Rehabilitation from Hip and Groin Surgery

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Introduction

Assessment of groin pain in the young adult population is complex and requires a systematic and integrated approach to create a marriage between the history, the investigations used and the physical examination. Through this process it is possible to ascertain the relationships between the primary and secondary conditions or clinical entities Holmich, and accurately identify the source of pain verses the source of dysfunction.

Historically when describing groin pain in athletes, the term "Athletic Pubalgia" is often used to imply the insidious onset, complex and persistent nature of groin pain in professional athletes. Therefore, it is not unreasonable in academic terms to describe groin pain much like we do with low back pain, where we use the term non-specific low back pain, and thus we use a regional description to encompass a range of musculoskeletal conditions that may cause this pain.

From a literature-based process, we have moved to using terms such as; adductor–related; abdominal-related; pubic joint related; hip joint related. The challenge for the clinician is to be able to apply the knowledge from the literature that describes regional problems, that may be non-specific in nature, to clearly identifying the anatomical structure and pathological process that needs immediate treatment and management.

Groin Pain Overview

Groin pain and tenderness are common in athletes from a variety of codes of football, skiing, hurdling, and hockey. These are all sports that involve high-speed torsion of the trunk, side-to-side cutting, kicking, quick accelerations and decelerations, and sudden directional changes, and encompasses sports that require specific use (or overuse) of the proximal musculature of the thigh and lower abdominal muscles.

In Europe, this problem is most common among soccer players, and the prevalence has been estimated from 5 to 28 % [1].

In the acute setting the most common causes of groin pain in athletes are musculotendinous injuries to the adductor and hip flexor musculature, with less common, but not to be excluded lower abdominal strains to the fascial and tendinous insertions.

Per Renstrom [1] outlined the possible mechanisms for groin injury specific to football to be; an imbalance between the adductors and the abdominals, an imbalance between the anterior and posterior chains, elasticity of the pubic symphysis, a combination of abdominal hyperextension and thigh abduction with the pivot point being the pubic symphysis, a pull on the strong adductors may weaken the posterior abdominal wall. And estimated the prevalence male > female (~3:1).

Acute injuries are usually fairly straight forward during the diagnostic process, the key comes in identifying any underlying chronic problem that may have predisposed to the acute injury and will influence the treatment and rehabilitation process.

Acute groin injuries may become chronic if not effectively managed, as the damaged tissues will have a reduced load bearing capacity and will be likely to deteriorate further under load.

Persistent injuries are much harder to evaluate and manage as the chronicity of groin injuries increases so does the likelihood of more than one discrete pathological entity occurring. In this scenario a multifactorial approach to examination and treatment if often required. Furthermore the damaged tissues cannot function normally, making it likely that the biomechanics of the region will be subtly changed, causing relative overload and possible injury to other structures.

Puig et al. [2] following a systematic review of the literature concluded that the pathophysiological processes of this lower abdominal pain resulting from over use is unclear, but muscular imbalance might be involved in the pathogenicity.

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This is interesting when you look at Cowan et al. [3] who studied the relationship between motor control of the pelvis and long standing groin pain in 10 symptomatic and 12 asymptomatic AFL players. They showed that the asymptomatic players were able to perform an active straight leg raise (ASLR) task with Transversus abdominus contracting in a feed-forward manner, but in the symptomatic players there was a delay in TvA alone, with all other abdominal muscle working normally.

However, caution is needed in extrapolating too much information from this study and applying it inappropriately. But it serves to highlight that clear differential diagnosis may not always be possible, and sometimes there is a need for an indirect diagnosis, to ascertaining the route cause of the dysfunction first before the clinician can address the anatomical pathology.

Principles of Assessment

The most critical part of any assessment is the history taking, and getting the "story" right. This needs to be compiled of open-ended questioning and specific questions to tease out the components of the presenting problem, do not be afraid to ask direct and specific questions that require a closed answer, if the assessment is left too open then it may result in the clinician chasing the problem, becoming frustrating for both the clinician and the patient. Asking the appropriate questions should be based upon a thorough understanding of the literature, the underpinning science and the patterns that have been demonstrated.

Greater light on the history can be placed when one combines the information from two authors published, that of Bradshaw [4], Holmich et al. [5] and Holmich [6]. We can gain a lot from these authors who have advanced the knowledge of groin pain over a number of years.

Holmich, was the first to propose the notion of looking at the groin in terms of clinical entities, rather than trying to come up with one clear anatomical diagnosis, he presented the notion of accepting that there are multiple clinical entities that can co-exist, and as a result try and highlight which is the primary driver in the pain process.

Holmich et al. [5] has done an intra and inter reliability study of athletes with groin pain. He was able to show a good physical examination could accurately differentiate between clinical entities. The protocol was designed to detect one or more pathoanatomical structures associated with symptoms. A good place to start; abdominal groin pain OR adductor groin pain OR hip pain.

His results were able to show that there was clinical overlap in 40% of the cases. However, he did not use investigations as part of his diagnostic pathway, nor did he consider the hip joint as part of the examination. Of the 207 athletes he examined, he was able to show that the primary complaint in 57.5 % (119) was adductor related, with Ilio-psoas-related being primary in 35.3 % (73). However, possibly slightly more interesting is the fact that of the 33.3 % (69) of athletes who had a secondary complaint, Ilio-psoas related pain was present in 19.3 % (40). The majority of which were females who ran in a straight line.

This point is relevant when you compare it to Bradshaw's study [4] where he examined 208 patients, and found that hip pathology was present in 44 %, adductor related in 23 %, and psoas in only 7 %.

The comparison of these two studies, taking into consideration their limitations, may lead you to believe, that Ilio-psoas related pain, is potentially a presentation that occurs in relation to hip joint pathology, or at the very least the Ilio-psoas muscle in the presence of other pathology takes on a guarding role to "protect" the groin region, and thus is rarely the primary problem.

Of note, neither study, identified a high incidence of abdominal related groin pathology or sportsman's groin (2–6 %).

History

Location of pain – Greg Lovell, in a review of 189 cases, looked at the final consult what was the end diagnosis/pathology that was treated and compared it to the location of pain that the patient had complained of at the initial consult. He was able to show a strong correlation between the area of pain and the pathology involved Malycha and Lovell [7].

Anterior thigh – Iliopsoas, Hip pathology, NOF stress #
Inguinal Canal – Incipient hernia
Pubic Region – Osteitis pubis, Pubic Instability
Inner thigh – Adductor lesions, Obturator neuropathy

This was further enforced by Falvey et al. [8] who was able to show a correlation with the location of pain in reference to the groin triangle and its association to the underlying pathology.

Despite this correlation it is important to remember that with groin pain multiple diagnoses are common:

Nonmusculoskeletal Causes – Psoas muscle abscess, Spine problems, Hernia, Endometriosis, Ovarian cyst, Peripheral vascular disease.

Unknown Etiology – Transient osteoporosis of the hip, Bone marrow edema syndrome,

Synovial Proliferative Disorders – Pigmented villonodular synovitis, Synovial Chondromatosis, Chondrocalcinosis

Metabolic Causes – Paget disease, Primary hyperparathyroidism,

Extra-Articular Pathology – Coxa saltans (internal or external), Psoas impingement, Abductor tears (rotator cuff tears of the hip), Athletic pubalgia, Trochanteric bursitis, Ischial bursitis, Osteitis pubis, Piriformis syndrome, Sacroiliac pathology, Tendinitis (hip flexors, abductors, adductors).

Traumatic Causes – Subluxation or dislocation, Fracture or stress fracture, Hematoma Contusion, Labral Pathology,

Femoroacetabular impingement (FAI), Hypermobility, Trauma, Dysplasia

Infectious/Tumorous/Metabolic Conditions – Septic arthritis, Osteomyelitis, Benign Neoplasms of bone or soft tissue, Malignant neoplasms of bone or soft tissue, Metastatic disease of bone

Inflammatory Conditions – Rheumatoid arthritis, Reiter syndrome, Psoriatic arthritis,

Chondral Pathology – Lateral impaction, Osteonecrosis, Loose bodies, Chondral shear injury, Osteoarthritis,

Capsule Pathology – Laxity, Adhesive capsulitis, Synovitis or inflammation

To further complicate the matter, Mitchell [9] reviewed 81 patient's pre hip arthroscopy (53 female) and found an average of 6.4 sites of pain, with the pain being experienced any where from the lumbar spine to the calf and shin. To note all 81 of the patients had deep inside anterior groin pain as their primary complain. There was an average symptom duration of 4.3 years, which may account for the many different pain locations as various different compensations would have occurred. The other interesting finding from this study is that 60 % of these patients were not diagnosed with hip pathology on their first consult.

Groin localisation is important but may be difficult, as it may be felt in a number of different areas simultaneously [10].

Presenting complaint – listen closely to the choice of words, as this can often give an indication of the structures involved (joint, muscle, nerve), in general a pain that is vague, deep and non-specific (it covers an area) is likely to be joint in nature (hip or pubic joint), A sharp pin point pain brought on by a specific movement may be indicative of a muscular problem. Simplistically, ask "can you put one finger on the problem", if they can this is more indicative of a specific muscular problem, e.g. sportsman's groin, however, if they use the flat of their hand, or cannot localise, then it may indicate a deeper seated problem from the joint, or overlapping clinical entities. The Orthopaedic surgeons, make reference to a "C" sign in relation to hip joint pain, where the patient cups the hip joint between their index finger and thumb and says "it is in here".

The age of the patient can be a big indicator of the type of pathology. Different conditions occur at different age groups e.g. irritable hip syndrome (10–15 years) vs. OA hip degeneration (>45 year typically). ROM decreases with age; Congenital hip dysplasia is seen in infancy, primarily in girls; Legg Calve-Perthes disease more common in boys aged 3–12; Elderly women are more prone to osteoporotic NOF fracture. Do not miss slipped upper femoral epiphysis (SUFE) which typically occurs in 12–15 year old overweight boys (4:1), with an incidence of 3 per 100,000, they commonly present with a limp, and medial thigh pain.

Always ask if there was an incident or specific mechanism of injury, often the injury has occurred during a sporting movement and thus the exact mechanism cannot always be recalled, or there has been a gradual onset of worsening symptoms, that have not hampered sports but just resulted in reduced performance, and as a result the patient is presenting some months (or even years) down the line. In these scenarios it is important to try and differentiate as much as you can.

Bradshaw el al. [4] was able to show that the type of activity was also correlated to the pathology, in that if you were involved in a kicking sport there was a greater incidence of developing pubic pathology, however, if you were involved in a twisting sport (without kicking) or you ran in straight line, the incidence of hip pathology was greater.

When trying to ascertain the irritability, do not just ask about aggravating and easing factors, be specific with your functional questions (examples below), but try and find out about, movements they avoid, or they feel weak or a loss of power when performing, or even just a lack of confidence. The patient may well have avoided certain movements for some time in order to function and they have forgotten by the time they present for the consultation.

Examples of specific questions are:

(a) Putting on socks & shoes/trousers – generally done the same time every day, so gives a level of functional outcome, and will impingement the hip and groin.
(b) Climbing up and down stairs – gives a functional outcome of single leg stance and load on the hip and hemi-pelvis.
(c) Getting in and out of the car/bed – possible inflammatory component if first thing in the am, or just the mechanism of impinging the hip and tensile loading the groin.
(d) Driving for long periods – sustained compressive load on the hip, or over-activity of the hip flexors with relation to subtle pelvic dysfunction.
(e) Sleeping/rolling over in bed – classically related to the hip joint, but can be pubic joint in nature.
(f) Abdominal work (sit up)/coughing – classically related to a sportsman's groin, but also can be associated with a pubic joint injury.
(g) Accelerated/unguarded movements – associated with groin disruption
(h) Catching/giving way/'grasp sign' – classically associated with a hip joint pathology.
(i) Overuse injuries account for up to 80 % of athletes presenting with hip & groin pain [11].

In essence you are trying to establish a mechanism of injury for the groin injury, which can be summed up into two words "exceeded capacity". Those two words incorporate the following.

- The area was not strong enough
- There was a muscle imbalance and poor synergy
- The load was so high that anyone would have been injured
- Were they fatigued?
- Do they have altered movement patterns or altered motor control

- Was there a change in their compliance of their tissues (timing of contraction from eccentric to concentric), the body of evidence is now really clear that flexibility does not have a strong correlation to injury or to reducing the risk of injury.

There is always an extensive differential diagnosis, with up to 30% of all athletes having multiple pathologies (Lovell 1992) meaning that you may have up to three or more working hypotheses at any one time.

It is easy to find an adductor strain or tendonopathy, but miss the underlying hip pathology that predisposed the condition. This should be reflected in your questioning, the clinician needs to tease out every detail, otherwise there is an incomplete history, which may lead to an inaccurate diagnosis.

Physical Examination

It is also easy to attribute a complaint to a musculo-skeletal dysfunction without having a working hypothesis as to the ongoing pathology, e.g. a movement dysfunction at the hip into extension, due to poor gluteal activation and tightness of Iliopsoas TFL, and the adductors, but there is an underlying hip synovitis.

That said sometimes all you can do is address the underlying abnormalities, until you have a solid working diagnosis. One must always keep an idea as to the possibilities of the underlying pathology while going through this process.

For every test carried out you should ask yourself two questions:

- Does it add to the picture already formed?
- Am I reliable?

Having a systematic approach will help to make sure that all bases are covered.

When conducting the physical examination, always inspect the area, looking for any bruising, swelling or colour changes. If it is not appropriate because of the age or gender of the patient, then ask them whether they have noticed any of the above while in the shower?

It is important to observe how they move, as everyone moves differently, this movement observation needs to be related to the demands of their sport, or physical activity.

From the literature there are only a few tests that have been researched to try and find a correlation with clinical testing and groin pain.

Verrall [12] performed three clinical tests on 89 AFL players with and without groin symptoms. The three tests used were single adductor test, squeeze test, bilateral adductor test. The three pain provocation tests demonstrated only moderate sensitivity (range 30–65 %). Positive predictive values were moderate to high (67–93 %) depending upon the individual test. The Bilateral Adductor test was the most sensitive test with the highest positive predictive values.

Verrall later demonstrated a reduction in hip range of motion in athletes with chronic groin injury diagnosed as pubic bone stress injury [13].

Holmich (2004) investigated clinical examination techniques for groin pain in athletes and evaluated the reliability of these tests in 18 athletes (9 symptomatic, 9 controls). The examination techniques used were; long lever squeeze tests for pain and strength, pain on palpation of Adductor longus insertion, pain on passive abduction, pain on palpation of the pubic symphysis, pain on palpation of the Rectus abdominus muscle insertion to the pubic bone, pain and strength on a resisted sit up, pain on palpation of psoas, pain and strength of the Iliopsoas muscle, pain and tightness on passive stretching of Iliopsoas. The only test without acceptable inter-observer reliability was the strength test for Iliopsoas.

Diagnostic examinations may or may not prove helpful in formulating a final diagnosis. There are various different combinations of investigations that can be conducted to ascertain the true nature of the pathology in the groin. Invariably, this cannot be done with one investigation, the challenge for the clinician is to pick the combination of investigations that provides the most clinically relevant information that adds to the presentation.

In summary, when taking your history and conducting your examination of the patient, it is important to:

- Listen to the patient
- Build the picture, by applying the science in the literature to the presentation in front of you
- Look for the patterns described in the literature
- Be aware of your beliefs and biases.

Always ask yourself when planning the objective

- Is my test valid
- Am I reliable
- Does it add to the picture? Or is it just an unrelated dysfunction?
- When assessing try and prioritize the areas into clinical entities

At the end of every consultation, try and conclude by having three working hypotheses:

- Anatomical – Adductor longus vs. conjoint tendon vs. intra-articular hip joint
- Pathological – reactive enthesopathy, inflammatory, tear, degenerative
- Functional – what movement discrepancies or weaknesses may have led to the problem

Adductor Related Groin Pain

Adductor Muscle Strain

In sport the most common injury to the groin is likely to be an adductor strain. Ekstrand et al. [14] reported that 13 % of all injuries in one season of the Premier League (n = 326)

were adductor muscle injuries. O'Connor [15] reported that 23 % of all injuries over two seasons (n = 100) in rugby union occurred in the adductor muscles. While Molsa et al. [16] commented that in ice hockey adductor muscle injuries accounted for 43 % of all muscle strains over three seasons (n = 134).

As previously mentioned the pelvis is a force producer and the highest net force often occurs here. When developing power (force x velocity) there are huge muscular actions at the pelvis trying to generate speed of movement when accelerating, cutting, twisting, and kicking. Torry [17] describes the role of the adductors as working as a brace around the hip joint, in that, they work with the hip abductors to maintain pelvic stability during stance phase in gait and running, while simultaneously, dampening the contraction of the abductors after the propulsive phase.

In the acute phase there are three types of adductor injuries [18]

- Bony avulsion
- Avulsion of the fibrocartilage (enthesis)
- Tear at the musculo-tendinous junction

The latter most commonly occurs at Adductor longus (70 %), with Magnus second (15 %), it is less common to damage the other adductor muscle (15 %) [19]. These injuries should be straight forward to manage, however, Orchard et al. [20, 21] reports that there is a recurrence rate of 22 % in the AFL of adductor strains. This observation goes far to highlight the complex nature of the mechanics around the groin.

As far as the enthesis (the fibro-cartilaginous join from tendon to bone spanning approximately 1–2 mm, and largely avascular) goes Adductor longus has a unique one in that in a sagittal section, coronal view, appears like a triangular fibrocartilage, perfectly designed to absorb the tensile and shear forces of the oblique nature of the adductor longus tendon.

The diagnostic challenge for the clinician is to be able to distinguish between an acute strain to a "healthy" muscle and a strain to a muscle that has adaptive changes, i.e. neural overactivity due to radiculopathy, or early signs of tendonopathy.

Presentation is likely to occur after a sudden change in direction, or an eccentric adductor muscle contraction with concurrent hip external rotation and abduction (mechanism in most football codes). It will be well-localised and tender to palpation, with pain on passive abduction, pain on resisted adduction or combined flexion and adduction. By varying the degree of rotation, the lever arm and the range that the leg is tested in, it may be possible to determine which adductor is injured.

Management

Adductor Muscle Injuries

Inflammation is our friend in the first 48 hours, so we avoid the use of NSAID's, ice and compression is critical, it is thought that compression is more important as it can influence the swelling and the pacinian corpuscles in the skin and thus influence both pain and reflex inhibition. Early movement is useful, however, you want to avoid any stretching for the first 48–96 hours, as often because of the common innervation and functional similarity, if one of the adductors has been strained the other muscles in the group respond by increasing their tone and thus guarding the area, any attempt at increasing range in the short term may provide an increase in strain rate to the guarding muscle group and the joint, and if there is an underlying joint dysfunction this may delay healing and perpetuate the pain cycle.

The same principle applies for direct soft tissue work. Finally there is a propensity in elite sport to travel to get the latest treatment for the injury, the merits and risks have to be weighed up between the strain placed on the groin with flights lifting heavy bags and travelling versus the virtues of rest. The same principle applies to a weekend warrior who has hurt his groin playing in a Sunday league, and wants to come in for treatment on a Monday morning, the benefit gained from 30 to 60 min treatment versus the value of resting for 24–48 hours before travelling needs to be weighed.

The merits of early injection therapy is discussed in the chapter on medical management.

After 48 hours continue modalities, gradually increase stretching and strengthening exercises, focusing on active abduction/adduction, adduction/flexion against resistance, stabilising exercises, CKC & OKC, progress to deep massage, functional strengthening, Cross training (bike, pool, straight line running).

Progress to; shuttle runs, crossover drills, sports specific conditioning.

After the immediate medical management of the soft tissue injury, and you have allowed for an appropriate time frames for healing, one can commence a rehab phase. The key thing with the rehab is restoring the balance around the hip while aiming to maximise function for return to sport. The goals of this phase can be taken from two key papers. Tyler et al. [22] monitored 47 NHL players over 2 seasons and measured their isometric hip strength pre-season, 8 players had 11 adductor muscle strains over the 2 seasons. When the data was reviewed they found that the players who did not get an injury had an adduction strength that was 95 % of their abduction strength, however, the players who received a groin strain, their adduction strength was only 78 % that of their abduction strength. When analysed further they concluded that if the adduction strength was 80 % or less than that of the abductor strength then you were 17 times more likely to get a groin strain. This philosophy of hip muscle ratio balance being important versus peak strength has been echoed by O'Connor [15] who commented on an over focus on gluteals at the expense of the adductors, allows the ratio to become poor. He goes on to mention that the Hip flexors should be incorporated into this and that the focus should be on total hip strength. Furthermore, he found that flexibility in the hip and groin was not related to injury.

Recurrent Adductor Muscle Strain

They are a lot more common than would be desired. They can be due to inefficient rehabilitation in the first instance, resuming sport to quickly, not resolving associated problems, such as lumbar spine/altered biomechanics.

Orchard el al. [10] suggest that there should be a restoration of strength to approximately 90 % of the non affected side on isokinetic testing, and a restoration of range/flexibility comparable to the other side, and that there should be full functional field testing before the athlete is allowed to return to their sport.

Despite this many athletes can pass the "test" before they have reached full recovery, and in terms of hamstring injuries abnormalities on MRI have been shown to persist for up to 6 weeks post return to full play in the AFL [10].

In running sports there is a need to asses running style Adductors play a major role in dampening the contraction of Gluteals in the propulsion phase of running (Tidow and Wiemann), and work synergistically with the hip abductors to maintain the stability of the pelvis during the stance phase. Pelvic stability is required to prevent excessive eccentric load on the adductors.

Pubic Joint Injury

Persistent adductor related groin pain may involve a whole host of pathologies/clinical entities [5], and can incorporate Adductor tendonopathy; adductor enthesopathy; pubic bone stress reaction, pubic disc degeneration; pubic symphysitis, pubic instability; "osteitis pubis"; Pubalgia. While Holmich has called for this to all be termed "adductor-related groin pain", Mens [23] has gone further to describe it a "adduction-related". This simple distinguishing statement, goes a long way to highlight the difference between an anatomical description versus a function description. This subtle differentiation is echoed by Orchard et al. [10] who state that "whilst all muscles have anatomical individuality, they do not have functional individuality".

The extensive nature of the differential diagnosis, with the potential for multiple co-existing pathologies can mean that a persistent injury to this region is frustrating for the athlete and clinician.

The literature has attempted to define persistent groin pain by looking at regional descriptions for the symptoms, and thus we have a number of different terms to describe groin pain. It may be that so far we have been unable to clearly differentiate and include them in the diagnostic tree, a pubic joint injury, and what we have attempted to describe in the past have just been subsets of a pubic joint injury/overload.

A pubic joint injury occurs with an overuse injury of the pubic Symphysis, leading to a bone stress reaction, which in turn leads to joint and disc degeneration. Initially there may or may not have been an acute injury to the adductor muscle group, with or without an inflammatory response. The athlete usually presents with a gradual insidious onset of pubic groin pain and weakness, pain can be felt in the adductors, anterior thigh, lower abdomen, perineal and testicular regions. Symptoms can be vague, can move from proximal to distal or left to right, and can be bilateral. Pain is usually worse with exercise such as twisting/turning/kicking, they can also get pain with abdominal contractions, coughing, at night rolling over in bed and on standing up, all of which have overlap with abdominal and hip joint related symptoms. It does not have to manifest as pain, but rather a feeling of weakness or vulnerability, and an inability to generate force, they may report a loss of kicking length or top-end running speed with a decrease in performance, rather than missed games. NSAIDs, decrease symptoms, but do not give permanent relief. Short periods of rest reduce the severity of the symptoms but on resumption of normal sporting activity the pain often returns to its original intensity and severity. Natural history of the condition is of one of progressive deterioration with continued activity until such time as the symptoms prevent participation.

Most at risk are young men, aged 16–30 years of age, it is rare in women and children or older men. It is rationalised that this may be due to the anatomy of the recto-gracilis ligament which is much more patent, wider and thicker in the female pelvis [18]. The highest incidence occurs in sports that involve agility and kicking [4] and in the AFL is reported as the second worst injury in terms of missed games. There is an association with a sudden increase in load beyond the regular training volume of the individual.

Other risk factors include: lumbar spine and SIJ dysfunction; increase in rectus abdominis tone; shortened iliopsoas muscle; increased adductor tone; reduced lumbo-pelvic stability; and probably the highest correlation is with limited hip internal rotation (general ROM) [24].

This condition has been previously called "Osteitis Pubis", first described by Beer in 1924 [25], but is now regarded as a poor descriptive term as it suggests "inflammation of the pubic bone". This confusion over the nomenclature was largely settled with a study conducted by Verrall et al. [26] who conducted a biopsy of ten footballers with chronic groin pain undergoing surgery. They found there were no inflammatory markers present, and concluded that the term "Osteitis pubis" is inaccurate. Instead they found the formation of new woven bone, and the increased signal seen on MRI suggests a bone stress response.

Despite this, the radiological consequence of bone marrow oedema in sport is not pathognomonic, it is argued that it represents load and nothing more and is just part of the mechanotransduction adaption of the Osteocytes in the bone in response to increased activity.

In an attempt to answer this question Lovell (2006) studied MRI for bone marrow oedema (BMO) and its relationship to training and symptoms in 19 elite junior soccer

players. They demonstrated that 11 of the 18 (61 %) asymptomatic players showed moderate to severe BMO on MRI. There was a poor correlation between BMO and the development of pain. They concluded that progressing the load slowly in athletes with a low training load is a useful strategy for preventing pain and symptoms in junior soccer players. However, it does raise a further question, "is the increased signal/presence of BMO a pre-cursor to the development of groin pain?" They are completing the follow up on these players now to see whether those with high signals developed persistent groin pain later in their career.

So why is there a greater incidence of pubic joint injury reported now than there was 20–30 years ago? Firstly the advent of MRI imaging means that our investigations are clinically more sensitive and able to pick up and define pathology where previously it was left to a clinical impression. But we also need to look at more generic factors, there is an increase in volume of sport at a younger age, the sports are faster and yet paradoxically, it has been reported that there is an increase in weight but reduced fitness of junior football players (AFL). A sports epidemiologist noted that the difference in activity between 1970 and 2000 in kids aged 10–14 is dramatic. There has been a big decline in overall activity levels due mainly to TV/computers and less physical education and 'play'. Also single parent kids do not play as much sport and smaller families mean less play (these days if you don't have a brother you don't play much sport). He suggested that today's kids would need to do a 10km walk a day to catch up to the general activity levels of the late 1960s!

On examination there is exquisite tenderness over the pubic bone, especially over the inferior pubic rami, but also the superior pubic rami and along the pubic joint line. Adductor muscle guarding may be present as demonstrated with a reduced "fall out test". There is likely to be pain and or a loss of power on squeeze testing, these tests should be conducted with the feet close together/touching, and one of the examiners fists between the knees, or ideally using a pressure cuff (measuring up to 300 mmHg). This can be tested in three different positions, 0, 60 and 90° of hip flexion. Finally, looking for a positive Pubic Symphysis Stress Test (PSST), this involves placing the patient in a modified Thomas's test position over the end of the plinth. And sequentially placing them in the following four positions:

1. Passive hip extension to EOR, looking for passive load transfer in the sagittal plane, this is testing the tensile integrity of the pubic joint and the peri-articular structures thus testing the form closure about the pubic joint.
2. Passive abduction while maintaining full extension, looking for passive load transfer in the coronal plane, which means that the superior aspect of the joint is being compressed while the inferior aspect is being gapped, again testing the form closure and pressure sensitivity of the joint.
3. Returning to the first position and resisting hip flexion, with a static isometric contraction, this has the added value of increasing the torsional stress about the joint in the sagittal plane, and testing the form closure about the joint.
4. Finally returning to position 2, and performing a resisted static contraction of into adduction, this will increase the compressive element on the superior joint while increasing the torsional strain on the inferior joint. Again testing the force closure about the pubic joint at higher loads.

A positive test is reproduction of pain or any change in tone/tightness on the flexed limb (the opposite limb being tested), if the latter is present that is know as a cross-over sign and is a clinical indicator to stop running.

Further tests to be conducted include:

Adductor squeeze in bilateral SLR:

This is a high load test that incorporate, an isometric contraction of the abdominals, hip flexors and adductors in 30° hip flexion. This will provide maximal compression to the pubic joint, and is primarily a provocation rest, however, in later stage rehab can be used as a clinical outcome measure for return to running and return to sport.

Short and long lever adductor loading.

Two consecutive tests, where the hip is taken into FABERs position and then end of range abduction. In both positions, the examiner monitors, any change in tone in the adductors (primarily longus) as a sign of guarding, and thus any subsequent loss of range. Finally when the end of the available range has been reached the subject is asked to contract maximally, and it is ascertained whether the contraction can be over-powered, if so it would imply that there is a dysfunction within the musculo-tendinous complex or an inhibitory mechanism from the joint itself.

Treatment and Management of Pubic Joint Injury and Their Subsets

The focus should be a gradual progression of training load based on the athletes ability and training history [12, 16]. Any previous groin pain should be respected as it may have altered the normal pelvic mechanics, and the therapist should attempt to maximise the range of motion in the hips, especially internal and external rotation [13].

Management should continue along previously advocated sound principles like; a balance between the local and global muscular systems, correct timing and muscle stiffness appropriate for the task, functional re-education of movement patterns, special emphasis should be placed upon adductor length and the use of a slide board to restore the anterior/posterior chain balance.

Remember that load has to be progressed without pain as pubic pain can increase adductor tone.

Pubic Joint Injury Rehabilitation

The principles of this approach has been modified from Anthony Hogan.

Unload [26] – it is essential to "buy time" from the athlete to allow the pathology to heal on a cellular level. Bone stress in any other area of the body (e.g. Navicular) would be treated with the upmost respect and caution and allow 8–12 weeks to settle, a similar approach needs to be adopted for a pubic joint injury where there is a component of a bone stress injury. Once you are happy that the clinical signs have settled (self assessment of squeeze test and BKFO) then loading can commence. We are guided when to load by the clinical markers and not by time frames. That said when you start to load you must establish warning signs and educate the athlete to report any change early rather than persisting with the program. Initially, loading without pain is desirable, certainly in response to any acute joint injury. However, with more persistent adductor related groin pain, you may allow a level of discomfort to be experienced during the loading phases. This will need to be monitored closely clinically, if there is any persistent pain post loading, and increase in muscular stiffness or soreness the next morning and any inhibition of activities of daily living these are warning signs that the loading phase is too advanced for the state of the healing of the tissues.

The use of compression shorts (largely proprioceptive and heat) can be invaluable, there is also certainly evidence to suggest that the use of a Sacro-iliac belt may help to return pelvic biomechanics to their homeostatic state. As Mens [23] demonstrated that the use of the belt could not only change groin pain but also improve muscle functional synergy and power output on a PSST, and squeeze test.

Mens et al. [23] took athletes with pain in the groin(s), provoked by playing sports, with duration of complaints for at least 1 month and pain provocation on isometric adduction of the hips. They found that groin pain was bilateral in 41 %; pain was also located at the posterior aspect of the pelvis in 32 %. They concluded that adduction-related groin pain with a positive belt test may be treated by stabilisation of the pelvis, and is not necessarily related to adductor tendon pathology.

Manual therapy – the role of manual therapy can take many different forms, from manipulation, mobilisations, soft-tissue release, myofascial release and trigger point therapy, to neural mobility and dry needling/intra-muscular stimulation. They all work on various mechanisms from mechanical stimulus, neurophysiological mechanisms, peripheral mechanisms, spinal mechanisms and supra-spinal mechanisms [27]. In essence the goal of the clinician is to restore normal pelvic mechanics both in terms of arthrokinematics and myokinematics, so that there is an optimum homeostatic state as possible to commence and optimise the rehabilitation. As without restoration of muscle function and effective energy transfer/force production across the pelvis the chance that the athlete may break down again remains high.

Local strength – Holmich conducted the only RCT on persistent adductor related groin pain [28] where he took 68 subjects and split them evenly between two groups, an active training group and a Physiotherapy group. They both underwent a treatment period of 12 weeks, and at the end of this period he was able to show that the active training program was more effective than a conventional physiotherapy program. However the conventional physiotherapy program consisted of Laser, TENS, frictions and stretches, while the active group did ball squeezes, trunk exercises and slide board, work. At this time it would be common place that exercises focusing on local strength would be a significant part of any Physiotherapy program. The take home message from this paper is that it is important for any Physiotherapist that the specific local strength should be the primary part of any program administered to any patient and other aspects such as manual therapy should be there to compliment the exercise goals.

Thorborg et al. [29] Tested isometric hip adduction and abduction strength in elite soccer players and matched controls: a cross sectional study. Conclusion: Eccentric hip adduction strength was greater in the dominant leg than in the non-dominant leg in soccer players, but not in matched controls. Eccentric hip abduction strength was greater in soccer players than matched controls, but soccer does not seem to induce a similar eccentric strength adaptation in the hip adductors.

Therefore eccentric hip adduction and abduction strength plays an important role in treatment and prevention of groin injuries in soccer players. Lower extremity strength deficits of less than 10 % on the injured side, compared to the uninjured side, are often considered the clinical milestone before returning an athlete to sports following injury and rehabilitation.

Furthermore a side-to-side eccentric hip adduction strength symmetry cannot be assumed in soccer players, since eccentric hip adduction is greater on the dominant side. Knowledge of a side-to-side eccentric hip adduction strength difference is relevant, when using the non-injured side as control in the strength assessment of injured soccer players.

Functional Strength

The guidelines given by Holmich are further enhanced when combined with the paper by Wollin [30] where he looked at return to play guidelines in 4 case studies of academy footballers. While the evidence is not as strong as that of Holmich, empirically, there is increased value clinically when you combine the guidelines of the two papers.

Wollin [30] was able to show that when the targets for a large ROM eccentric to concentric adductor loading exercise (3 sets of 12 reps with 6 KG) and a slide board

skating drill (3–5 sets at 3 m for 1 min) was completed, these clinical and non-functional tests equated to a return to short sprinting performance that was comparable to the rest of the team who had not sustained an pubic joint injury (Osteitis pubis).

There is also some limited anatomical evidence that Adductor Magnus has some fibres that attach to the posterior and inferior aspects of the pubic Symphysis and thus may have a role in improving force closure around the joint. Restoration of Adductor Magnus function, cross-section area and density through single leg activity in greater than 45° hip flexion (Magnus is the strongest hip extensor in hip flexion) will help to improve the force capacity across the joint and thus load transfer.

Bone modelling, this may be a little beyond the scope of this chapter, however, it deserves a mention. When implementing a rehabilitation program for a pubic joint injury the therapist has to take into consideration the fact that a subset of the pubic joint injury maybe a pubic bone stress injury. Therefore adapting the loading parameters to account for bony remodelling and cellular communication is poignant.

Bone remodels through mechanotransduction, this is a normal cellular process, where a load is applied externally to the bone producing a mechanical stimulus, there is fluid flow in the canaliculi which is picked up by the osteocytes through mechanorecpetors, which in turn will promote the turn over in cells between the osteoclasts and osteoblasts [31].

In a series of studies carried out to identify bone response to loading Rubin et al. [32] showed that Strain rate is more important than strain amplitude which implies bone formation is enhanced by dynamic loading thus magnitude and frequency of loading are important parameters for bone formation.

Rubin et al. [32] showed that low magnitude and high frequency, which are common in activities of daily living.

Fritton et al. [33] showed that high impact physical activity including jumps in unusual directions have a great osteogenic potential.

Bone formation is stimulated by dynamic vs. static loading, therefore low magnitude high frequency may be as stimulating as high amplitude low frequency [34].

Burr et al. [35] demonstrated that shorter and frequent bouts of exercise enhance bone mass – Bone accommodates quickly to mechanical loading. Great improvements in bone mass have been demonstrated by splitting exercise bouts into shorter and more frequent sessions. Dividing 360 cycles into shorter bouts with recovery period (3 hours) significantly increases the rate of bone formation.

Bone strain distribution – Bone is sensitive to the applied strain distribution. Applying the same load at different location stimulates new bone formation. Running has been described as osteogenic "sub-optimal" due to it's even strain distribution. Unusual bone strain patterns are good for improving bone quality via alterations in trabecular microstructure [36].

Skill Integration

Establishing a strength balance, applying the principles outlined from a total hip strength [15] and abductor to adductor ratio [22]. Looking at specific local strength in both a functional a non-functional manner, and applying the principles of loading appropriate for the tissues involved (bone, enthesis, tendon, muscle) will allow for effective adaption of the pathology and injured tissue to provide a good stable background where the athlete can move forward and incorporate specific skill acquisition.

The application of these specific skills need to be implemented from the therapist and designed appropriately for the sport and the individual's movement patterns.

Holmich et al. [28] 18 % of male soccer players reporting adductor-related pain every year, therefore Holmich and colleagues conducted a randomised clinical trial. The program consisted of static and dynamic exercises that were aimed at improving the muscles stabilizing the pelvis and the hip joints, in particular the adductor muscles.

In the active training group, 24 patients (79%) successfully returned to sports activity. The time to return to previous levels of activity ranged from 13 to 26 weeks (median: 18.5 weeks). Only four of the patients in the physical therapy group successfully returned to active sports participation. This difference, as well as improvement in adduction strength, showed the significant benefit derived from active training, compared with physical therapy. With regard to other outcome measures, trends in favour of active training did not reach statistical significance. In the subjective assessment, significantly more patients in the active training group than in the physical therapy group rated their condition as much better.

The authors conclude that the active training program was highly effective in returning athletes with longstanding adductor pain to full sports participation. A program aimed at improving muscle strength and coordination is more effective than the traditional physical therapy program and receives higher subjective ratings from patients.

Mens et al. [23] took athletes with pain in the groin(s), provoked by playing sports, with duration of complaints for at least 1 month and pain provocation on isometric adduction of the hips. They found that groin pain was bilateral in 41 %; pain was also located at the posterior aspect of the pelvis in 32 %. They concluded that adduction-related groin pain with a positive belt test may be treated by stabilisation of the pelvis, and is not necessarily related to adductor tendon pathology.

Monitoring Progress

When progressing the rehab, the therapist should be able to constantly monitor changes in pelvic function, the guidelines recommended would be:

- To establish one, or a series of baseline tests and a normative score, or target score for that individual
- Measure first thing in the am.
- Measure as soon as at the training park or just before training
- Measure post training
- Measure post treatment

The key guidelines to monitoring the progress of the rehab are to establish some parameters for self monitoring and baseline scores for the individual either pre injury or post injury.

Guidelines that have been used are:

- No pain or increase in stiffness the morning after.
- No change in squeeze scores when self monitoring with one fist between the knees, or when using a sphygmomanometer,
- Baseline measures should be established with a squeeze score, (0, 60, 90°) with a pubic Symphysis stress test and with a bent knee fall out.
- Guidelines during loading should be, in the acute phase or with a reactive component, no loading into pain. In the more persistent phase, some loading into discomfort may be acceptable, then we would allow loading into discomfort that measures a 3–4/10 (0 = no pain and 10 is pain taking you to the emergency room) and no higher. Provided that discomfort does not persist post loading, or has any influence on the ability to perform the individuals activities of daily living.
- Ideally the baseline scores should be measured, first thing in the am/as the athlete arrives at the training ground.
- If the initial score is poor, treatment should be administered to restore normal pelvic mechanics. Following treatment if there is an improvement in the score then a loading phase should be administered.
- Following the loading the baseline scores should be reassessed. If there is a significant deterioration then it may be an indication that the loading phase was greater than the capacity of the groin. This serves as a tool for potentially adjusting the next training session.
- First treatment to the pelvic region should be administered, as the primary hypothesis would be that the loss of function would be due to a change in the pelvic mechanics. If there is a quick return to normal baseline off minimal therapeutic intervention then training should continue along the prescribed guidelines, however, if there is not a full restoration after treatment then the next training session should be potentially adapted, depending on the response the next morning.

There are many potential roadblocks to progress with persistent groin pain, frustration at the speed of the progress can be a key parameter that needs management. To aid with this make sure that there is effective use/management of the following:

- Cross training – essential for maintenance of cardiovascular fitness, but do not allow for adaptation of essential muscles as they train
- Weights room – only upper body in the short term, but need a "gym monkey" as picking up and moving weights as if done by the patient can be detrimental for the groin.
- Early running – use of ladders and different drills that control stride length can be very useful.
- Use many small exercise progressions to keep the mind engaged, as the real value in the rehab is the consistency of loading, however, without variety the program becomes very monotonous, and this can lead to a lack of compliance, so being inventive with the progression and interactions of the exercises can make a big difference.
- Try to utilise clinical milestones where possible as this can serve to be a motivating tools, e.g. you cannot run until you can do X
- External pressure from management, family and agents amongst some needs to be monitored and managed accordingly.

The goal of any rehab program should also be to restore normal movement patterns, aim for thoughtless fearless movement.

Abdominal Related Groin Pain

Differential Diagnosis

The prevalence of such a lesion found on exploration in athletes with chronic groin pain is reported to be high. Smedberg et al. [37] showed an 84 % incidence of hernia in symptomatic groins and a 49 % incidence on the asymptomatic side in the athletic population.

Researchers suggest that these injuries occur because the adductor action during sporting activity creates shearing forces across the pubic symphysis that can stress the posterior inguinal wall.

Consequently repetitive stretching or a more sudden intense force can lead to their separation from the inguinal ligament.

Such an injury could develop as a result of repeated micro-trauma or overload, or after a single traumatic incident leading to failure of the musculotendinous unit. This may also account for the common finding of co-existing PJI and adductors tendonopathy or enthesopathy. Which came first, by this stage is often immaterial, but it is important to constantly re-evaluate for changes in the presentation that may reveal an underlying pathology (sports hernia).

The presence of a sportsman's groin can be difficult to detect on physical examination, even by an experienced practitioner. A high index of suspicion is required and the presence of a dilated internal ring, with or without tenderness, must be suspected as a cause of chronic groin pain in athletes.

Ekberg et al. [38] found that pain longer than 3 months had two or more separate pathologies.

Lovell [39] 27 % of all 189 had multiple pathologies, 26 % with sports hernia had a secondary diagnosis.

Orchard et al. [40] report that 80 % of those not treated successfully may have had an ongoing alternative pathology.

Much like adductor related groin pain there are many different pathologies that can be involved in the production of abdominal related groin pain from:

Sportsman's Groin

Sportsman's groin (and all its derivatives) can incorporate a number of different descriptions, which previously have been given individual clinical criteria. It is the authors contention that they are all part of a clinical continuum, and describe various stages of the disease process, but all make up the diagnosis of a Sportsman's groin. The varying terminologies used in the literature are as follows.

- Fascial strain/disruption – this predominantly occurs in the external oblique fascia and aponeurosis but can occur at the internal oblique and transversus as well, with repetitive movement into extension the elastic tissue can become elongated leading to microscopic tears in the fascial plane at the transition area for the inguinal canal. If the athlete returns to training/match play before the soft tissue has had a chance to fully heal then there may be re-tearing of the same weak scar tissue or adjacent tissue. Conversely if the tissue is allowed to over scar or there is a reaction within the fibroblasts within the fascial tissue, it may lead to over scarring and adherence. Because of the nature of the peripheral sensory nerves within the fascia this can lead to neural entrapment [41].
- Compartment pressure – this occurs due to a lack of compliance and sliding of the abdominal fascial tissue, due to scarring, and up regulation of fibroblasts to myofibroblasts which occurs in response to cytokines increasing contractile component and reducing the dynamic sliding of the elastic layers resulting in potential compartment style pressure [42].
- Gilmore's groin/Conjoint tendon injury/Posterior Abdominal wall disruption (PAWD) – A large majority of the awareness of lower abdominal pathology should be attributed to Gerry Gilmore [43], who describes a definitive injury whereby there are a number of structural problems, which often co-exist: A tear in the external oblique aponeurosis (as described earlier); tear in the conjoint tendon (posterior wall of the inguinal canal); Dehiscence (separation) between conjoined tendon and inguinal ligament; Thinning/disruption of the posterior abdominal wall (transversalis fascia); but there is no hernia present.
- Nerve entrapment/irritation – Akita et al. [44] described the production of chronic groin pain through the entrapment of the Boarder nerves (Ilioinguinal, iliohypogastric, Genito-femoral). Anatomically all the nerves can pierce the inguinal ligament and External oblique aponeurosis, through this they can undergo repetitive mechanical tractioning and irritation, potentially causing ischaemia and disrupting the myelin around the nerve, leading to an entrapment neuropathy and potential neuropathic changes in the tissues, such as trophedema, hyper-algesia, and collagen degradation [45].
- Inguinal ligament neuralgia – described by David Lloyd et al. [46], where he notes an Acute/chronic injury of inguinal ligament at pubic tubercle, and describes the appearance of a tatty scarred inguinal ligament at the insertion into pubic tubercle with holes & ruptures
- Incipient hernia – This is a hernia that is beginning to happen/develop but has not developed yet, and is akin to thinning of the abdominal wall tissue.
- Occult hernia – When you suspect a hernia based on the symptoms but you can not clearly see it on examination.

Malycha and Lovell [7] describe an incipient direct inguinal hernia with an associated bulge in the posterior inguinal wall extending anteriorly in 80 % of cases in their series of 50 athletes.

Hackney [47] found a weakening of the transversalis fascia with separation from the conjoint tendon in all of his 16 cases.

Simonet et al. [48] found tears in the internal oblique muscle in the ten elite ice hockey players

Brown [41] a small tear of EO aponeurosis at the site of emergence of the terminal branches of the anterior primary rami of the Iliohypogastric nerve.

Lovell [39] reported when looking at 186 male athletes who had complained of groin pain lasting longer than 8 weeks found that 50 % of them had a sports hernia.

Polglase et al. [49] reported on 64 athletes, showing anatomical defects of the inguinal canal in all. Most of these patients were AFL players. Operative findings included a deranged posterior wall of the inguinal canal in 85 %, splitting of the conjoint tendon in 26 % and previously occult indirect inguinal hernias in 8 %

The true definition of a Sportsman's groin remains unclear. To make things clearer the author would present that a definition for Sportsman's groin that encompasses all of the clinical entities described above should be:

> "Pain or a lesion superior and / or lateral to the superior pubic tubercle as a result of a laxity, thinning or deficit in the lower abdominal region with or without bulging of the posterior abdominal wall, where there is no true hernia present"

In order to fully understand the true nature of a Sportsman's groin, it is pertinent to have a quick refresher of the functional anatomy of the inguinal canal and lower abdominal region.

Anatomically the inguinal canal is a gap through the abdominal wall passing posterior to anterior and lateral to medial passing over and incorporating the inguinal ligament, it is made up of:

Roof – Internal Oblique & transversus abdominus

Floor – inguinal ligament & lacunar ligament

Anterior wall – external oblique aponeurosis & internal oblique aponeurosis

Posterior wall – transversalis fascia & conjoint tendon

The muscles fibres of the transversus and internal oblique arise from the inguinal ligament and insert into the pubic crest and along the pectineal line. These muscles are said to unite into a common tendinous insertion called the conjoint tendon.

It is at this point that the defect occurs possibly due to a tear posteriorly, where it inserts into the pubic crest and more laterally into the pectineal line, resulting in a weak posterior wall and subsequent bulging [39].

As mentioned above the defect in the posterior wall is generally thought to be in the vicinity of the conjoint tendon. So is this area particularly prone towards injury because it is a transition zone for changes in collagen and tissue type. And that it becomes the pivot point for a multitude of forces.

Functionally it is a cavity with four different elastic layers lying on top of each other that all have to interact and slide on one another to effectively produce and transfer force. They have to take the force produced from the hip and transfer it to the pelvis which in turn transfers it to the trunk, and at the same time, control the load and reciprocal movement of the upper limbs. As you can see from the anatomical structure it is primarily made up of non-contractile tissue, and thus will be very well placed to absorb and transfer elastic energy. In that fact lies the potential problem and underlying mechanism for injury, as the area has to take the high forces of mechanical energy produced by the hip and transfer it to elastic energy for force transference around the body, while still maintaining patency of the canal.

Mechanisms

Aetiology? – there are three main mechanisms:

Karlin [50] reports there is often a violent external rotation of the thigh while the leg is abducted and the foot planted

Shearing at the inguinal region – grappling or wresting in a tackle

Repetitive micro-trauma – through repeat kicking and end of range hip extension

Raised intra-abdominal pressure – holding your breath while lifting heavy weights or exerting a force.

All three can occur simultaneously, best described by Dr John Finley, physician in chief to the Detroit Red Wings for 42 years, has proposed a theory (personal communication Brown [41]) he felt that in the modern era of professional and amateur hockey, when the incidence of injury increased, the players played many more games. on land training has become more rigorous. when a player accelerates, changes direction or shoots, he pushes down by closing his glottis and therefore increases IAP pushing outward. To contain the pressure and protect the abdominal viscera from coming out, the EO, IO and TA, contract to protect the integrity of the groin. in addition if a rotation movement is undertaken, it is initiated by these muscles. At the time of repair, they have noted well developed bulky internal oblique muscle in all of their patients.

The limited space of the inguinal region disappears and more and more outward pressure is applied to the EO aponeurosis envelope. At a critical point, the pressure is so much that a tear occurs in the fascia with the fulcrum being the scarred ilioinguinal nerve or its branches – placing the nerve under tension, with each incident the tear increases in size and is associated with further scarring.

It is the authors opinion that the reality of these individual pathologies is that they may all just be part of a continuum of the disease process. Where fascial disruption, can lead to compartment pressure and nerve entrapment, or at least nerve injury and overload, degrading the tissues with neurogenic mediators (Substance P & CGRP) resulting in posterior abdominal wall damage and with continued stress overload of the inguinal ligament and thus the tatty tethered appeared described by Lloyd. This disease process can take a number of years, and so when the patient presents at any one moment in time, it is understandable that they can be attributed with a number of different entities, making it confusing for the clinician and the patient. When in fact there is one injury but it is observed and presents at different stages of the injury process.

The question immediately arises, what is a normal anatomical structure for these athletes, if you were to explore asymptomatic athlete would you find the same level of derangement and "wear and tear"

History

Characteristic history of vague insidious onset of deep groin pain usually the pain is unilateral over the lower abdomen and may extend into the upper thigh, the dull ache may radiate to the scrotum, hip and back.

Complaint – A yard short; The second half/playing twice a week; Getting in & out of the car/rolling over in bed; Pain with cough or sneeze; Weight transfer after activity.

Onset & periodicity – Shortening onset (comes on sooner); lengthy recovery (last longer) with increasing severity.

Aggravated factors can be; coughing, sneezing, but not always related to intra-abdominal pressure. Aggravating movements include sit ups, kicking, sprinting (ipsilateral hip extension and contralateral torso rotation) or even getting up out of a chair

Initially it can be relieved by rest, but will recur with exertion even after prolonged periods of rest, medication or physiotherapy

In hockey players pain is felt during the propulsion phase of skating (first few strides) and during the slap shot motion and is consistently located on the opposite side to the player's forehand shot [51]. In football codes, they may report that they can't drive off to run/ping a ball. this is in contrast to PJI where they can accelerate but cannot hit top end speed, and find they cannot kick the ball as far.

There is usually associated adductor muscle spasm/guarding.

Physical Examination

Pain may be reproduced with resisted adduction, but this may be due to co-existing adductor pathology, and as a sign is not consistent.

A defect (if any) is not necessarily palpable unless the athlete has recently undertaken activities which provoke the symptoms

Localised tenderness above the pubic crest over the conjoint tendon, pubic tubercle, mid-inguinal region is common and may be exacerbated by resisted sit ups.

A small cough impulse may be detected by an experienced practitioner but is not diagnostic.

Contributing factors – weak adductors, weak hip muscles, reduced hip range – flexible, posture, imaging of pelvis – structure

Assessing the external ring – not something to do if you are not experienced, it should require a certain amount of patient mileage to be able to clearly differentiate between a dilated ring that is truly pain producing and not just sensitive as it is being palpated.

It has been reported that palpating a dilatation of the superficial inguinal ring by inverting the scrotal sack and following the spermatic cord "Like placing a finger into a button hole" that reproduces the athlete's pain is a positive indicator [43]. This can also be found on the asymptomatic side (Orchard et al. 1998) the defect may be bilateral in as many as 48 % [52].

Of all these clinical signs there is a massive overlap with other pathologies, the consistency of the findings are irregular, and of those mentioned above, especially the presence of a dilated ring or pain reproduction on palpation, what is sensitivity and specificity of these findings? What would be the occurrence in the normal population?

These questions aligned with the evidence that anatomists have found that greater than 25 % of the adult population who do not complain of pain have a (congenital?) posterior wall bulge [40].

The process with the Physical examination should be to try and establish a direct marriage between tenderness on palpation; weakness; and provocation on testing. E.g. a fascial strain may be tender on palpation and painful on provocation, but not elicit any weakness when loaded. Versus a true internal oblique tear and dehiscence (Gilmore's groin) which will be tender, provocative and weak. The bonus comes with the other indirect and contributing factors, that increase the index of suspicion that there may be abdominal wall injury.

Imaging

Imaging is vital to aid in the effective differential diagnosis. But it should always be guided by the Physical examination, as imaging may not be sensitive enough to pick up all aspects of the pathological process. Certainly X-ray and herniography add little to a good physical examination. The modalities of choice would be MRI and US Doppler.

MRI can reliably see: Inguinal ligament & normal anatomy – Gross scar tissue; gaps; defects & disruptions, can not see subtle changes; scar tissue, or fluid collection [53].

US – (Brown [41]) Should have a specific protocol – Scanning of the adductors, especially the origins off the pubic bone. Scanning of the lower abdominal wall, esp. the RA, Obliques, and Inguinal ligament. Dynamic evaluation for hernias and fascial injuries. Power Doppler examination for areas of active inflammation. Positive findings Anechoic areas within soft tissue representing fluid within tears; Hyper echoic areas within soft tissue fascia representing scar; Areas of fascial dehiscence or tears are demonstrated during dynamic maneuvers (e.g. sit up) Areas of active inflammation are shown by Power Doppler interrogation.

Management/Treatment

In the literature the definitive treatment for a sportsman's hernia is surgery. Within the surgical ranks there are various procedures that can be carried out. Essentially they all involve reinforcement of the posterior wall, either through open repair or via laparoscopic exploration. The majority of

the evidence supports the use of surgery following failed conservative treatment.

Sportsman's groin – the primary treatment of choice has been a definitive repair. The godfather of hernia repair was Edwardo Bassini, since then there has been various other adaptations of the 1884 Bassini repair, which have been used for a Sportsman's groin, these are: Marcy Modification, Andrews modification, Maloney Darn modification. The other alternatives are the Shouldice or Lichtenstein repair. It is a modified version of this that Gimore uses to repair his groins.

Gilmore

20 min op, cut along the inguinal fold, occlude veins, locate and tag the inguinal nerve, and flip inferiorly, locate and tag spermatic cord.

Identify the PAW – less white, reinforce with stitches, take conjoint tendon from above and fold down to reinforce, two layers of stitches bottom layer dissolvable, top layer permanent. all takes place posterior to abdominal wall.

Muschaweck

Muschaweck [54] minimal repair – Opening of the posterior inguinal wall only at the area of the defect (intact structures remain intact), Suture line over the pubic bone (tension of the Rectus muscle is reduced), Conservation of sliding mobility of the abdominal wall.

Elastic doubling & fascial separation +/– neurectomy, Relief of rectus abdominus off the pubic bone – special suture repair.

Lloyd

Utilizes a laparoscopic repair via a posterior approach to address the inguinal ligament. The laparoscopic approach also offers unparalleled views of the pubis, internal rings, transversalis fascia, aponeurotic arch, cooper's ligaments, and musculotendinous insertions into the pubis. Laparoscopic division of inguinal ligament and scar tissue, removes sutures from previous surgery. This exposure allows mesh reinforcement of the entire myopectineal orifice, potentially providing structural reinforcement of this region. Lloyd reports treating 250 sportsman's hernias over a 10 year period with only one failure, with 60 % playing sport at 2 weeks and 80 % at 3 weeks [46]

This represents a paradigm shift in thought about the underlying pathophysiology, were by all previous attempts at repair focused on re-enforcing the conjoint tendon and inguinal ligament, whereas this approach focuses on releasing the inguinal ligament, but then reinforcing the posterior abdominal wall with mesh.

While repair of the hernia appears to result in the resolution of symptoms, it is theoretically possible that this reinforcement contributes to the structural integrity of the groin in those athletes who have an associated musculoskeletal problem. Or at the very least changes the force distribution through the pelvis and enforces a prolonged period of inactivity and rehabilitation, were previous adherence to conservative management may have been poor.

Rehabilitation of all types of surgery is particular to the surgeon, and dependent on the extent of the anatomical derangement and re-enforcement required. But generally they recommend:

Avoid sudden sharp movements

Isometric 1st day after surgery

Progress to concentric then eccentric exercises

Walking in the 1st week, jogging at 10 days, straight line sprinting from 21 days, then sports specific conditioning.

Those who have operated on ice-hockey players recommend that they avoid skating for 4 weeks and then a gradual return to activity over 6–8 weeks.

Longer term there needs to be a balance of the slings in terms of flexibility, strength and stability, anterior vs. posterior chains, proximal vs. distal musculature.

When faced with a Sportsman's groin, if a surgical intervention is not desired at that moment in time, then a conservative approach can be adopted by applying the laws of physics to tissue adaptation.

Young's modulus – a measure of elasticity – equal to the ratio of the stress acting on a substance to the strain produced.

Hooke's law – a law stating that the strain in a solid is proportional to the applied stress within the elastic limit of that solid

Wolff's/Davis's law – biological systems quality and orientation of connective tissue adapts to mechanical stress to best resist extrinsic forces – "dynamic flexure"

To be effective a rehabilitation program should be able to account for and address all the potential mechanism as to why the injury occurred in the first place.

Wang [55] has described how tissues adapt to loading, where the (ECM)extra-cellular matrix is stimulated by mechanical forces, which simultaneously stimulates the humoral factors (Cytokines) which in turn stimulate the ECM and become more susceptible to mechanical forces. Khan and Scott [56] describes the process at Mechanotransduction. The physiological process where cells sense and respond to mechanical loads.

Mechanotherapy

The prescription of exercise to promote tissue healing which relates to tendon, muscle, fascia, cartilage and bone.

Regain force coupling anterior and posterior slings; movement correction & MT – pelvic symmetry; regain sliding of facial layers; regain neural mobility; Use injections & pharmacotherapy for pain Mx; set an appropriate time frame then re-evaluate; load the abdominals – multi-direction and daily; maintain pre-existing fitness – regain CV status

Principles of loading; identify the plane of movement weakness; movement specific (not muscle specific); initiate

with isometric load in inner range (6 s reps); progress to outer range with eccentric control; add in inertial torque into extension from limbs

Provide a rotation challenge/perturbation; Aim for time under tension and sustained load (>2–4 min); Goal is "strain hardening" and de-sensitization. Increase stress rate – 6 s maximal isometric contraction. planks and manual resisted sit ups; progress by increasing load (wt vs. lever arm) maintain position. Roll outs

The progress time e.g. build to 30 s (sub max). Planks with perturbation/limb movement; Increase the strain rate – time under tension (>2–4 min); Circuits looking at combination of movements in multiple planes, with either high stress (load) or high strain rate (time and tension) e.g. eight exercises each 30 s; Progress to dynamic challenges rotation control; fast perturbations; long lever loads; reactive & rebound activity.

Rehab should include: Establish benchmark; Early loading for tissue regulation and pain; reduction; Progress to dynamic loading – Stress/strain/elastic; Integrate dynamic loading – speed; Balance the hip & pelvis; Progression based on obj functional & clinical markers

Time frame to consider surgery; Total Hip strength; Adductor specific loading – clinical milestones;

Summary

The diagnostic challenge with abdominal groin pain is that more often than not the diagnosis is via exclusion and not inclusion. The clinician needs to establish a marriage between the History, the investigations and the physical examination. A simple algorithm that can help is:

Rule out the Hip joint as a source of pain, diagnose/rule out the adductor related groin pain component to the pathological process. Ask the questions – is there a true hernia? Is there a rectus abdominus tendonopathy? Is there a true iliopsoas related groin pain (if so what is the relevance)? Only if the answer to all of the above is NO, or they cannot explain the abdominal related groin pain, do you suspect a Sportsman's groin and put into action a management plan accordingly.

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