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Abstract	Groin pain represents a widespread problem in sport in both amateur and professional areas. However, the term "groin pain" should describe the symptoms or a symptom, namely, the pain in the groin area, a medical problem with still unclear pathophysiology. One of the reasons for this could be the anatomical complexity of the pubic area and the frequent overlapping of different pathology. The term groin pain or pubalgia is according to some authors ambiguous or at least simplistic and not suitable for the complexity of the medical issue in question. It is better defined as groin pain syndrome. Conversely to this lack of clarity, the groin pain syndrome has spread from a typical pathology of high-profile athletes into all levels of athletes. It currently affects mostly intermediate-level athletes, as their fitness levels for sport activity are often not suitable for its prevention, while the athletic load is high enough to favor its onset. The diagnosis of groin pain syndrome has been reported by Spinelli more than 70 years ago as a medical problem affecting fencers (Spinelli, Orthop Trauma App Mot 4:111, 1932), and since then, controversy and different conceptual interpretations started. From a rehabilitative point of view, it is very important to underline the enormous importance for proper and early diagnosis. Only after a proper diagnosis is made, it is possible to refer the patient to the most appropriate type of treatment either conservative or surgical. In any case, further studies are required for better assessment of the natural course of athlete's groin pain and to optimize clinical evaluation in screening patients. Also further studies would be needed to validate with scientific evidence the conservative rehabilitation plans.

Keywords (separated by " - ")	Groin pain - Athlete's pubalgia - Groin injury - Sport hernia - Symphysis syndrome

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The Groin Pain Syndrome

8

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8.1 Introduction

Groin pain represents a widespread problem in sport in both amateur and professional areas. However, the term "groin pain" should describe only the symptoms or a symptom, the pain in the groin area, a medical problem with still unclear pathophysiology. One of the reasons for this could be the anatomical complexity of the pubic area and the frequent overlapping of different pathology [1]. The term groin pain or pubalgia is according to some authors ambiguous or at least simplistic and not suitable for the complexity of the medical issue in question. It is better defined as groin pain syndrome [2]. Conversely to this lack of clarity, the groin pain syndrome has spread from a typical pathology of high-profile athletes into all levels of athletes. It currently affects mostly intermediate-level athletes, as their fitness levels for sport activity are often not suitable for its prevention, while the athletic load is high enough to favor its onset [3]. The diagnosis of groin pain syndrome has been reported by Spinelli more than 70 years ago as a medical problem affecting fencers [4], and since then, controversy and different conceptual interpretations started [5, 6].

Sport activities most at risk are represented in Europe by football and then, with less impact, by hockey, rugby, and distance running [7–16]. However, none of these publications relate the incidence of the injury to the number of licensed athletes into the various activities in question, and most of these studies would be rejected if we follow the minimum criteria of a meta-analysis [17].

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8.2 Etiology and Clinical Classification

Different entities of groin pain are classified according to the type of pathologic lesion and to symptoms that are reported by the patient. Very often, an inaccurate diagnosis, leading to inadequate therapeutic interventions, can further lead to a very debilitating medical problem, sometimes forcing the athlete to long suspension of sport activity.

In our view, this discrepancy of clinical judgments is mainly generated by the excessive overlapping of possible clinical entities. For example, some authors [16, 18] identify from 15 to 72 cases of groin pain including mainly muscle and tendon pathologies (insertional tendinopathy, ectopic calcification, avulsions, hernia) but also bone and joint diseases such as stress fractures, osteochondrosis or osteonecrosis, infections, cancer, bursitis, nerve entrapment, and pain of the visceral source.

Considering the importance of a correct diagnosis, the first step in this direction seems to adopt a correct and rational nosological framework. One of the most systematic, practical references derives from Brunet's [19] and from Durey's and Rodineau's studies [9]. According to the experience of these authors, the groin pain in athletes refers to three different anatomo-clinical entities often associated as follows:

1. Parieto-abdominal pathology, affecting the lower part of the anterior abdominal muscles (external and internal oblique muscles and transverse muscle), fascia transversalis, conjoint tendon, and inguinal ligament
2. Adductor muscle pathology mainly affecting the adductor longus and pectineus muscle
3. Pubic symphysis pathology

Bouvard's theory [1] is also interesting and worthy to note. These authors have proposed a revision of Brunet, Durey, and Rondineau's [9] classification and suggest a single disease presenting in four different clinical forms:

1. The pubic osteoarthropathy affecting the pubic symphysis joint and the adjacent bone branches due to microtraumatic etiology. This needs to be differentiated

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from the rare infectious pubic osteoarthritis [10, 20, 21]. Sometimes bone modifications could be evident appearing in the form of erosion, or as real "nail shots" sometimes with bone fragments. Occasionally, erosions may occur in such marked and conspicuous manner to include in the differential diagnosis of neoplastic erosive osteopathy [22].

2. The inguinal canal pathology with diagnosis initially formulated by Nesovic [23], arbitrarily named "sports hernia" since in this case, a real hernia is not present [9, 14, 24]. Many authors report a high percentage (36–84 %) of non-palpable hernias but with similar symptoms in the groin [25–30]. All painful symptoms caused by inguinal canal posterior wall anatomical defects are included in this category, that is, localized weakness of fascia transversalis, an area where striated muscles are absent [14]. Pathology of the inguinal canal posterior wall can be confirmed by ultrasonography [31, 32]; herniography has only historical significance since it is very invasive [11, 26, 27]. Moreover, anterior wall inguinal canal lesions such as conjoined tendon or external oblique muscle tear should be considered [33] as they may occasionally lead to ilioinguinal and iliohypogastric nerve entrapment [6, 14, 17, 29, 31]. This group also includes external oblique muscle aponeurosis lesion and inguinal ligament and fascia transversalis lesions [14, 31, 34–37].
3. Rectus abdominis insertional tendinopathy [9, 12, 38–40].
4. Hip adductor muscles bone–tendon junction and muscle–tendon junction tendinopathy possibly complicated by obturator nerve entrapment [29, 41, 42].

Benazzo et al. [43] proposed a similar clinical classification, especially in terms of nosological rationality, and subdivided the possible clinical cases into three groups:

1. Adductor and/or abdominal muscle insertional tendinopathies, occasionally associated with pubic osteoarthropathy, likely due to microtraumatic repetitive stress. The basic anatomical lesion is represented by an adductor muscle–tendinous unit sprain affecting in most cases the adductor longus, with a potential rectus abdominis involvement at the level of its distal insertion. In this context, it may also be associated with a secondary bone alteration at the pubic symphysis. According to the authors, this type of injury would be the most prevalent in football.
2. Abdominal wall lesions, especially the inguinal canal lesion as hernia, structural weakness of the posterior wall, and the conjoint tendon abnormalities.
3. The less common causes of groin pain, not directly linked to abdominal wall pathologies. These clinical situations defined by the authors with the term "pseudo-pubalgia" include iliopsoas, quadratus femoris and obturator internus muscle strains or tears, nerve compression syndromes (especially affecting the obturator, ilioinguinal, femoral cutaneous, femoral, pudendal, iliohypogastric, and genitofemoral nerve), abdominal muscles perforating branches compression, and spinal nerves anterior roots pathologies. A condition included in this group, and relatively frequent in football, is the obturator nerve entrapment syndrome, with pathogenesis that, although not yet clearly defined, seems to be due to a fascia inflammatory process which could cause an obturator nerve (anterior branch) involvement of its part over the adductor brevis muscle. Furthermore, in this group, there are bone lesions, such as the osteitis pubis, the iliac bones, femoral head stress fractures, pubic symphysis stress lesions, diastasis, osteochondritis dissecans, osteomyelitis, and tumors.

However, besides the proposed three clinical classifications, we can still find many authors that consider pubalgia as a "unique" clinical entity which is summarized in inguinal canal pathology [8, 14, 36, 44], adductor muscle insertional tendinopathy [17, 45], or pubic osteoarthropathy [46]. As it has been pointed out in some studies [36, 47], it is very important to distinguish the so-called true pubic lesions, directly affecting the pubic skeletal structure, and the false pubic lesions represented by insertional tendinopathy, hernia, sport hernia, and nerve entrapment. In addition, it should be noted that some authors [48] do not agree with the inguinal canal diagnosis and consider that it is only associated with a more general groin pain framework. Inguinal forms relate almost exclusively to the male population, affecting football players in 70 % of the cases, followed by hockey players, rugby players, and long-distance runners [2, 14, 49]. However, other authors consider that the term groin pain or pubalgia should be used only for the parietal lesions and that all other forms should have a different and very specific nomenclature.

According to these authors [2, 48, 50], all "no parietal forms" include the following:

1. Rectus abdominis tendinopathy
2. Adductor longus m., pectineus m., and gracilis m. tendon damages and adductor muscle belly lesions
3. Iliopsoas muscle lesions
4. Pubic osteoarthropathy
5. Pubic stress fracture
6. Coxofemoral pathologies
7. Maigne's intervertebral syndrome, though with rare incidence

Other authors also agree in some way to this clinical approach. According to Gilmore [14], in case of symptoms that he described with the term "groin pain disruption," it is possible to find simultaneously a conjoined tendon lesion, and its avulsion from the pubic tubercle, an external oblique muscle aponeurosis injury, or a dehiscence between the conjoined tendon and the inguinal ligament. In addition, in 40 % of the cases, there is an adductor muscle weakness.

According to Albers [51], in 90 % of the surgically treated groin pain cases, we can find a focal fascial protrusion called "bulging." In particular, there is often an abnormally high conjoined tendon insertion pointed out. For these reasons, the author underlines the fact that groin pain is caused by a myofascial pubic–abdominal abnormality (pubalgic abdominal myofascial abnormality, PAMA). According to the theory that the term "pubalgia" is only used in cases of parietal disease, it is possible to find in bibliography a widespread consensus on the dominant factors in the pubalgia framework (i.e., inguinal canal widening, inguinal canal posterior wall weakness, groin pain disruption, and PAMA).

In any case, given the "key concept" that the term groin pain, or pubalgia, represents only the description of a symptom or a cohort of symptoms and is not a diagnosis, speaking of "pseudo-groin pain" and/or "pseudo-pubalgia" represents a conceptual error. For this reason, currently, the more rational clinical classification is, in our opinion, the one proposed by Omar et al. [52]. It suggests a differential diagnosis of groin pain syndrome based on 37 major diseases, subdivided in 10 different categories (Table 8.1).

Table 8.1 The differential diagnosis of groin pain in athletes proposed by Omar et al. [52] (modified)

Category 1: Visceral causes
Inguinal hernia
Other abdominal hernias
Testicular torsion
Category 2: Hip-associated causes
Acetabular labral tear and femoroacetabular impingement
Osteoarthritis
Snapping hip syndrome and iliopsoas tendonitis
Avascular necrosis
Iliotibial band syndrome
Category 3: Pubic symphyseal causes
Rectus abdominis strain
Adductor muscle–tendon dysfunction
Rectus abdominis–adductor longus aponeurosis tear
Osteitis pubis
Category 4: Infectious causes
Septic arthritis
Osteomyelitis
Category 5: Pelvic inflammatory disease
Prostatitis
Epididymitis and orchitis
Herpes infection
Category 6: Inflammatory causes
Endometriosis
Inflammatory bowel disease
Pelvic inflammatory disease
Category 7: Traumatic causes
Stress fracture
Tendon avulsion
Muscle contusion
Baseball pitcher–hockey goalie syndrome
Category 8: Developmental causes
Apophysitis
Growth plate stress injury or fracture
Legg–Calvé–Perthes disease
Developmental dysplasia
Slipped capital femoral epiphysis
Category 9: Neurologic causes
Nerve entrapment syndromes (e.g., ilioinguinal nerve)
Referred pain
Sacroiliitis
Sciatic entrapment (piriformis syndrome)
Hamstring strain
Knee pain
Category 10: Neoplastic causes
Testicular carcinoma
Osteoid osteoma

8.3 Injury Mechanisms and Predisposing Factors

Intrinsic and extrinsic factors may predispose the athlete to the groin pain syndrome. Among the intrinsic factors, those receiving the greater consensus in literature [1, 10, 32, 53–59] are as follows:

1. Hip and/or sacrum–iliac joint diseases
2. Lower limbs asymmetry
3. Lumbar hyperlordosis
4. Functional imbalance between abdominal and adductor muscles, with a weakness of the abdominal muscles compared to the adductors leading to their excessive stiffness or a weakness of both muscular groups, leading to a reactive contracture of adductor muscles
5. Excessive hamstring stiffness
6. Adductor weakness
7. Previous injury

It is important to remember that some authors [60] proposed as intrinsic cause a core muscular weakness or a delayed onset of transversus abdominal muscle recruitment.

Furthermore, there is an ongoing debate in literature regarding the age and/or sport experience as risk factors for groin injury [60–62].

The extrinsic factors [19, 23, 40, 63–65] are as follows:

1. Inadequacy of sport equipment: a typical example in football is the use of cleats, too long on dry surfaces or too short on soft ground [3].
2. Inadequate pitch surfaces [40, 63].
3. Errors in training planification [65].

Regarding the inadequacy of pitch surfaces, we must make some important clarifications. A parameter which we must carefully assess is represented by the interaction, in terms of mechanical constraint, between the pitch and the shoe. An interesting data in this regard comes from the

American National Football League (NFL), which shows that abductor tendinopathy would increase by 27 % on the artificial turf pitches when compared to natural turf pitches [66], although these data do not find further confirmation in the literature [67, 68]. Also some natural grass surfaces may be a risk factor for the onset of abductor tendinopathy. The association of hot climates and some types of grass having a particularly strong and deep root system creates an excessive constraint between the shoe and the ground. Conversely, other types of grass with an insufficient radical apparatus, if used in cold climates, would not be able to create a sufficient mechanical constraint between the foot and the playing surface. Both situations could represent a risk factor for onset of adductor tendinopathy especially in athletes with pelvic instability [66].

One of the sports where groin pain is most frequent is football [69]. Many technical movements in football may favor the onset of the injury: jumps, dribbling, cutting movements in general, and tackles performed sliding with abducted leg and adductor muscle contracted. These are factors that cause high stress on the pubic symphysis, triggering a synergic mechanism between adductors and abdominal muscles [43]. Moreover, shooting and running performed on irregular surfaces represent other intense and abnormal functional stress factors [70].

In this context, it is important to consider the Maigne theory [71], based on the functional imbalance of the football players' column biomechanics. Specifically, this theory argues that football players are playing in a constant hyperlordotic gait which creates a conflict at the dorsal-lumbar spine level between the vertebral joints and genito-abdominal nerves, responsible for the groin region sensitive innervations. This theory could justify the high incidence of groin pain in football reported by different authors [72, 73].

There is no strong evidence in the literature supporting a causal association for any extrinsic or intrinsic risk factors and pubalgia onset. In effect, the majority of the studies are based on conjecture, expert opinion, or case series.

Athletes affected by groin pain would most likely be subjected to a combination of excessive muscular contractions by abdominal and adductor muscles. Torsion and impact causing bone stress can occur during running, violent movement performed with poor muscle control (such as sprint, shoots, tackles, change of direction), and mechanical constraints especially of torsion type at the pubic symphysis level [12, 32, 63, 65, 74]. The majority of authors agree that during normal activity, the abdominal and adductor muscles have an antagonistic but biomechanically balanced function. In the case of groin pain, there is no more muscle balance between the adductors and abdominals, with the adductor muscles being too powerful and the abdominals too weak or with adductors being extremely stiff thus producing an abnormal tension in the pelvis with a negative impact on the pubis [19, 23, 36, 44, 57, 75, 76]. Finally, quadriceps muscle hypertonia would further aggravate this functional imbalance [76].

It is important to underline the rectus abdominis and adductor longus origin from a common aponeurosis insertion at the periosteum of the anterior aspect of the pubic body and their antagonist function during rotation and extension [77].

Moreover, we must remember that also a force ratio less than 80 % between the adductor and abductor muscles has been identified as a potential groin pain risk factor [45]. Other authors found that the same deficit between the extensor and the flexor trunk muscle force ratio could induce groin pain [16]. Finally, other studies [1] include poor proprioception among the predisposing factors. However, our therapeutic experience does not allow us to share this hypothesis; in effect, both static proprioception management and dynamic proprioception management reflect an extremely multifactorial control mode which makes it difficult to provide evidence in this specific field.

It is important to remember that six of the seven adductor muscles[1] are innervated by the obturator nerve and that their origin is in close proximity to the pubis. This allows them biomechanically to act in open kinetic chain as hip adductors and have an important stabilizing role in the closed kinetic chain. Not surprisingly, athletes affected by groin pain generally have significant concentric muscle strength in the lower limb muscles while simultaneously presenting with a deficit of postural muscle strength [1, 45].

8.4 Clinical and Diagnostic Examination

Symptoms of groin pain are bilateral in 12 % of cases, affecting the adductor region in 40 % of the cases and the perineal area only in 6 % of the cases [14]. The onset of reported groin pain symptoms is insidious in 2/3 of the patients and acute in 1/3 [14]. The groin pain clinical framework is characterized by subjective and objective symptomatology.

Subjective symptoms are mainly identified in pain and functional deficit [78, 79]. The intensity of pain has highly significant variability and can range from a mere annoyance to acute pain. The intensity of which can even affect the patient's normal daily life activity, such as walking, dressing, and getting out of bed or car, and sometimes even preventing

[1] There are seven adductor muscles; the closest to the surface is the pectineus. The adductor longus, the gracilis, and the adductor brevis are located within the second layer. The adductor magnus is in the deep muscular layer. The pectineus muscle is innerved by the femoral nerve and the obturator nerve. The adductor magnus is innervated by the obturator nerve or by the ischiatic nerve and the tibial nerve. The adductor longus and the adductor brevis are innervated only by the obturator nerve. In the gluteal region, the muscles performing adductor functions are the obturator externus muscle innervated by the obturator nerve, the quadratus femoris muscle innervated by the ischiatic nerve, and the quadratus femoris muscle nerve.

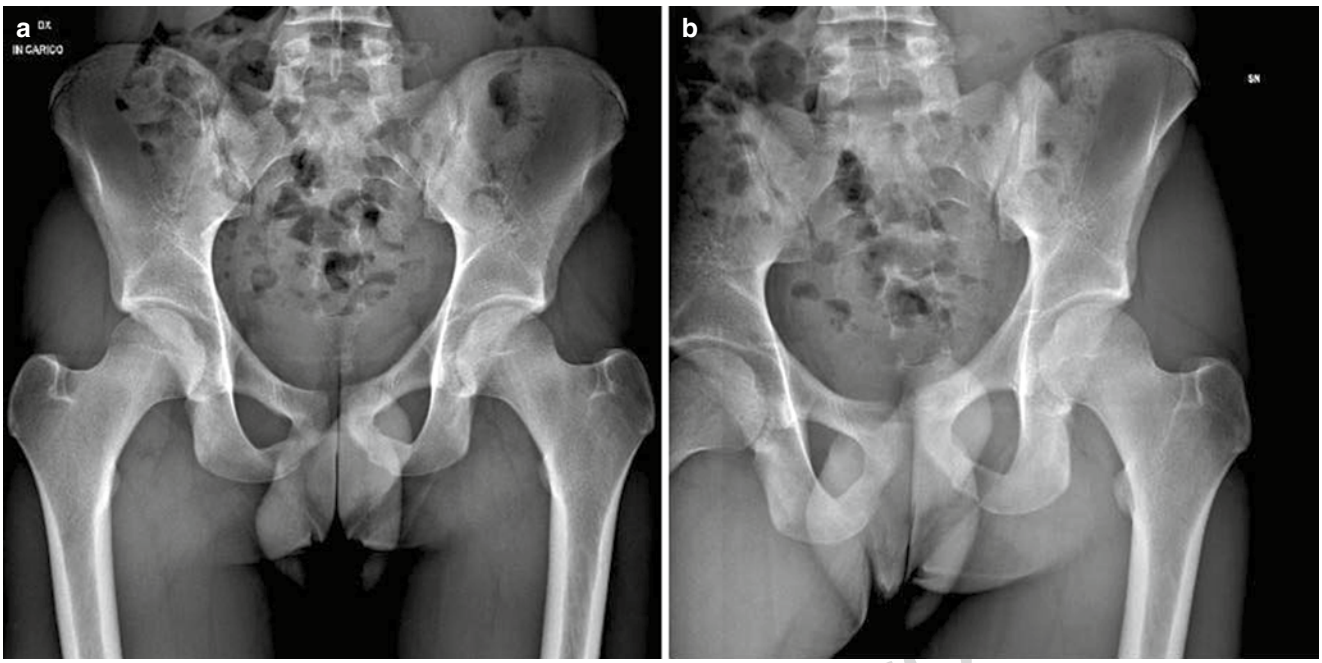

Fig. 8.1 A double-stance X-ray (**a**) compared to a dynamic flamingo view X-ray (**b**) made in alternating single-stance support (in this case in single right stance). The subject, a 25-year-old professional football player, shows a vertical offset greater than 3 mm between the pubic horizontal branch that allows us to make the diagnosis of symphysis instability

sleep. The painful event can occur during competition and/or training. It can already be present prior to exercise and disappear during warm-up, reappearing later during activity or appearing after the exercise, while cooling down, or even the morning after. In extreme cases, symptoms can effectively preclude performance. Pain may radiate outward and extend along the adductor and/or abdominal muscles in the direction of the perineum and the genitals. This generates possible diagnostic errors [79]. The functional deficit is obviously correlated with pain intensity.

From an objective point of view, the patient can complain of pain at palpation, resisted contraction, and during stretching. In addition, clinical examination is based on several muscle tests based both on active contractions and on passive and active muscle stretching [80–83]. Moreover, in this context, it is important to observe how the patient moves, walks, and undresses [84].

8.4.1 Imaging

Radiological investigations can help in groin pain syndrome diagnosis. Pelvic X-rays highlighting the pubic symphysis are always advisable to rule out possible bone erosion, pubic branch dissymmetry, osteoarthritis (also frequent in young subjects), hip joint pathology, and especially tumors or avulsion fractures [85–87]. It is important to emphasize how through a dynamic X-ray made in alternating monopodalic support, the so-called flamingo views (Fig. 8.1), when a vertical offset greater than 3 mm between the pubic horizontal branches is found, we can make the diagnosis of symphysis instability [44, 88, 89]. Musculoskeletal ultrasound (US) finds its indication in inguinal hernia suspicion. It can highlight edema areas, hematomas (in the case of muscle–tendon tears), myxoid degeneration areas, chondral metaplasia or metaplastic calcification, and fibrosis [30, 90] with the advantage of having the possibility of being carried out in dynamic conditions. This highlights musculofascial movements and, in particular, inguinal bulging (inguinal canal posterior wall weakness). However, US currently falls short in the identification of inflammatory and degenerative bone processes.

Nuclear bone scan is a highly sensitive but nonspecific tool. Every type of symphysis bone lesion of traumatic, tumoral, or infectious etiology would lead to an increased uptake activity at the symphysis level [30, 91, 92]. However, a previous uptake that normalizes after conservative treatment is an important factor which may play a role in making a decision for possible return to sports activity [91, 93, 94].

Magnetic resonance imaging (MRI) is considered the gold standard examination providing detailed information concerning both bone and insertion structures [8, 30, 86, 89]. An MRI groin pain-specific protocol should include sequences covering the entire bony pelvis as well as higher-resolution sequences dedicated to the pubic symphysis region. A relatively outperformed model like a 1.5 T MRI unit is an adequate instrument to generate high-quality images of the pelvis, while a 3 T scanner can

offer indubitable advantages in signal and resolution but is also prone to generate more imaging artifacts [95]. Images must be acquired in standard coronal, sagittal, and axial planes; however, it is important to underline that coronal oblique imaging plane performed along the anterior margin of the iliac crest is a very important sequence for optimal assessment of the rectus abdominis/adductor longus common aponeurosis at the pubic level [96]. Some authors proposed the use of intravenous contrast, but its use generally adds little in the identification of lesions, and a non-contrast protocol at 1.5 T can be considered standard [52].

One of the most important advantages in the use of MRI for the assessment of patients affected by groin pain is its high sensitivity for a wide array of both musculoskeletal and visceral lesions that may concur to the symptomatology. In effect, it is not uncommon to discover an unsuspected lesion with pelvic MRI. For these reasons, it is important to include in MRI protocol several large field of view sequences covering the entire bony and visceral pelvis even if there is a strong suspicion for a simple pubic symphysis lesion. In fact, it is not uncommon that the groin pain is caused by bursitis, benign and malignant soft tissue tumors in various locations around the pelvis, visceral pelvis sources such endometriosis and inflammatory bowel disease, osseous injuries such stress fracture, primary osseous tumor such as osteoid osteoma, or scarring and fibrosis related to prior herniorrhaphy. With a deep MRI evaluation protocol, the majority of these lesions should be observed or at least suspected [97].

8.5 Rehabilitation and Treatment Strategy

8.5.1 Type of Exercise and the Progression of Work Plan

Concerning the type of exercise, the study with the strongest evidence considers strengthening exercise as the main component of the work plan [80, 98, 99]. Target muscles involved are the adductor, abductor, hip flexor, and deep and superficial abdomen muscles. The progression begins with isometric contractions and continues with concentric and eccentric exercises, reaching the functional standing position. This is to be as similar as to those required by the athlete's specific sport activity during the last stage of the rehabilitation protocol. Isokinetic exercises should also be present throughout the protocol. Holmich et al. [80] used a predetermined graduated exercise protocol, while many researches adopt the following criteria for exercise progression:

1. Absence of pain during exercise
2. Full acquisition of functional control
3. Ability of performing functional exercise or a predetermined number of repetitions

The available evidence suggests that strengthening exercise represents an important component in an effective work plan. However, variability between the different protocols in terms of the muscle concerned does not allow for a conclusion to be reached on the specific target muscle group [80, 98, 99]. Conversely, research shows a uniformity of exercise progression from the isometric modality to be completed by sport-specific functional standing positions.

8.5.2 The Intensity, the Frequency, and the Duration of Exercise

To the best of our knowledge, only one reliable study may be found in the available literature providing enough detail concerning intervention frequency and duration of exercise [80]. This study suggests a work plan of 90 min of strengthening exercises for the hip and abdominal muscles to be performed three times per week for an overall duration of 8–12 weeks. According to this research, the outcome is good, allowing the athlete to return to sport activities without groin pain.

The duration of conservative treatment is between a minimum of 2–3 weeks [14] and a maximum of 6 months generally [100]. The majority of authors agree on a duration of around 6 months [23, 92, 94, 101–104]. In summary, it is clear that the variation in duration of rehabilitation work plans used reflects the variation in the severity and multifactorial characteristics of groin pain.

8.5.3 Therapeutic Interventions

In essence, the majority of studies report the use of one or more co-interventions, from manipulation techniques and massages [92, 102–104] to anti-inflammatory [18, 98, 100, 101, 105] and corticosteroid medication [58, 106, 107]. Some studies included jogging, running, and cycling as co-interventions [56, 98, 99, 104]. Furthermore, some studies underline the importance of physiotherapist-supervised exercise programs [56, 99, 102].

8.5.4 Surgical Treatment

As previously discussed, groin pain may be caused by several pathologies responding to conservative therapy. However, if conservative therapy fails, then a surgical option must be considered. In this final section, we will briefly describe the most common diseases requiring such treatment.

8.5.5 Inguinal Hernia

Athletes are susceptible to inguinal (direct and indirect) hernias like the general population and sometimes even more, especially in sports like weightlifting. However, in athletes, direct hernias are more frequent [108]. Real-time dynamic US during a provocative maneuver, such as Valsalva, may help visualize a subtle hernia possibly causing symptoms only during sport activity and otherwise difficult to detect. The risk of complications such as bowel incarceration and strangulation is not an issue in this case; it is impossible to participate in sports due to pain. This is why in most cases posterior wall weakness of the inguinal canal are surgically repaired [109].

Even though surgical treatment is successful in the large majority of cases, one should bear in mind the possibility of surgical complications and, in some cases, the inability to achieve prior levels of athletic performance [52]. It has been proposed that this variability in surgical repair outcome is occasionally due to the increasing stabilization of the pubic region because of progressive fibrosis [52]. However, patients with inguinal hernia have little chance of success with conservative treatment [52, 110]. After herniorrhaphy, an average of 87 % of the athletes have a positive outcome and are able to return to full and unrestricted athletic activity in 4 weeks or less [29, 110, 111].

8.5.6 Sports Hernia

Sports hernia, also known as sportsman's hernia, athletic hernia, and incipient hernia, represents a difficult clinical problem [112].

The diagnosis of sports hernia is formulated when no inguinal hernia is found but there is persistent inguinal pain during sports activity. The symptoms resemble an hernia and are present only during sport. We must also point out that some authors underline that sports hernia is often associated with femoroacetabular dysplasia and/or femoroacetabular impingement [113].

There also is no hernia present on physical examination and ultrasound, hence the term sports hernia (Fig. 8.2). Sports hernias rarely improve without surgery [11, 114–118], and surgical repair should be considered when conservative treatment over a period of 6–8 weeks has failed. Careful examination has to additionally exclude other potential pain sources [112, 119].

Some authors propose laparoscopic repair with prosthetic mesh [120, 121]. This "tension-free" technique involves placing prosthetic material suitably shaped, nonabsorbable, and biocompatible. This acts as mechanical reinforcement of the abdominal wall [120, 121]. However, the mesh has no elasticity and creates more scar tissue, and

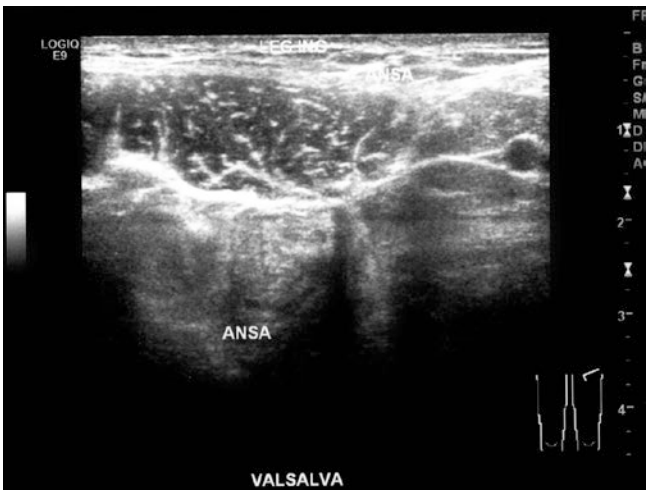

Fig. 8.2 Left inguinal ultrasound in a 27-year-old professional footballer that shows a modest pre-hernial area with about 8 mm of intestinal loop in correspondence to the weak zone. This situation is pathognomonic for sports hernia

mesh-related complications can occur years after surgery. Another laparoscopic method used for the treatment of sport hernias is inguinal release procedure [122]. After laparoscopic repair, the recovery before full return to competition is generally between 2 and 8 weeks [110, 115, 119, 123–128].

Some authors prefer open surgical inguinal repair: Shouldice repair, Maloney darn, or Bassini with or without adductor longus tenotomy or only the "minimal repair" of the weak area of transversalis fascia [14, 129, 130]. In a meta-analysis study [119], the authors found that the period of time to return to sport is on average 17.7 weeks for patients who underwent open approaches and 6.1 weeks for laparoscopic repairs. Several authors underline mesh-related complications such as infections with chronic groin infection and fistula formation. These complications sometimes require mesh removal [131] or cause mesh migration and penetration into the bladder or bowel [132, 133]. In addition, a foreign body reaction with decrease of arterial perfusion and testicular temperature [134] accompanied by secondary azoospermia may occur [134, 135].

It is interesting to note that Muschaweck et al. [112, 130] after previously utilizing the Shouldice repair under local anesthesia for years, in 2000 developed a new surgical technique called the "minimal repair technique." The aim of this surgical intervention was to stabilize the posterior wall by a tension-free suture without the use of a prosthetic mesh and by repairing only the weak spot of the transversalis fascia. The authors chose to avoid the use of a prosthetic mesh to allow the athlete's full elasticity and muscle sliding between the abdominal muscles after surgery [112]. According to some authors, opinions regarding this technique apart from avoiding prosthetic mesh insertion have several advantages.

These include not requiring general anesthesia, less traumatization, and a lower risk of severe complications. The authors underline a quicker resumption of sports activity following this surgical technique compared to the laparoscopic or open surgery with mesh insertion. They report that on average their patients resumed moderate training after 7 days and felt complete relief of pain after 14 days. Return to full activity was achieved after 18.5 days [112].

8.5.7 Adductor Tendinopathy

With the increase of knowledge of the pubic symphysis' complex anatomy, the incidence of isolated adductor tension lesion has seemingly decreased [96]. In any case, adductor tendinopathy is one of the most common causes of pubalgia in athletes and is most often associated with either rectus abdominis/adductor longus aponeurosis lesions or midline pubic plate lesions (i.e., lesions originate at the midline of the pubis and propagate either unilaterally or bilaterally, also called "midline core muscle injuries"). One of the main causes of athletic pubalgia is the imbalance between the abdominal and hip adductor muscles, with the abdominals too weak or the adductors too strong [5]. Adductor tendinopathy is frequently related to an adductor longus overuse or to its aponeurotic injury [136]. A vast majority of patients respond positively to conservative treatment, both in the case of overuse tendinopathy or in muscle–tendon injury. There are not many scientific papers on failed conservative treatment on chronic adductor-related groin pain [137]. Adductor tenotomy is proposed for cases nonresponsive to conservative treatment [5, 136–139]. The criteria for surgery is a history of long-standing (ranging from 3 to 48 months according to various authors) and of distinct pain at the origin of the adductor longus muscle, refractory to conservative treatment. The operation is performed by releasing the anterior ligamentous fibers of the adductor longus while keeping the fleshy part of the muscle intact on the deep aspect, thus minimizing the loss of adductor strength after surgery and constituting a template for future regrowth of the tendon. In the patients undergoing tenotomy, there is an average of 10 % postoperative strength reduction which does not result in any obvious functional or speed limitation because other muscles in the adductor group, namely, adductor brevis, adductor magnus, and pectineus, take over adductor longus function [140]. In the reported studies [129, 136, 137], the subjects returned to competitive sport after 19.8 weeks (range 27–14 weeks). The cited studies report that following surgery, 70.6 % of the subjects (range 90–62 %) performed sport activities at the same level, 24 % (range 32–9 %) performed sports activities at a reduced level, and 5 % had to stop sport activities altogether. It is interesting to note that some authors associate the adductor tendon release to a pelvic floor repair [45, 141].

Fig. 8.3 MRI axial STIR showing bone marrow edema extending to the whole surface of the right pubic branch in a 27-year-old professional football player. This bone marrow edema extending into the anteroposterior totality of pubic rami is pathognomonic for osteitis pubis and should be distinguished from sub-entheseal marrow edema at the pubic tubercle level sometimes present in a rectus abdominis and/or adductor longus tendinopathy without osteitis pubis at the symphysis

Surgically treated adductor acute tears are rarely described in scientific literature. We could find only one study [138] reporting three cases of acute proximal adductor longus insertional tear repaired with anchor sutures and followed by postoperative rehabilitation. The patients followed in this study resumed their full sport ability after 5, 6, and 7 months, respectively.

8.5.8 Osteitis Pubis

Osteitis pubis is a common medical problem in soccer players, long-distance runners, and hockey players. In terms of etiology, the main risk factor is believed to be pubic symphysis instability [52]. This causes a chronic, repetitive shear and an imbalanced tensile stress of the muscles inserted on the pubic symphysis. This biomechanical alteration can cause an inflammatory response with osteitis and periostitis.

Normally, from a radiological point of view, into the MRI pubic symphysis evaluation, any subchondral bone marrow edema, bony sclerosis, or cystic or osteophytic formation is termed osteitis pubis. This type of assessment is not entirely correct. In effect, a true active osteitis pubis should include at least an element of subchondral bone marrow edema (often asymmetric) spanning the pubis joint anterior to posterior on axial fat-suppressed sequence (Fig. 8.3). This bone marrow edema extending into the anteroposterior totality of pubic rami should be distinguished from

sub-entheseal marrow edema at pubic tubercle level sometimes present in a rectus abdominis and/or adductor longus tendinopathy without osteitis pubis at the symphysis [96, 142]. It is in any case important to note that osteitis pubis is strongly associated with rectus abdominis and/or adductor longus tendinopathy [96]. Osteitis pubis is normally a "self-limiting" disease and requires a lengthy treatment of 12-month duration on average [105]. The management is initially conservative with physical rehabilitation, NSAID, and/or steroid injections. The historical surgical treatment options were symphysis curettage and arthrodesis and are now abandoned by the majority of surgeons. This is due to the lack of results and frequent side effects. In most cases, adductor tenotomy/surgical abdominal strengthening is reserved for the subjects with symptoms nonresponsive to conservative treatment [52, 107].

In any case, it is important to note that for some authors [143], "osteitis pubis" is a vaguely defined diagnosis. Osteitis pubis is a term originally used to describe an infection at the pubic bone at the symphysis joint level. In effect, the osteitis pubis characteristic radiologic findings, that is, widening of the symphysis, bone resorption, and sclerosis along the pubis rami, can often be found also in athletes without groin pain. This could be explained by the fact that groin-straining sport activity, for example, football or ice hockey, increases the shearing forces at the symphysis joint level. The high stress level in the symphysis might thus lead to these radiological signs, therefore indicating an increased mechanical load at the joint level rather than pathology. Hölmich [143] compares this situation with a knee joint effusion: this is in itself not an injury but a result of an overused or injured knee and therefore is not a diagnosis in itself. Especially concerning the bone marrow, edema is possible that this one in athletes represents a normal sign of bone remodeling, which may become symptomatic once loading exceeds a certain threshold. According to the authors, for these reasons, the term "osteitis pubis" should not be used as a specific diagnosis in the case of groin pain, unless an infection is present in the pubic bone. In effect, the term should be used to describe "osteitis pubis-like" radiological changes at the symphysis joint level.

8.5.9 Hockey Goalie–Baseball Pitcher Syndrome

This unusual syndrome is caused by an epimysial or myofascial herniation of the adductor longus muscle belly. It occurs several centimeters away from the site of its pubic attachment [141]. The etiology of myofascial herniations in hockey goalie–baseball pitcher syndrome has not been established. However, several authors suggest a relationship with chronic repetitive stress at the level of neurovascular penetration [144]. The treatment for chronic pain is surgical epimysiotomy and debridement [145].

8.5.10 Acetabular Labral Tear

Generally, hip pathology may cause groin pain due to synovitis, osteoarthritis, intra-articular loose bodies, and tears of the ligament teres. The most common problems are acetabular labral tears [146]. The anterior–superior part of the labrum is poorly vascularized, and for this reason, it is susceptible to injuries, particularly during hyperextension and external rotation [146, 147]. Dance, golf, hockey, and soccer are sports associated with a higher incidence of hip injuries [148].

Labral tears are initially managed conservatively with rest and NSAID therapy. Subjects with persistent symptoms often require labrum surgical debridement. During the operation, the surgeon might decide to also correct other morphologic abnormalities of the acetabulum or the proximal femur predisposing the patient to femoroacetabular impingement. This will prevent progressive cartilage loss and osteoarthritis [149, 150].

Hip arthroscopy is both a diagnostic (gold standard) and therapeutic tool, although it is technically more difficult than arthroscopy of other joints such as the knee or shoulder. During this procedure, to access the hip joint, it is necessary to distract the hip for approximately 10–15 mm. This traction may cause several complications such as neuropraxias [149]. In a number of other case series, arthroscopy has shown to provide benefit in recent traumatic labral injury [151–153]. It is also important to note that the often disappointing chronic hip pain is probably due to degenerative change and chondral lesions of the acetabulum [154, 155].

8.5.11 Internal Snapping Hip

The internal snapping hip or coxa saltans may be an occasional cause of pain in the anterior part of the hip and in the inguinal region. This pathology is characterized by a typical snapping sensation frequently accompanied by a snapping sound that the patient adverts when the tendons near the hip joint pass over an osseous protuberance. The internal snapping hip may be of extra-articular or intra-articular source. The internal snapping hip is defined as extra-articular when it is caused by the snap of the iliopsoas tendon over the iliopectineal eminence, at the level of the anterior region of the hip. The slippage and the resulting "snap" of the iliopsoas tendon occur usually when the subject passes from a position of flexed, abducted, and externally rotated hip to an extended adducted and internally rotated position. When this situation is chronically repeated, it can give rise to iliopsoas

tendonitis and bursitis [156]. Conversely, the intra-articular internal snapping hip is caused by acetabular labrum lesions or articular cartilage lesions that may be interposed between the surface of the femoral head and the surface of the acetabulum during hip motion. A further cause of intra-articular internal snapping hip can be represented by the presence of loose bodies within the joint such as cartilaginous fragments and/or calcifications [156]. The conservative treatment consists of pain control with NSAID therapy and/or corticosteroid injections in cases of bursitis; iliopsoas muscle stretching is also recommended [156, 157]. Surgical lengthening of the iliopsoas tendon (in extra-articular internal snapping hip) or cartilage repair and/or the removal of loose bodies (in intra-articular internal snapping) occasionally is necessary in patients that do not respond to conservative treatment [147].

8.5.12 Osteoid Osteoma

Osteoid osteoma is a benign bone tumor usually observed in subjects between the ages of 5 and 30 years. Usually it is most common in the long bones, especially in the femur and tibia. It can also involve the pubic bones where it may cause groin pain [52]. Total removal of the osteoid osteoma generally results in a complete resolution of symptoms, while its partial removal may lead to recurrent symptoms [158, 159].

8.5.13 Nerve Entrapment

The groin and upper thighs and sensory and motor innervations are provided by several nerves including the obturator, femoral, iliohypogastric, genitofemoral, ilioinguinal, and lateral femoral cutaneous nerves. An entrapment of any of these structures may cause groin pain [48, 58, 155]. For example, obturator nerve entrapment may be caused from a fascial thickening of the adductor compartment or a "mass effect" caused by an obturator hernia, a pelvic fracture, or an acetabular paralabral cyst [41, 52, 160]. Femoral nerve entrapment may be caused by some surgical procedures such as hip arthroplasty, herniorrhaphy, or abdominal hysterectomy [142]. Ilioinguinal and genitofemoral nerve entrapment can be observed after abdominal surgery in blunt trauma or in muscle hypertrophy [147]. If the nerve entrapment is suspected, elimination of symptoms by local anesthetic infiltration and nerve conduction studies can be considered.

The treatment of nerve entrapment syndromes often requires a surgical solution normally consisting in debridement of the perineural scar tissue or division of constricting fascia [147].

8.6 Return to Play

At the beginning of this chapter, we pointed out that the "key concept" in the diagnosis, and therefore the treatment, of groin pain is that the term "groin pain" does not represent a diagnosis but only a symptom or better a cohort of symptoms. For this reason, it is clear that it is not possible to generalize regarding the time to return to sports after conservative or surgical treatment. Besides the fact that every sporting activity must be assessed according to the specific imposed functional demands, the recovery times and the therapeutic program are obviously dependent from the groin pain etiopathogenesis. Furthermore, it is clear that, independently from the groin pain etiopathogenesis, it is extremely important to adopt a strategy which allows to reduce to a minimum the risk of recurrence. In general, we can say that a correct balance of muscle forces acting on the pelvis in addition to an adequate strength of the core muscles may represent the principal strategy to adopt. However, to date, literatures are still lacking good evidence studies that may indicate both the effectiveness of a preventive strategy or the means most indicated to its development.

Conclusions

The athlete's pubalgia is an interesting and controversial subject of discussion, especially regarding therapeutic management, either conservative or surgical.

It is very important to underline the enormous importance in this field for proper and early diagnosis. Only after having diagnosed precisely, the etiology is that it is possible to refer the patient to the most appropriate type of treatment. For this reason, clinical examination should be supported by appropriate imaging studies which help the treating specialist in reaching a diagnosis. Conservative treatment, where it is recommended, should follow clearly defined intervention criteria in relation with the patient's functional progress and in full respect of the pain reported by the subject.

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AU1	Please confirm the affiliation details for Bisciotti Gian Nicola.	
AU2	Please provide department name for Bisciotti Gian Nicola	
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