagnosis to be aware of in the patient's history. Disorders such as rheumatoid arthritis (RA), psoriatic arthritis or ankylosing spondylitis, malignancy, or low back pain can also be part of the etiology of the hip pain. A history of alcohol or steroid use is important in patients suspected of having osteonecrosis.

The precise location of the pain can sometimes be difficult for the patient to describe, but if possible it should be identified. Characterizing the complaints is an important part of the diagnostic procedure, and apart from localizing the pain, efforts should be made to clearly recognize the nature of the pain: if the pain is provoked or alleviated by anything; if there is a radiating element to the pain; the present activity level of the patient in activities of daily living (ADL), work, and sport; and also previous treatment(s) and response to such treatment(s).

18.5.2 Physical Assessment

Physical assessment should begin with observations of static (i.e., stance, alignment) and dynamic functions (i.e., gait pattern and rhythm, climbing stairs, running) and should be done both from a frontal and sagittal planes. Trendelenburg gait is the result of insufficient muscle function in the gluteus medius and minimus and sometimes the tensor fascia lata. To unload these weakened abductors and avoid pain production, the patient often shifts the center of gravity over the affected limb during the stance phase of gait, resulting in a pelvic drop on the contralateral unaffected side and trunk shift over the affected side. Coxalgic gait is the result of the patient quickly unloading the painful leg while bearing weight. This results in a decreased stance phase and stride length during gait on the affected side. In some cases the patient has a stiff hip gait and will walk by rotating the pelvis and swinging the legs in a circular fashion. More strenuous activities such as running may need to be investigated, as activities of daily living are often not always a problem for athletes, as their problems are mainly related to athletic performance. Running should be investigated for any unloading or compensating strategies, which these patients will sometimes display due to pain.

18.5.3 Range of Motion

Active and passive range of motion with the patient in the supine position should be measured and compared with values of the opposite side. Flexion, extension, abduction, adduction, and internal-external rotation should be evaluated in both flexion and extension. Internal rotation is usually most affected in most types of arthritis (osteoarthritis and RA) as well as FAI, and this motion commonly will stimulate pain along with the limitation in range of motion. The ROM of the hip joint has been suggested as a risk factor for groin injuries [31]. There are many reasons for pathologic changes of the hip joint ROM,

some of which are easily modifiable, whereas others are more difficult. Acquired tightness of the rotators, flexors, extensors, abductors, or adductors of the hip joint are all potentially able to be loosened with stretching exercises, soft tissue release techniques (manual therapy, massage, dry needling, proprioceptive neuromuscular facilitation techniques), as well as balanced muscle training addressing both the affected muscles and the antagonist muscles. One study found increased hip abduction ROM after an exercise program including both concentric and eccentric adductor exercises but no stretching exercises for the adductor muscles [32]. Generally there is no evidence that stretching can prevent groin injuries. However there are indications that a normal ROM of the muscles and joints probably is important.

In cases with cam and/or pincer bony morphology stretching could potentially lead to further structural damage to the hip joint [33]. If the impingement problem is symptomatic with hip joint and groin pain, damage to the acetabular cartilage as well as to the labrum of the hip joint may be prevalent. If this is suspected, active and passive stretching techniques should be completely avoided, as this may cause further injury to acetabular cartilage and labral structures.

18.5.4 Muscle Strength Testing

Hip strength assessment plays an important role in clinical examination of the hip and groin region. Decreased muscle strength seems to be a consistent finding in patients with hip and groin pathology [13]. Furthermore, decreased hip adduction strength in football and ice hockey players, seems to increase the risk of sustaining a groin injury [12, 34].

A reliable, inexpensive, and easy way to quantify isometric and eccentric hip muscle strength in clinical practice is by using a handheld dynamometer (HHD), which is a portable strength testing device [35]. When using the HHD, it is important to be aware of factors that may compromise its reliability, such as experience with the testing procedure and the tester's strength. In situations where the tester is unable to fixate the HHD due to decreased strength compared to the tested athlete, maximal muscle strength is no longer measured, and reliability is therefore affected [36]. In such cases an external fixation device, such as a belt, may be introduced to secure a high reliability [37].

The HHD can be used to track progression in hip muscle strength during treatment and postoperative rehabilitation. Comparison, if possible, should always be made with the contralateral healthy leg, pre-injury measurements of the affected leg if available, or using normative values, preferable from Handball players. In cases where the athlete is affected bilaterally (e.g., bilateral long-standing adductor-related pain) and comparison with the contralateral side is not suitable, the strength ratio between hip adductor and abductor may be a more relevant measure, as the contralateral leg cannot be used as a reference point. In football, and presumably also in handball, normative values suggest a hip adductor/abductor ratio of around 1.2–1.4 [38].

Another quick assessment of the hip and groin function can be performed with the Copenhagen five-second squeeze test [39]. This test is performed as the adductor squeeze test described above. The athlete is instructed to score the experienced pain in the groin region on a Numerical Rating Scale ranging from 0 (no pain) to 10 (maximal pain) subsequent to a maximum adductor squeeze for five seconds. Based on the experienced pain level, the athlete can be given a green (0–2), yellow (3–5), or red (6–10) light representing an approximation of readiness to participate in training. Such an approach has been shown to correlate with self-reported hip and groin function measured with the HAGOS questionnaire and thus can be used to provide the clinician with a quick and valid indicator of hip and groin function [39].

18.5.5 Specific Tests

18.5.5.1 Musculotendinous Pain

Palpation of the majority of the important anatomical structures can be done with the patient in the supine position, for example, the pubic symphysis, the tendons and their attachments, and the muscle bellies. Additionally, the external orifice of the inguinal canal should be palpated with the patient standing.

The palpation of the adductor insertion is done with the hip flexed, abducted, and externally rotated, and the knee slightly flexed. The examiner, using the right hand on the right leg, and left hand on the left leg, palpates the adductor longus tendon with two fingers and follows the tendon to the insertion at the pubic bone. The insertion area, including the bone, is tested with firm pressure to a radius of about 1 cm. Pain on palpation suggest adductor-related groin pain [8] (Fig. 18.1).

The iliopsoas can be palpated both above the inguinal ligament at the level of the anterior superior iliac spine (ASIS) and under the ligament, medial to the sartorius muscle, and lateral to the femoral artery. The patient is supine, and gentle abdominal palpation is performed using both hands. The fingers are gently pressed posteriorly while pushing the abdominal structures away to reach the iliopsoas muscle. The patient is then asked to elevate the leg 5 cm, and the psoas can be felt and palpated for any pain. The tendon of the iliopsoas muscle can be identified during the palpation distal to the inguinal ligament by asking the patient to elevate the examined leg 5 cm from the examination bed/table, while the fingers position is adjusted until the tendon is palpated under the fingers. Then the patient relaxes and the tendon can be palpated for any pain. If any of these palpations are painful, iliopsoas-related groin pain is suspected [8] (Fig. 18.2).

Fig. 18.1 Adductor palpation

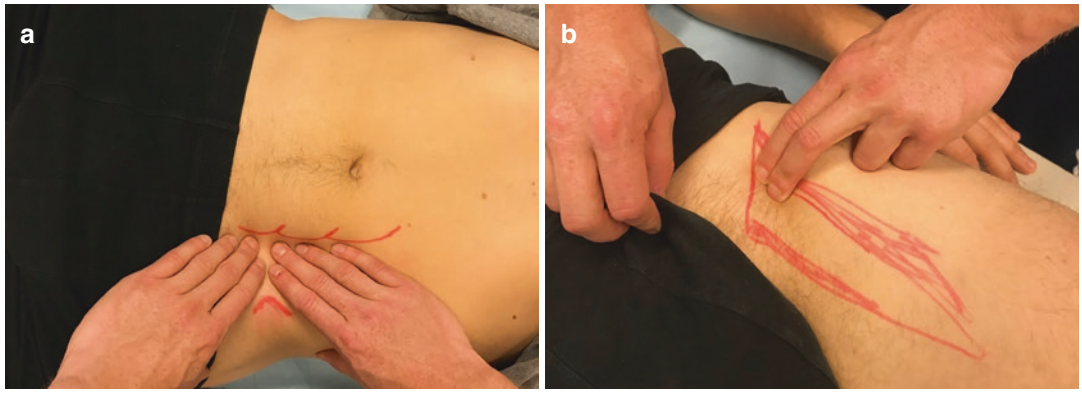

Fig. 18.2 (**a**) Psoas abdominal palp. (**b**) Psoas under inguinal ligament palp

The external orifice of the inguinal canal is approximately the size of a fingertip, and when an inguinal hernia is present, the orifice is enlarged, and the hernia contents are pushed against the finger during maneuvers which elevate the intra-abdominal pressure, such as coughing. The incipient hernia is not a true hernia, and there is no bulging. Pain when palpating the orifice and/or dilatation is a characteristic finding with an incipient hernia. When palpation of the conjoined tendon insertion at the pubic tubercle just medial to the inguinal ligament is painful, this is also a positive test of inguinal related groin pain [8, 15].

The piriformis muscle is tested in the supine position with the hip in flexion and adduction and can be stretched rotating internally. The patient will feel a pain in the inferior part of the gluteal area sometimes radiating down the lines of the ischial nerve in case of a piriformis-related pain problem.

Fig. 18.3 Adductor squeeze test

Adductor Squeeze Test

There are a number of adductor squeeze tests, but the most sensitive is performed with the patient in the supine position. The examiner stands at the end of the treatment couch with hands and lower arms between the feet of the subject to hold them apart. The feet of the subject point straight up, and the subject presses them together with maximal force without lifting the legs or pelvis. The test is positive if it reproduces pain from insertion site of the adductor longus where the patient also was tender at palpation [8, 40] (Fig. 18.3).

18.5.5.2 Femoroacetabular Impingement Syndrome

The patient usually complaints of a sharp pain deep in the groin during hip flexion, internal rotation, or abduction movements. Other symptoms such as painful clicking are not infrequently observed and may suggest involvement of the hip labrum [41]. The ability to make deep squats is often compromised as well as sudden stopping/starting and cutting movements. The patient often has decreased hip range of motion and hip muscle strength [42]. Most frequently flexion and internal rotation are the most limited motions, but external rotation and abduction can also be decreased. Hip muscle strength seems to be impaired particularly for hip flexion, extension, abduction, and adduction.

The diagnostic process of FAIS remains a challenge as specific clinical tests seem to have low diagnostic accuracy [43]. Therefore, before introducing specific intra-articular hip tests, the clinician should seek to rule out other potential causes masquerading as intra-articular hip pain [44]. This can be done by examining the musculotendinous structures in the groin (as presented above) and by using sensitive tests to rule out a stress fracture of the hip (Fulcrum Test), referred pain from the lumbar region (Repeated Motions and Extension-Rotation-Test), and pelvic girdle pain (Thigh Thrust Test) [44]. Subsequently, the **impingement test** (also known as the Flexion Adduction Internal Rotation – FADIR) should be applied to investigate for potential FAIS [16, 45]. However, it should be noted that this test is not very specific (low specificity) but very sensitive (high sensitivity) and thus positive in most of the patients having an intra-articular problem [43]. For the impingement test, the patient is supine, and the hip is passively flexed to 90º, adducted

and internally rotated. This movement brings the anterior femoral neck in contact with the anterior rim of the acetabulum. This test will reproduce the typical groin pain that may be present with this condition. It is important to realize that a multiplicity of other structures will be impinged, squeezed, and compressed with this test, including the iliopsoas muscle and tendon, the rectus femoris, the inguinal canal, and the nerves and vessels in the region. It is therefore important to rule these structures out before deciding that a positive impingement test means that the radiological morphological findings are causing FAIS. A positive test is not diagnostic of an intra-articular hip joint problem, but if it is negative an intra articular hip joint problem is not likely [43].

Other tests such as hip internal rotation with/without hip flexion have also been suggested to be indicative of FAIS when range of motion is limited and end range is painful [45]. As with the impingement test, it is important to rule out other painful structures when interpreting the test (Fig. 18.4).

18.5.6 Radiology

Radiographic abnormalities are common in athletes involved in the football codes [46], in basketball, in ice hockey [47], and presumably also in handball. The current evidence of the use of radiographs, ultrasonography, and magnetic resonance imaging (MRI) is based on relatively few heterogeneous studies of varying methodological quality, and the correlation between identified radiological abnormalities and symptoms may be low (Fig. 18.5).

Standard radiographs with the patient standing with neutral pelvic tilt and 15° internal rotation of the legs and a true lateral view are in most cases very helpful to rule out other potential causes of hip and groin pain, such as femoral neck stress fractures, and are useful to determine the presence of cam and/or pincer morphology [45]. No specific radiological measures, such as

Fig. 18.4 Anterior impingement test FADIR

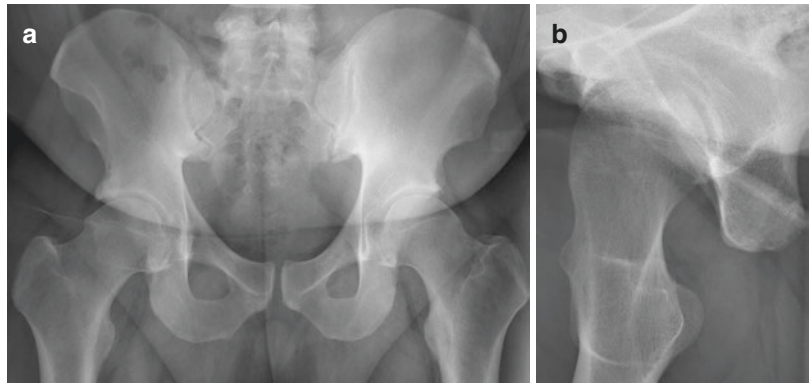

Fig. 18.5 (**a**) Bilateral cam. (**b**) Cam lateral view

the alpha angle or lateral center edge angle, can be recommended to define the presence of cam or pincer morphology, respectively [16]. Cam morphology is however often defined as an alpha angle >55° [16] 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 [24]. Pincer morphology is often defined as a lateral center edge angle >39° [16] 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 (Fig. 18.6) [24]. The clinician should, however, be cautious when interpreting the findings of cam and/or pincer morphology, as the prevalence of such morphologies are high in athletes regardless of symptoms [48] and in athletes with adductor-related groin pain [49]. Furthermore, poor correlation between radiological findings and pain in subjects diagnosed with FAIS has been reported [50]. If present, such morphologies therefore do not necessarily support a diagnosis of FAIS as the primary source of hip and groin pain. Standard radiographs is also valuable to assess for other potential causes of hip and groin pain, such as femoral neck stress fractures, osteoarthritis, or hip dysplasia [16]. Hip dysplasia is defined as a lateral center edge angle <20 and borderline between 20° and 25° and is of special interest as this condition too may give rise to hip labrum and/or acetabular cartilage damage [51].

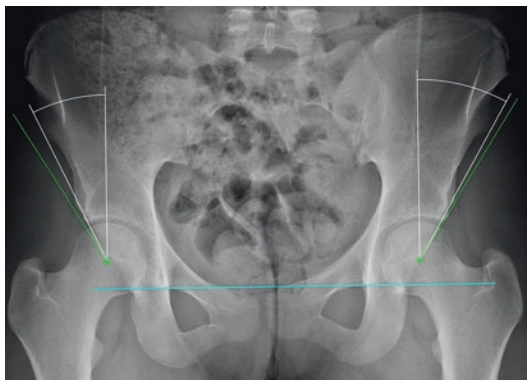

Fig. 18.6 Lateral Center Edge angle

Other imaging modalities such as MRI or ultrasonography can also be very helpful but must always be correlated carefully to the clinical situation. For intra-articular hip injuries 3.0 T MRI is considered the preferred imaging modality for identifying acetabular labral tears and chondral lesions [16]. When interpreting the MRI findings, the clinician should however be aware that the sensitivity and specificity of this modality is not perfect [52, 53]. Furthermore, acetabular labral tears may be asymptomatic [54].

An ultrasound-guided intra-articular diagnostic injection is an important aid in the examination of athletes with potential intra-articular hip injuries [16]. An intra-articular diagnostic injection may also be performed under fluoroscopy, enabling a thorough dynamic examination, a more accurate impingement site recording if and when present and potential correlation between symptoms and morphologic impingement sites. A systematic review suggested that pain relief following an intra-articular diagnostic injection supports the diagnosis of FAIS [55].

In skeletally immature adolescent players, imaging is also important to detect osseous avulsions in acute proximal or distal muscle distraction injuries and with suspicion of injury to the growth plate of the femoral neck.

The osteolytic changes including widening of the pubic symphysis and sclerosis along the rami of os pubis is often seen on X-ray and can also be seen as bone marrow edema on MRI in the pubic bone adjacent to the symphysis joint. However, this condition, originally called symphysitis or osteitis pubis, have been shown scientifically to be common also in asymptomatic footballers and thus reflect the considerable strain that the pelvic girdle is exposed to in cutting sports and is not the sign of injury.

18.5.7 Patient-Reported Outcome Measurement (PROM)

When evaluating athletes with hip and groin pain, the subjective perspective of the athlete can pro-

vide valuable information on the severity and impact of the hip and groin pain. Such information can be quantified using reliable, valid, and responsive Patient-Reported Outcome Measurements (PROMs).

For patients with hip and/or groin pain, different PROMs can be recommended based on a recent systematic review [56]. For athletes presenting with hip-related pain or undergoing hip arthroscopy for intra-articular hip pathology, the Copenhagen Hip and Groin Outcome Score (HAGOS), the Hip Outcome Score (HOS), and the two versions of the International Hip Outcome Tool (iHOT-12 and iHOT-33) have all shown sufficient reliability, validity, and responsiveness to be recommended in clinical practice.

However, HAGOS is the only PROM to date that can also be used to evaluate self-reported function in patients presenting with groin pain arising from musculotendinous structures [57]. As many athletes present with clinical signs of both hip and groin pain, HAGOS is a viable tool to monitor and track self-reported function in the daily clinic. HAGOS is self-explanatory, takes 10 min for the athletes to fill in, and consists of 37 questions divided into 6 subscales: pain, symptoms, physical function in daily living, function in sport and recreation, participation in physical activities, and quality of life. As such HAGOS measures hip and groin function in relation to different constructs, such as sport function which is highly relevant for athletes [57].

18.6 Treatment

Hip and groin injuries can be challenging to treat. However, a systematic approach using the Doha [15] and the Warwick agreements [16] combined with sound treatment principles based on science and experience often leads to good results.

Groin injuries sometimes have a tendency to become long-standing and even chronic [20]. In most cases this is probably because they are not diagnosed and treated properly early on but also because the players are in many cases able to warm up and then play in spite of the injury [58]. Playing with groin pain is a familiar phenomenon in football [58] and presumably also in handball players and could easily delay diagnosis [59]. The injury could then gradually become worse and more and more difficult to treat and at the same time secondary problems from other supporting structures may arise.

18.6.1 Acute Muscle-Tendinous Injuries

The POLICE (Protection, Optimal Loading, Ice, Compression, Elevation) protocol can be used as early treatment just like with other muscle injuries. Early mobilization including reaching the outer range of motion is recommended. In addition isometric contractions can be commenced gradually at an early stage. Within the second week, careful but more demanding lengthening contractions can be included in the rehabilitation program. Hip adduction with an elastic band could be added to increase muscular activity. This has been shown to result in significant eccentric strength gain [60]. Sports-specific drills such as running, accelerating, sprinting, change of direction, and skating can be gradually included in the program. Finally, the Copenhagen Adduction exercise should be introduced starting with 1 set of 5 repetitions on each side and gradually working toward 2–3 sets of 12–15 repetitions on each side [61]. The Copenhagen Adduction exercise has been shown to increase eccentric hip adduction and abduction strength and may also be used to increase core endurance. When performing the Copenhagen Adduction exercise, it is important that the athlete maintains a straight back and hip alignment to prevent potential back problems. Furthermore, the upper leg should be supported to avoid unnecessary stress medially on the knee [61].

Return to sport should not begin before isometric and eccentric strength as well as ROM have normalized, and sports activities such as sprinting, changing direction, forceful skating strides, and jumping exercises can be performed pain-free. It is advisable to maintain a training routine using the Copenhagen Adduction exercise after return to play, and this can easily be incorporated into the normal handball training session.

18.6.2 Long-Standing Adductor-Related Groin Pain

A randomized clinical trial has found a structured training protocol to be highly effective in the treatment of long-standing adductor-related groin pain [32]. It consists of two modules. The first module (0–2 weeks) includes specific isometric and dynamic exercises at a fairly low level of muscular activity to teach the patient to reactivate the adductor muscles. The negative feedback that is caused by the pain will in many patients result in difficulties activating the muscles.

In the second module, the exercises gradually become more demanding; resistance training as well as challenging balance and coordination exercises are included. The exercise program should be performed three times a week. The total length of the exercise-training period was between 8 and 12 weeks. No handball or other sports activities are allowed in the treatment period.

Injection with cortisone is not recommended. Various manual additional therapies can probably be used as a supplement [62].

Treatment program for long-standing adductor-related groin pain	
Module 1 (first 2 weeks)	Adductor squeeze (ball between feet), 10 × 30 s Adductor squeeze (ball between knees), 10 × 30 s Abdominal sit-ups (straight and oblique), 5 × 10 reps Folding knife (ball between knees), 5 × 10 reps Balance (wobble board), 5 min One-foot sliding board, 5 × 1 min
Module 2 (from third week)	Side-lying hip adduction/abduction, 5 × 10 reps Hip extension, 5 × 10 reps Standing hip adduction/abduction (elastic band), 5 × 10 reps Abdominal sit-ups (straight and oblique), 5 × 10 reps Cross country skiing, 5 × 10 reps Sideward motion on "fitter," 5 min Balance (wobble board), 5 min Skating (sliding board), 5 × 1 min

18.6.3 Long-Standing Iliopsoas-Related Groin Injury

As there is no evidence-based treatment of long-standing iliopsoas-related groin pain, we recommend our experience-based treatment. The iliopsoas muscle needs to gain its strength again, and a systematic and gradual strengthening program [63] including isometric, concentric, and eccentric exercises is very often effective. This specific approach targeting the iliopsoas could be combined with a more general pelvic stabilization strategy and core stability exercises.

Additional therapies like stretching and trigger point stimulation may also be helpful. In persistently painful cases, an ultrasound-guided injection along the distal iliopsoas tendon with cortisone can be helpful. This can alleviate the pain and help the athlete perform and progress with the full rehabilitation program. In only very rare circumstances, a partial iliopsoas tenotomy might be indicated. As it will leave the hip flexion strength weakened, it is not recommended in athletes.

18.6.4 Long-Standing Inguinal-Related Groin Injury (Sports Hernia)

As there is no evidence-based treatment of long-standing inguinal-related groin pain, we provide our experience-based treatment recommendation. As we consider this to be a posterior wall problem, the first line of treatment is aimed at strengthening the muscles of the inguinal canal.

The patient is prescribed with exercises for strengthening the oblique abdominal muscles as well as the rectus abdominis both in the outer and the inner range of motion. Core stability exercises challenging the balance and coordination related to all pelvic muscles should also be implemented. In many cases this will allow the strengthened posterior wall to sustain the pressure, and the compressed structures will be relieved pain-free. If the exercise therapy is not sufficient, surgical treatment with various techniques often quite similar to those used for regular hernia treatment may be advocated, with both open and endoscopic techniques available. It is imperative to thoroughly rule out other potential concomitant pathologies, which may contribute to similar symptoms before decision-making for surgery.

18.6.5 Intra-Articular Hip Injuries

In clinical situations with signs of synovitis with no sign of any intra-articular injury, this may reflect overuse and will often tend to resolve fairly quickly. In situations where specific intra-articular injuries are present, such as damage to the acetabular labrum and/or cartilage conservative management such as education, watchful waiting, lifestyle, and activity modification may not be sufficient to decrease the symptoms and allow the athlete to reuptake athletic participation [64, 65]. In such cases specific physiotherapy-led treatment and/or operative procedures may be relevant to introduce [16]. Despite no level 1 evidence for the treatment of FAIS, it is the authors' perception that structured physiotherapy-led treatment should be tried before progressing to operative procedures. The physiotherapist-led treatment should focus on restoring known impairments related to FAIS, such as decreased hip flexion, extension, abduction, and adduction muscle strength [66–71] and decreased trunk endurance strength [72]. Furthermore, emphasis should be given to functional task performance, such as single-leg hop performance, plyometric ability, and hip stability [71, 73–76].

If physiotherapy-led treatment is unsuccessful, operative procedures such as hip arthroscopy, including labral repair and cam resection, should be considered. In case of hip dysplasia with a lateral center edge angle <20° (20°–25° being borderline) and/or acetabular retroversion, care should be taken, and in most cases it is recommended to consider periacetabular osteotomy as the primary procedure. Favorable outcomes on return to play following operative management of FAIS have been reported [77]. A recent systematic review including 18 studies, primarily on high-level athletes, found that 82% return to the same level of sport compared to before the onset of hip/groin pain, while 87% return to any level of sport [77]. However, athletes presenting with severe cartilage damage or symptoms of osteoarthritis, as well as athletes competing in high-impact sports, such as handball, may return to sport at a lower rate [77, 78]. Following hip arthroscopy, it is paramount to follow a structured rehabilitation program designed to restore optimal hip muscle strength, stability, neuromuscular control, and range of motion [16]. The effect of postoperative rehabilitation has only been poorly investigated [79], but like physiotherapy-led treatment of FAIS, the rehabilitation should focus on established muscular and functional hip deficits. The athlete should work from isolated hip exercises targeting the deep hip stabilizers progressing into functional activities. Isolated strength hip exercises, such as the Copenhagen Adduction exercise [61] and hip flexion with an elastic band [63], seeking to develop significant hip muscle strength should also be emphasized to increase the load absorption capacity of the hip joint complex. During the rehabilitation process, the clinician should pay attention to, and address, potential painful competing musculotendinous structures, such as the iliopsoas muscle [80].

No return to sport guidelines exist for athletes who have undergone hip surgery for FAIS; however, the athlete should aim for leg symmetry on hip muscle strength and one-leg jump performance. Furthermore, the clinician should be aware that psychological factors such as motiva-

tion, self-efficacy, and fear of reinjury may be important for successful return to play, and indications of such potential barriers should be address if present [81].

Impairments to be addressed during rehabilitation of athletes with FAIS	
Muscular impairments	Altered coordination of deep hip muscles Decreased core muscle endurance Decreased hip flexor strength Decreased hip extension strength Decreased hip adduction strength Decreased hip abduction strength Decreased hip rotation strength
Functional impairments	Decreased single-leg balance Decreased single-leg jump performance Decreased sprint performance Decreased agility performance

18.7 Summary

Hip and groin pain is prevalent in handball players constituting up to 12.5% and 11% of all overuse and acute injuries, respectively, recorded during a full handball season. Of these, adductor-related groin pain is the most common cause of hip and groin pain. The diagnosis of groin pain related to musculotendinous structures should follow the DOHA agreement on terminology and definitions in groin pain in athletes and be based on specific palpation and muscular resistance tests. Similarly, the diagnosis of intra-articular hip pain such as femoroacetabular impingement syndrome should follow the Warwick agreement and be based on a triad of symptoms, clinical findings, and radiological findings. The treatment should focus on active rehabilitation aiming to restore and build hip muscle strength and increase pelvic stability. In cases with FAIS or isolated intra-articular hip pathology, such as labral tear and/or cartilage damage, hip arthroscpy may be considered, and favorable outcomes on return to sport have been reported in high-level athletes.

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