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REVIEW

Inguinal-Related Groin Pain and/or Disruption in Athletes: Current Understanding, Assessment and Management Strategies

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Abstract: Inguinal-related pain and/or disruption involve the abdominal tendinous and fascial tissues that connect to the inguinal ligament and the pubic tubercle. Epidemiological studies show these issues comprise 5–20% of groin problems in male athletes but rarely occur in female athletes. In this narrative review, we aim to synthesize the current understanding, assessment and management strategies for inguinal-related pain and/or disruption in athletes. Although inguinal-related pain and/or disruption is less common than adductor-related problems, it is vital not to overlook it. While the condition is often referred to as "sports hernia" or "incipient hernia", it is now agreed that true hernias are rarely found in this context. Instead, these conditions are classified as muscle-tendon injuries, and our understanding of their pathology has evolved significantly over the past few decades. Key anatomical structures include the external and internal oblique muscles, transversus abdominis, rectus abdominis, inguinal ligament, fascia transversalis, conjoined tendon, and the inguinal canal, which contains important nerves and vessels. Clinically, inguinal-related groin pain is diagnosed from detailed history and physical examination. Consensus statements now clearly define inguinal-related groin pain and disruption providing a solid foundation for a clinical diagnosis. Pathological findings may include subtle abdominal wall deficiencies to more overt abdominal tears and overuse injuries and imaging may aid in establishing differential and more specific diagnoses. A standardized "one-size fits all" treatment algorithm does not exist; however, a multidisciplinary approach is essential. Collaboration among sports physiotherapists, sports medicine specialists, and experienced abdominal surgeons has proven effective, informed by data from randomized controlled trials. First-line treatment typically includes non-surgical strategies, such as targeted physical therapist-led rehabilitation and activity modification with a graded return to sports approach. If non-surgical approaches fail, laparoscopic repair techniques demonstrate higher success rates. Central to effective management is shared decision-making that weighs the athlete's goals, competition calendar, and overall health-status.

Keywords: groin pain, athletes, inguinal, posterior wall weakness, rehabilitation

Introduction

Inguinal-related groin pain and/or disruption involves the abdominal tendinous and fascial tissues attaching to the inguinal ligament and the pubic tubercle.[1–3] Historically, injuries in this region have been described using various terms, including *athletic pubalgia, sports hernia, Gilmore's groin*, and *core muscle injury*,[1–3] with terminology differing between the United States, Europe, and other regions of the world. Although these conditions are often referred to as a "sports hernia" or "incipient hernia", consensus exists that a true hernia is rarely found in this context.[1,2]

It is important to consider that a range of alternative or coexisting injuries and clinical conditions—such as hip joint pathology, iliopsoas-related groin pain, stress fractures, and adductor- or pubic-related groin pain—can produce groin pain in athletes.[1] These must be systematically screened for and ruled out before diagnosing inguinal-related groin pain and/or disruption.[1,2]

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The historical inconsistency in nomenclature highlights the lack of consensus and differing opinions among leading sports medicine and surgical experts regarding the exact pathology originating from inguinal-related tissues.[1–4] This uncertainty prompted the development of several important consensus meetings and statements over the past decade,[1,2] aimed at establishing a unified clinical language and approach for assessing and managing patients with inguinal-related signs and symptoms. These initiatives have helped unite sports medicine practitioners and relevant specialists in their shared goal of optimizing patient care.

This narrative review aims to synthesize current knowledge on inguinal-related groin pain and/or disruption, with particular emphasis on anatomical and pathophysiological considerations. It also offers an evidence-based summary of clinical examination and management strategies for athletes informed by the most recent research and best practice.

Anatomical Considerations Concerning Inguinal-Related Groin Pain and/or Disruption

Understanding the complex anatomy of the inguinal region plays a critical role when treating athletes and patients with inguinal-related groin pain and/or disruption.[5,6] Key structures include the external and internal oblique muscles, the transversus abdominis, the rectus abdominis, the inguinal ligament, fascia transversalis, the conjoined tendon, and the inguinal canal including traversing nerves and vessels.[5] The pubic symphysis serves as a central connecting and load-sharing point for all these muscles, tendons and ligaments.[5,7] The adductor and abdominal muscles, along with their associated tendons, attach to the pubic bone and contribute to large load transmission converging near the pubic symphysis close to the pubic tubercle, where they create opposing force vectors. (Figure 1).[7]

These musculotendinous structures work in conjunction with large ligaments.[5,8,9] The superior (SPL) and inferior pubic ligaments (IPL) provide essential structural stability to the pubic symphysis joint, whereas the anterior pubic ligament (APL) exhibits a more layered organization.[9] This anterior ligament forms as an extension of the inguinal ligament that passes in front of the pubic symphysis and serves as a convergence point for the attachments and originations of both abdominal and adductor aponeuroses and tendons. These intricate anatomical relationships underline the pivotal role of these structures in transmitting forces across the anterior aspect of the pubic symphysis.[8,9] The higher thickness of the SPL and IPL compared to the APL have been suggested to counter the higher force needed to withstand vertical forces and displacement compared to horizontal displacement.[10] In contrast, horizontal displacement might place more stress on the muscles and tendons associated with three main force vectors involving the inguinal ligament, adductors, and abdominals.

Magnetic resonance imaging (MRI) findings indicate a clear relationship between anterior parasymphyseal soft tissues and anteromedial symphyseal articular margins, as well as with fibrocartilaginous discs, and capsular

Figure 1 Anatomical structures attached to the pubic tubercle and their vectors as clock face. Adapted from Rennie and Lloyd. 2017.[7] Journal of the Belgian Society of Radiology. 2017; 101(S2): 16, pp. 1–4. Copyright via "CC-BY" license (https://creativecommons.org/licenses/by/4.0) Source: DOI: https://doi.org/10.5334/jbr-btr.1404.

tissues.[11,12] This anatomical area also appears to be the center of patient-reported tenderness (Figure 2),[13] as well as representing MRI abnormalities seen in athletes with groin pain, suggesting this may represent a particular tender and/or biomechanical weak spot.[11,12] On MRI, this type of injury has been described both as a pubic aponeurosis defect and adductor enthesopathy, given the similarity of imaging findings.[14] It is possible that there exists a continuum of pathology involving the adductor longus, gracilis, and rectus abdominis aponeuroses and their fusion,[12,14] which may explain why palpation at the adductor longus insertion area and its proximity, as well as the squeeze test, are the most prevalent provocative clinical tests in this region.[11,15] MRI abnormalities are typically concentrated in this area, often associated with bone marrow oedema (BMO) in the subchondral pubic bone or within the main pubic body, and/or in relation to the aponeurosis and anterior capsule.[11] Rectus abdominis and inguinal tenderness are also reported but occur less frequently.[11] Although less common, conditions related to the inguinal canal, located just above the inguinal ligament, are important to consider.[5,6]

The inguinal canal is a key anatomical structure of the lower anterior abdominal wall, featuring muscle–tendinous connections between the lateral edge of the rectus abdominis and the insertion point of the inguinal ligament at the pubic tubercle.[5,6] The canal forms a passageway from the abdomen toward the genitalia (Figure 3) and is bordered inferiorly by the inguinal ligament, the external oblique aponeurosis anteriorly, the internal oblique and transversus abdominis muscles superiorly, and the fascia transversalis posteriorly and laterally.[5,16–18] The conjoined tendon, also known as inguinal aponeurotic falx, is formed by the fusion of transversus abdominis and the internal oblique, and this connective tissue strengthens the medial portion of the posterior wall, and fuses at the edge of the rectus abdominis.[16–18] The inguinal canal contains several important anatomical structures. The deep inguinal ring, located halfway along the inguinal ligament, marks the opening through which abdominal structures pass into the canal.[16–18] The superficial inguinal ring, positioned just above the pubic tubercle, represents the medial exit of the canal.

Through the inguinal canal travels the spermatic cord, the vas deferens, blood vessels, and lymphatics in males, whereas the round ligament, which supports the uterus, is present in females.[16–18] During muscular contraction, the conjoint tendon, which connects the internal oblique and transversus abdominis muscles, lowers and closes the deep inguinal ring.[17] This action reduces the diameter of the canal, making it more oblique and longer, causing the deep ring to move upwards and outwards.[17] The "sealing" of the inguinal canal, dependent on the contraction of these muscles, helps to prevent undue stress on the canal's contents.[17] The anatomical and physiological disparities between men and women may contribute to differences in the presentation of inguinal-related groin pain.[16–18]

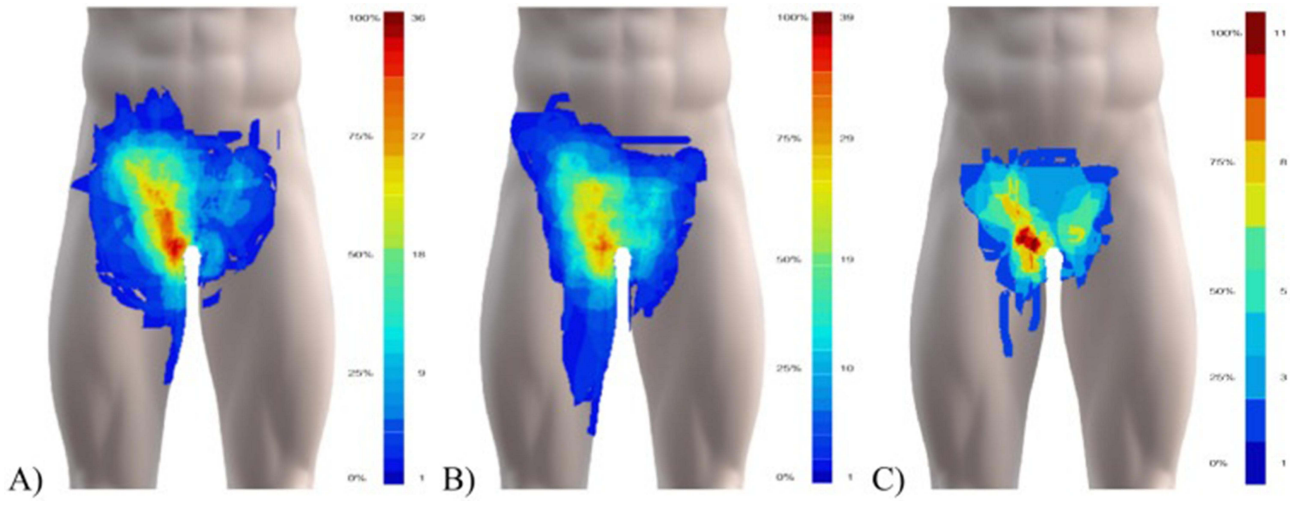

Figure 2 Pain map overlays from patients with (**A**) one (N = 88), (**B**) two (N = 64), and (**C**) three (N = 15) clinical entities of groin pain showing the overall spread and common regions. The colour-scheme range reflects the maximum overlap and the minimum one overlapping area, shown in percent and the absolute number of drawings from Serner et al.[13] Scientific Reports 12, 9789 (2022). Copyright via "CC-BY" license (https://creativecommons.org/licenses/by/4.0) Source: https://doi.org/10.1038/s41598-022-13847-1.

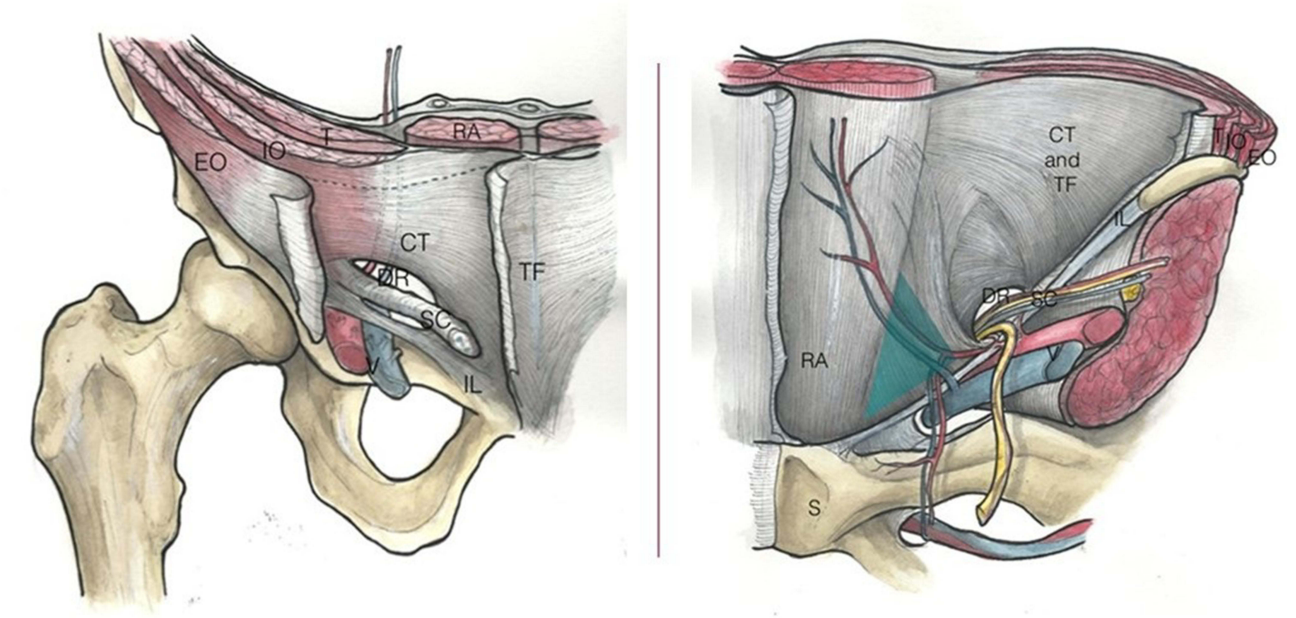

Figure 3 Schematic drawing from an anterior and posterior view of the inguinal canal including the Hesselbach's triangle and epigastric vessels. The internal deep ring is superior and located at the middle of the inguinal ligament. It is inferior and mediolateral to the conjoint tendon, and lateral to the inferior epigastric vessels. The external superficial ring is a triangular opening in the external oblique aponeurosis. The inferior epigastric artery (a) and vein (v) originate from the external iliac artery and vein and lie medial to the internal inguinal ring. Adapted with images reproduced with permission from Bou Antoun et al.[17] *Br J Radiol*. 2018; 91: 20170856. Source: https://doi.org/10.1259/bjr.20170856.

Abbreviations: CT, conjoint tendon; EO, external oblique muscle; EOA, external oblique aponeurosis; IL, inguinal ligament; IO, interne oblique muscle; RA, rectus abdominis; SC, spermatic cord; T, transverse muscle; TF, transversalis fascia; DR, deep ring.

Several nerves traverse the inguinal canal, including the ilioinguinal nerve and the genital branch of the genitofemoral nerve. These nerves provide sensory innervation to the lower abdominal wall and genital region (Figure 4).[5,19,20]

The ilioinguinal nerve, iliohypogastric nerve, and genital branch of the genitofemoral nerve all innervate the inguinal region.[5,19,20] The ilioinguinal and iliohypogastric nerves arise from the 12th thoracic and 1st lumbar spinal nerves. They travel posterior to the psoas muscle and enter the inguinal region by passing through the transversus abdominis muscle.[19,20] The ilioinguinal nerve usually runs over the cremaster muscle and exits the canal through the external inguinal ring.[19,20] In contrast, the genital branch of the genitofemoral nerve, which originates from the 1st and 2nd lumbar spinal nerves, enters the inguinal canal through the deep inguinal ring and exits through the superficial ring, accompanying the spermatic cord in males.[19,20] Variability in the emergence and distribution of these nerves has been observed, which may explain the overlapping sensory distribution and variability in pain presentation in athletes with inguinal-related groin pain.[5,20]

Pathophysiology and Etiology of Inguinal-Related Pain and/or Disruption

Inguinal-related groin pain and/or disruption are currently regarded as muscle–tendon injuries, although several theories have been proposed regarding their underlying pathology.[3,21–25] Over the past several decades, the understanding of this condition has evolved considerably. The posterior wall of the inguinal canal has been implicated as a potential pain source, through irritation of the ilioinguinal or genitofemoral nerves. This irritation could arise due to a bulge in the posterior wall or from tears/fibrosis from the abdominal musculature, such as the external oblique or conjoint tendon.[3,21–25] Inguinal hernia research has shown that nerve pressure or irritation within and around the inguinal canal—such as increased nerve diameter caused by compression—may be associated with groin pain in patients with inguinal hernia.[26,27]

In 1991, Taylor described tears/avulsions located in the anterior part of the internal oblique muscle insertion,[22] while Gilmore reported tears of the external oblique aponeurosis and the conjoint tendon, with dehiscence between the conjoined tendon and inguinal ligament, but in the absence of a true hernia.[23] The term "sports hernia" was later introduced by Malycha and Lovell in

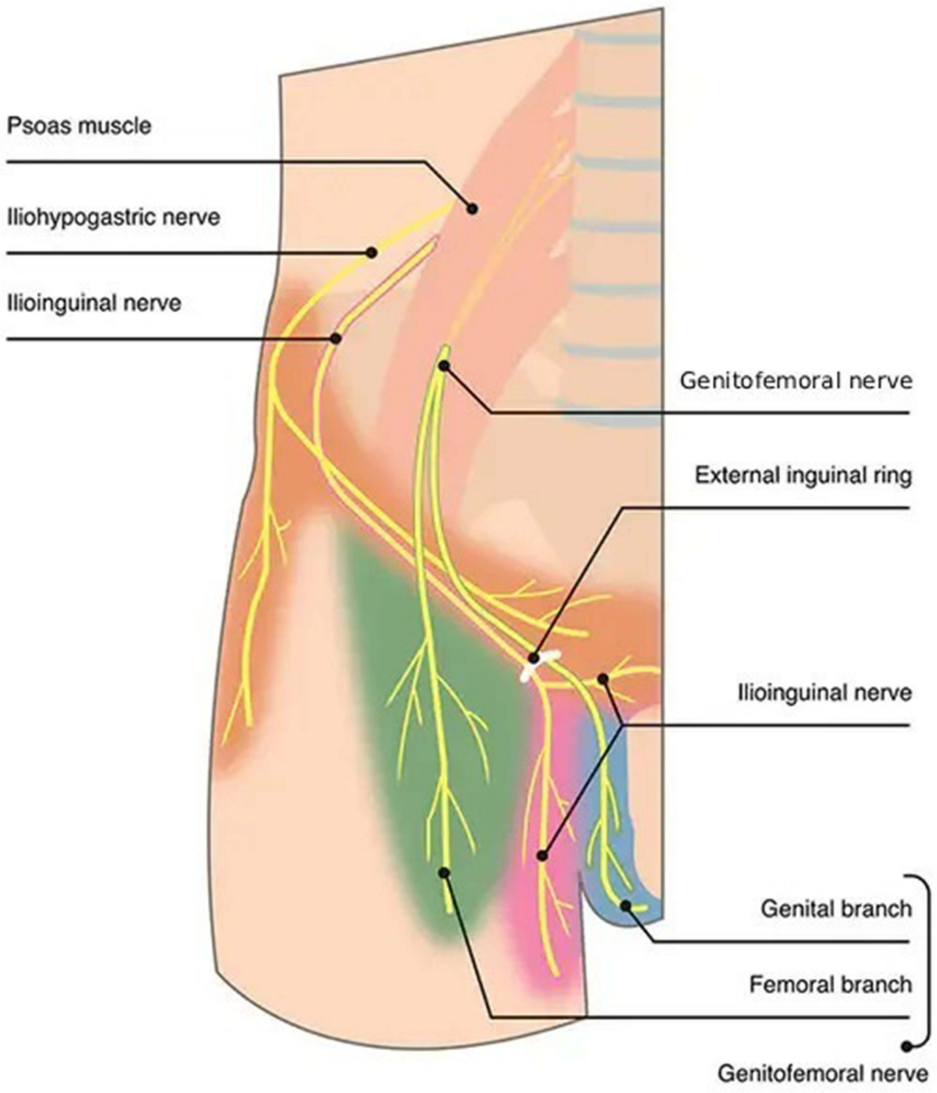

Figure 4 Nerves involved in groin pain in the inguinal region, reproduced with permission from Prof AJ Sheen - groinpainclinic.com.

1992 as their operative findings suggested a significant bulge in the posterior inguinal wall was often present.[24] Subsequently, Lloyd et al (2008) identified the inguinal ligament attachment as a key site of pathology,[25] suggesting that inguinal ligament enthesopathy or dehiscence near the pubic tubercle may represent an important lesion or stress reaction point that needs to be addressed in combination with mesh repair of the posterior abdominal wall.[7,25] The current leading theory regarding the most common inguinal injuries therefore suggests that pain arises from weakness or disruption in and around the posterior wall of the inguinal canal and the transversalis fascia at their weakest points.[4,28] This can lead to pressure and irritation of the nerves located in and around the inguinal canal.[1–3,20,28] However, repeated overuse or excessive force during sports activities may also lead to chronic changes such as degeneration or small tears in the external oblique aponeurosis, transversalis fascia, and conjoint tendon. These changes may compromise the integrity of the canal, leading to pain and dysfunction.[3] Irritation of the ilioinguinal or genitofemoral nerves, which travel through or adjacent to the inguinal canal,[19,20] may also contribute to the pain experienced by athletes with inguinal-related groin pain. Strain or inflammation affecting these structures, including the inguinal ligament, can exacerbate neural irritation and form part of the overall symptom complex.[19,20] Inguinal pain and/or disruption predominantly affects male athletes, with injuries often involving the adductors and abdominal musculature.[18,29] In contrast, female athletes are more likely than males to present with hip joint pathology, and associated or isolated iliopsoas-related pain.[29]

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One of the explanations for the difference in expert focus and opinions in the field may be that inguinal-related groin pain does not only represent a single specific pathology. Instead, it may result from a range of pathogenic findings, from more subtle posterior wall deficiencies to more overt tears in the abdominal wall structures, and/or overuse in addition to strain at the inguinal ligament attachment site, with potential various pathological nerve involvement (Figure 5).[3,20,28]

Meyers and colleagues[30] have emphasized that several core muscles may suffer from chronic overload, muscle imbalance, and microtrauma to the inguinal structures rather than a single specific lesion.[30] The concept of "core muscle injury" has been defined as "damage to any skeletal muscle within the area between the chest and mid-thigh"[30] and suggests that effective treatment must address both the local tissue disruption and the broader biomechanical and neuromuscular deficits contributing to the injury.[30] While the concept of "core muscle injury" is interesting from a mechanism of injury perspective, it unfortunately does not offer any specific and reliable definition to be used among clinicians, and includes everything from adductor-related, iliopsoas-related, or inguinal-related problems, as well as many other muscle-tendon related injuries in the region.[30]

The abdominals including the inguinal canal are subjected to significant mechanical stress during activities that require high core activity and intra-abdominal pressure, such as sprinting, twisting, and kicking.[31–35] When these forces exceed the tissue's capacity to withstand them, the pathologies may occur. Males produce significant distal joint velocities during soccer kicks compared to females. Skilled players use the "tension arc" to generate power[31–33] which place considerable loads and strain on the abdominal and inguinal region. This may explain findings of larger abdominal muscle hypertrophy, also close to the pubic symphysis, in soccer players when compared to controls.[33] The external and internal obliques, as well as transversus abdominis, play an essential role during kicking and changes of direction, and these muscles have also been shown to be highly involved in creating intra-abdominal pressure during unilateral leg movements and forced expiration.[35] Interestingly, they are also highly activated during coughing,[35] which may explain why some athletes with inguinal-related problems get known pain from sneezing and coughing. Pain is also very common during adductor squeezing, which potentially affects the structures that pass through the inguinal canal via co-contraction of the abdominals and the sealing mechanism.[17]

One reappearing hypothesis about athletic groin pain etiology is that inguinal-related pain and/or disruption may be related to overuse injuries in the context of underlying hip and trunk muscle imbalances.[36] Specifically, an imbalance in muscle strength, balance, stability, or endurance between a weaker abdominal musculature and a stronger hip-adductor muscle group, has been suggested to lead to an increased stress on the inguinal wall structures during athletic activities.[36] The evidence behind this theory is, however, not well documented. Most research on athletes with groin pain suggests that weakness is present in the adductors and the abdominals.[37–39] However, only one study has shown that while reduced adductor strength poses a risk factor for adductor-related groin injury, other groin issues may be at risk in athletes with eccentrically strong hip adductors.[40] An alternative explanation may be that athletes with strong adductors

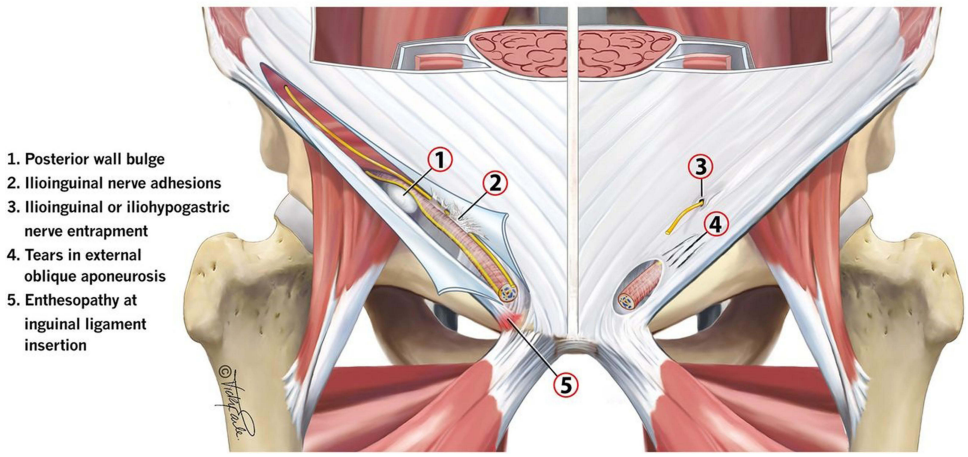

Figure 5 Potential causes of inguinal-related groin pain in athletes. Vuckovic Z et al.[3] BMJ Open Sp Ex Med 2022;8:e001387. Copyright via "CC-BY" license (https://creativecommons.org/licenses/by/4.0) Source: doi:10.1136/bmjsem-2022-001387.

can create large rotational forces at the hip and pelvis during maximal sprint acceleration and kicking, as high adductor muscle strength and activity has been associated with these type of sporting actions.[41–43] High adductor forces may place tremendous stress, not only on the adductor tendon and insertion but also on the medial insertional part of the oblique abdominals near the insertion point at the pubic tubercle as well as to the area in and around the medial superficial opening of the inguinal canal, the posterior wall, and the conjoined tendon. These forces are primarily created by the adductor, abdominal muscles, and their tendons via their insertional attachments.

It is important to note that in patients presenting with longstanding groin pain, eccentric weakness of both the abdominals and adductors is more common than being too strong across both, adductor-, pubic- and inguinal-related groin pain.[37,38] Whether this eccentric weakness stems from longer periods of pain inhibition and off-loading or from actual underlying congenital weakness, is still uncertain. Similar patterns of adductor and abdominal weakness are well-recognized in patients and athletes with longstanding adductor, pubic and inguinal-related groin pain[37–39] – as well as in athletes who undergo inguinal-related groin pain surgery[39] or adductor tenotomy surgery.[44] While surgical posterior wall repair seems to strengthen the abdominal wall and increase strength and control in athletes during post-surgical testing,[39] adductor tenotomy surgery patients who return to more demanding daily activities or sports, often may display continued postoperative weakness in the adductor muscle groups, which may not always fully recover to pre-injury levels.[44]

Inguinal-Related Injury Terminology, Definitions, and Consensus

Two key consensus statements, the Doha Agreement, and the British Hernia Society's Manchester Consensus, have sought to standardize terminology and diagnostic criteria.[1,2] They emphasize the crucial role of clinical examination over imaging, providing a reliable and thorough diagnostic process. Each statement has coined the condition as inguinal-related groin pain and inguinal disruption, respectively.

According to the British Hernia Society's Manchester Consensus, criteria for inguinal disruption include at least three of the following five clinical signs:[2]

- Pinpoint tenderness over the pubic tubercle at the point of insertion of the conjoint tendon.
- Palpable tenderness over the deep inguinal ring.
- Pain and/or dilation of the external ring with no obvious hernia evident.
- Pain at the origin of the adductor longus tendon.
- Dull, diffuse pain in the groin, often radiating to the perineum and inner thigh or across the midline.

Both the Doha Agreement and the British Hernia Society's Manchester Consensus form a similar definition for inguinal-related groin pain.[1,2] They agree that known pain and tenderness at the deep inguinal ring, the external inguinal ring, and the area of the pubic tubercle at the point of insertion of the conjoined tendon and the inguinal ligament constitutes the definition and main indication of an inguinal problem. These agreements provide a solid foundation for established criteria of clinical entities associated with inguinal-related groin pain and/or disruption.

Inguinal-related pain or disruption is primarily a clinical diagnosis derived from a detailed history and physical examination. The hallmark symptom is activity-related discomfort localized to the inguinal canal region, typically aggravated by physical exertion.[1,2] Symptom provocation is commonly attempted using inguinal palpation with and without scrotal invagination, the Valsalva maneuver and abdominal resistance testing.[45–47] However, interpretation of these tests requires caution as overall agreement is best when a single entity of groin pain is classified, but lower when multiple entities exist.[46] Abdominal resistance testing seems to have slightly lower inter-examiner reliability than inguinal palpation with or without scrotal invagination[45] and reproduces known symptoms in only 58% of cases, compared with 100% of cases for the inguinal palpation.[45] Thus, while resistance testing may support the diagnosis, a negative result does not exclude inguinal-related groin pain.[45,46]

Reliance solely on orthopedic tests and imaging can lead to missed diagnoses. A common pitfall is the false-positive flexion, adduction, internal rotation (FADDIR) test, where pain reproduction originates not from intra-articular impingement, but rather from stress on structures from the iliopsoas or in and around the inguinal canal.[15] For this reason, we recommend that the assessment begins with a structured evaluation of specific clinical entities—including adductor-,

pubic-, iliopsoas-, and inguinal-related structures[6]—to identify sensitized anatomical sites before proceeding with special tests such as FADDIR or abdominal resistance testing.

Finally, while inguinal disruption may be a more specific label than inguinal-related groin pain when an actual tear is present, caution and good communication are vital when using this type of label with patients, as such a label may drive unnecessary patient concerns and preferences for certain management strategies, such as surgery.

Clinical Presentation and Epidemiology

Athletes with inguinal-related groin pain and/or disruption typically present with an insidious onset of discomfort localized to the inguinal region and along the inguinal ligament. Symptoms are usually exacerbated by physical activity and may radiate to the abdominal wall, medial thigh, pubic symphysis, or genital region (Figure 6).[13] Sports involving high-speed cutting, sprinting, kicking, and pivoting are typically associated with inguinal-related groin pain. Epidemiology studies in athletes suggest that inguinal-related problems are present in 5–10% of new groin injuries during a football season in males,[48] whereas it is almost absent in female footballers.[49] While, adductor-related groin pain, is the most common clinically entity seen in males athletes[29,48] with up to two thirds having symptoms at the area of the adductor longus insertion and/or at the anterior subchondral pubic bone;[48] women athletes often display hip-related or iliopsoas problems.[29,49]

It is important to note that the symphysis pubis is a cartilaginous joint that contains a fibrocartilaginous disc between the adjacent pubic bones.[18] Small secondary ossification centres, in the form of the pubic apophyses, emerge anterosuperiorly.[50] These gradually enlarge and become incorporated into the pubic bones.[50] Such ossification centres are typically first visible in boys at around 16 years of age and in nearly all males by the age of 18.[50] Accessory ossification centres have been reported in 45% of females and 50% of males aged 17–18 years,[50] consistent with literature describing full fusion of the symphysis pubis in early adulthood.[51]

This developmental timeline helps explain clinical patterns: where male athletes younger than 18 years can develop symptoms around the pubic symphysis that resemble apophysitis, with increased irritability at the pubic growth centre. Although, the pubic growth centre may not fully close until the mid-twenties,[51] male athletes in their twenties more frequently seem to present with symptoms involving the surrounding muscles, tendons, bones and ligamentous structures—including the inguinal ligament and canal—as opposed to the apophyses which typically cause problems in more skeletally immature athletes.

Inguinal-related groin pain in male athletes is often present with other groin pain entities,[13,15,29] especially in athletes with more longstanding conditions, where tissue tenderness may increase pain intensity and involve a larger tender area in the groin and pelvic region.[13,15] The most common combination of entities seen with inguinal-related problems is inguinal-related groin pain together with adductor-related groin pain, but also often in combination with iliopsoas-related groin pain when three entities are present.[15] Several extensive studies not using the Doha agreement terminology also find a large proportion of known pain and tender spots that present in combination and are placed close to the adductor insertion and the superomedial aspect of the pubic symphysis, which is in proximity to the lateral border of the rectus abdominis, close to the conjoined tendon, and the insertion point of the inguinal ligament.[52,53] This overlap may also explain why pain at the origin of the adductor longus tendon—a recognized feature in the definition of inguinal disruption[2]—often reflects the co-existence of inguinal-related and adductor-related groin pain.[15] Increased tenderness in both regions is frequently observed during clinical examination.[15] In cases where patients are treated for an adductor-related problem, and there is a lack of response to an adductor-focused exercise-based treatment approach, then it is advised to reconsider the role of any present inguinal-related symptoms, and a change in management strategy may be required.

When more distinct ruptures occur, the adductor longus is typically the most involved structure. Tendon ruptures present in athletes aged 18 years and above, whereas apophyseal avulsions involving the pubic apophysis are more often sustained by younger male athletes under the age of 18. Such avulsions are rare, accounting for less than 1% of all apophyseal fractures in the pelvic region.[54]

Full adductor longus ruptures usually occur in athletes older than 18 years of age and have been described to involve concomitant injury, and recently the term pyramidalis-adductor longus-pectineus complex (PLAC) injury has been

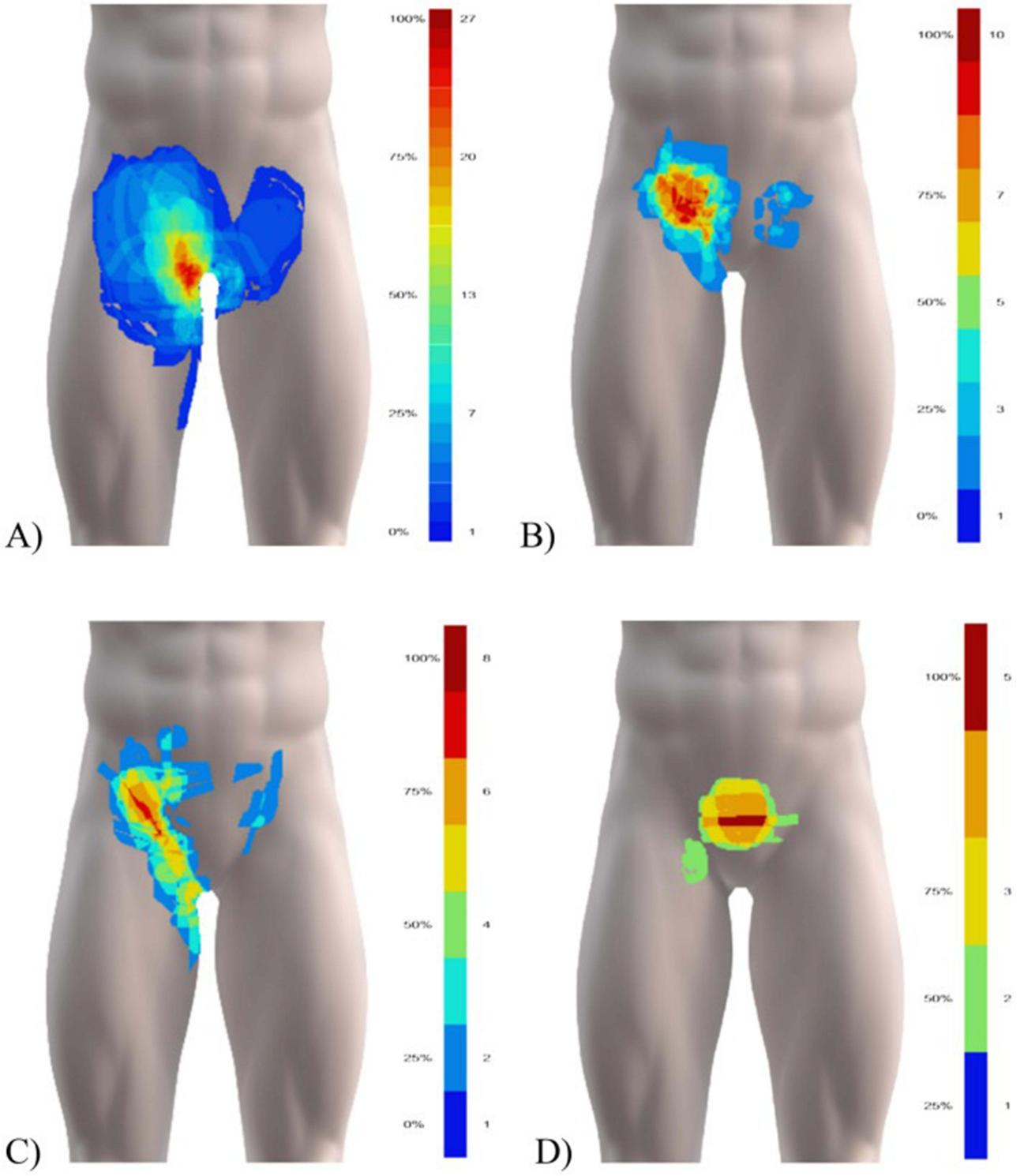

Figure 6 Pain map overlays of: (**A**) adductor- (N = 39), (**B**) inguinal- (N = 24), (**C**) iliopsoas- (N = 18), and (**D**) pubic-related (N = 7) groin pain showing common regions for each clinical entity. The colour-scheme range reflects the maximum overlap and the minimum one overlapping area, shown in percent and the absolute number of drawings. From Serner et al,[13] Scientific Reports 12, 9789 (2022). Copyright via "CC-BY" license (https://creativecommons.org/licenses/by/4.0) Source: https://doi.org/10.1038/s41598-022-13847-1.

introduced, and suggested to be in need of surgery.[55,56] However, it seems from conservative studies that these types of injuries do very well conservatively without the need of surgery at the one-year follow-up,[57] even in cases of concomitant injuries, including PLAC type of injury,[57] which questions the importance of PLAC terminology, as it does not seem to affect prognosis or a need for immediate surgery.[55–57]

Clinical Examination and Imaging

In males, the inguinal canal can be examined by palpating through the scrotal skin, while the Valsalva maneuver can help detect any bulging or herniation.[1,2,45,46] Direct or indirect inguinal hernia can also cause pain in athletes and is not to be missed, but it is not a very common finding in younger athletes. It remains recommended to look or feel for an apparent bulge or cough impulse over the deep and/or external ring in assessment in the standing position but remembering that inguinal-related groin pain and/or disruption cannot be excluded even if there is no clear bulging or a cough impulse present, as these are more typical signs when there is a direct or indirect inguinal hernia present.[1,2,4] The key during the clinical examination is investigating the lower abdominal pain closer and palpating along and just above the medial part of the inguinal ligament to its insertion.[6] Then, gently pressing towards the fascia transversalis, but also stressing the conjoined tendon, where these structures are located – so posterior-laterally, along the inguinal canal, and medially towards the insertion at the pubic tubercle. Furthermore, the focus should be to palpate for pain in and around the superficial inguinal ring before and during invagination when pressing one's finger posteriorly towards the back wall of the inguinal canal.[5,6] Imaging is not included in the formal diagnostic criteria for inguinal-related groin pain or disruption. However, imaging modalities such as MRI and ultrasound can be useful for ruling out alternative pathologies, such as more acute adductor and iliopsoas injury, severe pubic stress reactions and true hernias. Dynamic ultrasound may assist in detecting posterior wall bulging or subtle inguinal ligament abnormalities.[17,58] Still, both false positives and false negatives can often occur – and reproducing the patient's known pain during palpation of the specific structures is considered the main finding supporting the diagnosis.[1,2] MRI-based anatomical studies have suggested that a high insertion of the conjoined tendon is more frequently observed in athletes with inguinal-related groin pain, and this variation may act as a predisposing factor for injuries in the region (Figure 7).[59]

Pain presentation in athletes can vary, but a typical nociceptive pattern often involves a dull, aching, or stabbing sensation in the groin, corresponding to ilioinguinal and iliohypogastric nerve dermatomes, typically arising from musculoskeletal strain or injury. Conversely, sharp, burning, or electric-like pain radiating towards the suprapubic region, inner thigh, or testicles suggests nerve irritation and the presence of a neuropathic component.[20] When neuropathic pain is suspected, screening tools such as PainDETECT[60] can provide additional diagnostic insight. The PainDETECT questionnaire includes 9 items, of which 7 items involve (burning, tingling or prickling, touch-evoked pain, electric shocks, temperature-evoked pain, numbness and pressure-evoked pain) and are rated on a Likert scale with six options

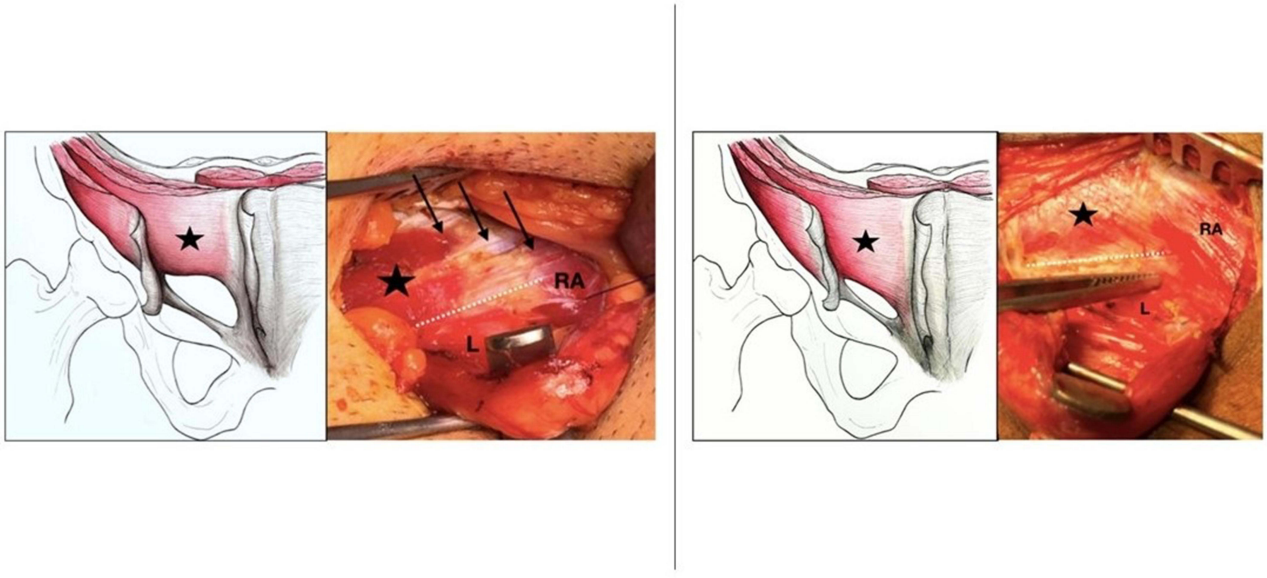

Figure 7 Schematic drawing and surgical laparoscopic view of a high and low muscular insertion of the conjoint tendon (star) with tendinous expansion and its inferior border (white dotted line). L, inguinal ligament; RA, rectus abdominis. From Antoun et al 2020,[59] European Radiology 30:1517–1524. Adapted with images reproduced with permission. Source: https://doi.org/10.1007/s00330-019-06466-4.

that ranges from "never" to "very strongly", as well as two items related to temporal pain characteristics (changes over time) and spatial (radiating pain). The score goes from 0–38 points, where 19 and above is the cut-point for defining neuropathic pain, 13 to 18 points indicate a mixed and unclear pain pattern, and below 13 indicates that a neuropathic pain pattern is unlikely.[60] While the prevalence of neuropathic pain is unknown in athletes, the prevalence of long-standing pain with neuropathic characteristics has been estimated to be in the range of 7–10% in the general population.[61] In comparison, it seems that the risk of persistent pain in the 6 months following inguinal hernia repair is around 12%, where nerve involvement/damage may be the most important pathogenic factor.[62] Interestingly, persistent pain seems more prevalent after open mesh surgery compared to laparoscopic surgery.[62,63] So, while keeping in mind that no good data exists on the presence of neuropathic pain in athletes with inguinal-related groin pain, whether they have received surgery or not - we urge clinicians to be aware of this phenomenon and to assess it whenever relevant. In athletes with longstanding pain and symptoms, it is not uncommon to observe neuropathic pain involvement. In such cases, further assessment may be needed. Image-guided nerve blocks targeting the ilioinguinal, iliohypogastric, and genitofemoral nerves may be considered as part of a combined treatment approach.

Outcome Testing

Most research studies do not assess athletes with inguinal-related pain and/or disruption with validated and quantitative functional scores.[64] Frequency and time to return to sport can be interpreted very differently and return to sport can be anything from return to training, return to competition at a lower level (than pre-injury), or return to full competition at pre-injury level, and then performance is not taking into account either.[64,65] A recent study including mainly footballers having targeted surgery for abdominal wall injury and/or adductor injury showed this very elegantly as they reported that while mean times to return to running was around 20–30 days, return to training was double the time or more, so 60–100 days, and return to competition was triple the time or more, with 90–130 days.[65] This is important as many studies claim that athletes are back after inguinal surgery within a few days or weeks,[66,67] and while this may be true, in terms of running, many are usually miles away from being back in competition and back at optimal performance. Few studies have used a validated outcome measure in the form of HAGOS.[68–72] HAGOS data have showed that the mean results after inguinal-related pain/disruption surgery[71,72] did not reach the range for healthy athletes at 6 weeks and 3 months in sports function and performance.[68–70] In addition, it has been shown that around 40% of patients still had mild pain during exercise (NRS 1–3) after three months, whereas 27% still had moderate to severe pain (NRS 4 or more) during exercise 3 months after surgery, which improved at 19 months and 83 months where only 25–38% still had minor to moderate pain during exercise.[73] However, this also fits with the clinical notion during rehabilitation that many patients are not completely symptom free at 3 months,[73] and that this is important to inform patients to align their expectations. Overly positive reported surgical case-series often help very little in the understanding of the recovery, as they most often do not collect any prospective data that involves validated and relevant patient reports.

Treatment Approaches

Currently, there is no standardized treatment algorithm for inguinal-related groin pain.[64,74] A multidisciplinary setup to manage inguinal-related groin pain is, however, essential. Sports-physiotherapists and sports medicine specialists need to work together with abdominal surgeons with experience in treating inguinal-related groin pain in athletes.[74] It has previously been suggested that inguinal surgery may be needed to resolve longstanding inguinal-related groin pain.[74–76] This notion is supported by two randomized controlled trials which have compared surgical treatment with non-surgical treatment.[75,76] A Swedish RCT (66 soccer players) investigated open surgical repair with neurectomy vs non-operative treatments,[75] and another RCT on TEP laparoscopic repair versus physical therapy (60 patients).[76] Both studies showed superior outcomes of surgical compared to non-surgical treatment with only few athletes having a successful outcome after non-surgical treatment.[75,76] This, however, does mean that all athletes with inguinal-related groin pain will require surgery.[74]

Non-Surgical Management

As mentioned above, not all athletes with inguinal-related groin pain and/or disruption will need surgery.[74] An Israeli study including 246 male football players with longstanding groin pain showed that in 129 players with adductor located symptoms, 33 (26%) also showed posterior inguinal canal weakness on dynamic ultrasound.[77] In those 129 players only 15 (12%) eventually required inguinal repair after failed conservative treatment.[77] In contrast, only 31 players had isolated inguinal symptoms, of which 14 (45%) showed posterior inguinal canal weakness on dynamic ultrasound. Here, 21 (68%) required inguinal repair after failed conservative treatment.[77] Lastly, in 73 players with combined adductor and inguinal symptoms 26 (36%) showed inguinal weakness on dynamic ultrasound, and 14 (19%) required inguinal repair after failed conservative treatment.[77] The study also highlights that even in players with posterior inguinal canal weakness on ultrasound, not all players went on to require surgery, as 31 (42%) of 73 players with this finding recovered from conservative treatment.[77] This study of 246 male football players suggests that only about 51 players (21%) with athletic groin pain seen in a specialized sports medicine clinic seem to need inguinal repair, and 158 players (64%) could be treated conservatively without any surgical intervention. Thus, conservative care should always be considered and is already implemented worldwide,[74,77–79] also when inguinal-related findings are clearly present.[74,77–79]

First-line treatment involves a trial of physical therapist-led rehabilitation focusing on pelvic core strengthening, and activity modification.[74,77–79] Just as with the evidence for longstanding adductor-related groin pain, an active exercise approach is better than a passive treatment approach, with a recent RCT study showing that 65% of athletes with inguinal-related groin pain and/or disruption returned to sports without groin pain after 2 months of rehabilitation compared to only 15% in the passive treatment group, which also shows that not all patients benefit from a non-surgical approach.[80] The rehabilitation of inguinal-related groin pain have the same focus as programs for other clinical entities, such as the adductors, starting off by isolating impaired and weak tissues.[81] The aim is then to integrate these structures into more sport-specific movement, function, and gradual return to sport.[81] The programme consists of progressive loading, and substantial time under tension, working with 2 to 3 sets of each exercise working from low towards higher load without provoking pain in the inguinal region.[81] Finally, more explosive and sport-specific exercises are used.[81] Because the rehabilitation requires progressive overload and good compliance and may last a long time, commitment from rehabilitating athletes is crucial.[81] In those patients with longstanding symptoms who do not respond to specific exercises and load management, surgery may well be the next option. Exercises also form an important part of post-operative care. Athletes are advised to immediately return to normal ambulation and aerobic activities but need to be aware of avoid heavy lifting and strenuous activities for a brief period to allow adequate healing of the surgical site and minimize discomfort while promoting early progression to normal function exercise and athletic activity. The immediate strength of the repair exceeds the forces made by most strenuous activities, and activity should be guided by pain and comfort. Exercises should focus on establishing the strength of the abdominals, especially rotational strength is important to address, not just in isolation, but also with important integration of pelvic flexion, rotation, and extension synergists. This means focusing on specific exercises and compound movements that involve the adductors and gluteal muscles as well.

Diagnostic Injections and Injection Therapy

Diagnostic injections and injection therapy can be employed as a second- or third-line treatment and is best used as part of the clinical reasoning process, helping to better identify patients who may require surgery. When symptoms persist after rehabilitation or surgery, image-guided nerve blocks targeting the ilioinguinal, iliohypogastric, and genitofemoral nerves may be considered. These injections often combine local anesthetics—for immediate pain relief—with corticosteroids to reduce inflammation and stabilize neuronal membranes, for analgesic effects.[20]

There is no clear evidence supporting inguinal nerve blocks in the management of acute post-herniorrhaphy pain, and their role in treating chronic inguinal pain remains controversial. One randomized controlled trial (RCT) found that anterior surgical neurectomy was significantly more effective than tender point infiltration (TPI) in reducing pain after anterior inguinal hernia mesh repair.[82]

Despite this, most therapeutic algorithms recommend initiating treatment with TPI due to its minimally invasive nature and low complication rate. TPI has been shown to be effective in nearly one-fourth of patients, particularly when baseline Visual Analogue Scale (VAS) scores are low. If TPI is unsuccessful, a tailored neurectomy have been shown to result in >50% long-term pain reduction and restoration of work capacity in most cases.[82]

Surgical Management

So, surgery is currently indicated in athletes who do not recover from 8–12 weeks of physical rehabilitation. The SPoRT Score Calculator can be used if imaging findings are available to aid in the decision of whether inguinal surgery is relevant or not (https://2uphnw-sayan-biswas.shinyapps.io/SPoRT_score/).[83] It involves, and combines MRI, US, and clinical findings, and thus is best used as part of a specialized doctor's appointment, when initial conservative treatment has failed and surgery may be indicated and considered. As The SPoRT Score Calculator has not undergone any further external validation, it is important that clinicians use this scoring system with caution, given its current methodological limitations, and use it after conservative treatment has failed to see if inguinal surgery could be a relevant option.

The surgical techniques used for inguinal-related groin pain are techniques that are based upon similar approaches used for operating "real" inguinal hernias. They can be divided into open techniques, with or without the use of mesh, or laparoscopic techniques, with the use of mesh in the form of both transabdominal preperitoneal (TAPP) and total extraperitoneal (TEP) techniques.[84] One of the open procedures is recognized as the minimal repair technique, which employs one continuous suture reinforcing the back wall.[66] If there is evidence of damage to the genital branch of the genitofemoral nerve, this is partially removed, although to date this remains a subjective finding with no scientific evidence to support its removal and/or division.[66] Laparoscopic surgery with mesh insertion and inguinal ligament release has also been described and performed.[25] During this operation, the inguinal ligament is inspected at the origin of the symphysis, and if there is evidence of enthesis irritation, the ligament is cut,[25] again no high-level scientific evidence has demonstrated the rationale for the "release" or the presence of enthesis irritation. A systematic review from 2021 showed that the posterior inguinal wall was addressed using open surgical approach in 10 studies (393 patients) and a TEP or TAPP approach in 12 studies (1120 patients).[85] Mesh was inserted in 34% of the open repairs and in 100% of the TEP/TAPP repairs. The same systematic review from 2021 found that the rate of return to play at preinjury level was 92% in athletes after surgical procedures limited to the inguinal structures, 89% after combined surgery to inguinal and adductor structures and only 75% after surgery limited to the adductor structures.[85] This is also consistent with the RTP times from a meta-analysis of 56 selected studies by King et al,[86] where RTP time was shorter in athletes with abdominal wall injuries (50 days) than in athletes with adductor injuries (128 days), or combined injuries (153 days), or osteitis pubis (162 days). The study by Hatem et al also found that return to play at preinjury was higher after TEP/TAPP repair (96%) than after open repair of the posterior inguinal wall (90%) for athletes with inguinal-related pain.[64] However, a high-quality randomized controlled saw no difference in return to full sport activity when comparing TEP repair (94%) versus open suture repair (90%).[87]

Traditionally, it has been emphasized that nerves should be preserved during an inguinal repair to avoid sensory loss and pain due to nerve injury/resection. However, in inguinal hernia surgery, some reports suggested that elective excision of ilioinguinal nerve causes minimal morbidities.[88–90] In addition, ilioinguinal neurectomy seems to be an effective treatment for relieving groin pain after open hernia repair, achieving more favorable outcomes than nerve block or mesh removal alone.[88] These studies must, however, be interpreted with extreme caution as dividing a nerve desensitizes the painful area and so may well be demonstrating a false positive result and has not been directly investigated in athletes either.[88–90]

Complications

Although exercise therapy is safe and free from complications in the management of inguinal-related pain or disruption, it is not universally effective—particularly in longstanding cases. In such situations, relying solely on exercise-based rehabilitation may prolong symptoms and contribute to a continued reduction in physical capacity and athletic performance. Injection therapy and nerve blocks can have complications such as thinning of skin, necrosis at the injection site, infections, impaired glycemic or blood pressure control in patients with history of diabetes mellitus and hypertension,

and impaired wound healing. The main postsurgical complication is pain. In a study by Piozzi et al, 6% had referred chronic inguinal pain with delayed return to sport activity.[91] These patients were submitted to medical treatment and physiotherapy. Inguinal pain resolution and return to sporting activity were reported by half of the patients after 3 months, with the rest recovering at 6 or 9 months, and only 2% not returning to elite sporting activity because of continued inguinal pain.[91]

Conclusion

Inguinal-related groin pain and/or disruption remains a complex clinical entity that requires a thorough and systematic assessment, integrating both a detailed history and focused physical examination. While reproduction of the patients known pain from inguinal palpation remains the best bedside diagnostic tool, adjunctive imaging can be invaluable in identifying differential diagnoses or coexisting pathologies that may influence management.

Non-surgical strategies—including targeted physical therapistled exercise and activity modification management—are effective for a substantial proportion of athletes. However, in refractory cases, surgical intervention, particularly laparoscopic repair techniques, has demonstrated higher success rates than continued conservative care.

Given the variability in presentation, underlying pathology, and athletic demands, shared decision-making should be central to management. This involves weighing the benefits, risks, and recovery implications of each intervention in the context of the athlete's goals, competition calendar, and overall health status (Table 1). A tailored, athlete-centered approach not only optimizes functional outcomes but may also reduce recurrence risk and facilitate a safe, timely return to sport.

Table 1 Comparative Pros and Cons of Inguinal Pain Management Approaches

Intervention	Exercise-Based Treatment	Injection Treatment	Laparoscopic Surgery	Open Surgery
Approach	Non-surgical: Physical therapist-led rehabilitation	Minimally invasive: image-guided corticosteroid or anesthetic injection	Minimally invasive surgery using small incisions, mesh, and a camera	Traditional surgical incision to repair torn tissues ± mesh reinforcement
Goal	Strengthen pelvic and core muscles, reduce groin strain, restore mobility	Temporarily block or reduce pain and inflammation. Adjunct treatment to exercise or for diagnostic purpose	Repair and reinforces the internal defects with mesh only	Repair damaged posterior wall of inguinal canal and tendons; reinforces groin with or without the use of mesh
Typical Duration	Return to sport after 8–12 weeks (or longer depending on severity)	Short-term relief (days to weeks); repeat injections may be needed	2–4 weeks recovery; return to sport after 4–8 weeks	4–6 weeks recovery; return to sport after 2–3 months
Pain Relief	Gradual relief through progressive loading and strengthening	Rapid but temporary pain relief	Faster relief post-op with typically less pain	Immediate structural repair, slightly increased post-op pain with recovery
Success/Return to Sport	~50–70% success with proper rehab	Variable: May delay definitive treatment	~90–95% return to sport	~80–90% return to sport
Risks	Low risk: Potential for recurrence or incomplete recovery	Low risk; potential tissue damage or infection at injection site	Surgical risks (less common); mesh-related complications and bowel/ bladder + other visceral injury	Surgical risks (infection, nerve injury/ neuropathic pain, recurrence and mesh-related complications)

(*Continued*)

Table 1 (Continued).

Intervention	Exercise-Based Treatment	Injection Treatment	Laparoscopic Surgery	Open Surgery
Cost	Low to moderate cost: Several physiotherapy sessions may be needed	Moderate cost: Imaging + injection procedure	Often highest cost due to specialized equipment/ surgeons – day case surgery	Moderate cost, surgical team, anesthesia (local anaesthesia reduces cost); day case surgery
Invasiveness	Non-invasive	Minimally invasive	Minimally invasive, requires general anaesthesiae	Invasive can be undertaken under local anaesthesiae
Use of Mesh	Not applicable	Not applicable	Mandatory for internal defect coverage	Optional use by surgeon for reinforcement over suture repair
Customization	High – can be tailored to athlete's sport-specific demands	Some variability based on injection site and substance	Technique and mesh placement can be tailored based on intra-abdominal findings	Limited intra-op customization – surgeon decides on suture or mesh repair based on expertise
Availability	Widely available through sports physios or rehab specialists	Widely available in pain clinics or radiology departments	Requires specialized surgical expertise and equipment	Available in orthopedic or general surgery centers – if under local anaesthesiae then general anaesthetic equipment is not required.
Recommended as/when	First-line treatment unless severe or longstanding case	Adjunct or temporary relief during rehab phase or after inguinal surgery or for differential diagnostics	When rehab fails in high-level athletes and/or minimal downtime is critical	When rehab fails in high-level athletes

Artificial Intelligence Generated Content (AIGC)

The authors used Grammarly Pro and ChatGPT-5 to assist with language editing and improve readability. All intellectual content and final revisions were conducted by the authors independently, without the use of Grammarly and AI. The authors take full responsibility for the integrity and accuracy of the manuscript.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

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