

Sports Hernias: A Systematic Literature Review

Paul H Caudill, John A Nyland, Chad E Smith, Jonathan G Yerasimides and John Lach

Br. J. Sports Med. published online 4 Jul 2008; doi:10.1136/bjsm.2008.047373

Updated information and services can be found at: http://bjsm.bmj.com/cgi/content/abstract/bjsm.2008.047373v2

These include:

Rapid responses	You can respond to this article at: http://bjsm.bmj.com/cgi/eletter-submit/bjsm.2008.047373v2				
Email alerting service	Receive free email alerts when new articles cite this article - sign up in the box at the top right corner of the article				

Notes

Online First contains unedited articles in manuscript form that have been peer reviewed and accepted for publication but have not yet appeared in the paper journal (edited, typeset versions may be posted when available prior to final publication). Online First articles are citable and establish publication priority; they are indexed by PubMed from initial publication. Citations to Online First articles must include the digital object identifier (DOIs) and date of initial publication.

To order reprints of this article go to: http://journals.bmj.com/cgi/reprintform

To subscribe to *British Journal of Sports Medicine* go to: http://journals.bmj.com/subscriptions/

Downloaded from bjsm.bmj.com on 7 October 2008 BJSM Online First, published on July 4, 2008 as 10.1136/bjsm.2008.047373

Sports Hernias: A Systematic Literature Review

Paul Caudill, MS¹

John Nyland, DPT, SCS, EdD, ATC, FACSM¹

Chad Smith, MD¹

Jonathan Yerasimides, MD¹

John Lach, MD^2

¹Division of Sports Medicine Department of Orthopaedic Surgery University of Louisville 210 East Gray St., Suite 1003 Louisville, KY, USA 40202;

²Norton Community Medical Associates 2355 Poplar Level Road, Suite 200 Louisville, KY, USA 40217

Address correspondence to Dr. John Nyland, Division of Sports Medicine Department of Orthopaedic Surgery, University of Louisville, 210 East Gray St., Suite 1003, Louisville, KY 40202; john.nyland@louisville.edu

Abstract

This review summarizes existing knowledge regarding sports hernia pathogenesis, differential diagnosis, conservative treatment, surgery, and post-surgical rehabilitation. Sports hernias occur more frequently in males during athletic activities that involve cutting, pivoting, kicking, and sharp turns such as those that occur during soccer, ice hockey, or football. Sports hernias generally present an insidious onset; however with focused questioning a specific inciting incident may be identified. The likely causative factor is posterior inguinal wall weakening from excessive or high repetition shear forces applied through the pelvic attachments of poorly balanced hip adductor and abdominal muscle activation. There is currently no consensus as to what specifically constitutes this diagnosis. Since it can be difficult to make a definitive diagnosis based on conventional physical examination, other modalities such as MRI and diagnostic ultrasound are often employed, primarily to rule out other conditions. Surgery appears to be more effective than conservative treatment and laparoscopic techniques generally enable a quicker recovery time than open repair. However, in addition to better descriptions of surgical anatomy and procedures, and conservative and post-surgical rehabilitation, well-designed research studies are needed with more detailed serial patient outcome measurements in addition to basing success solely on return to sports activity timing. Only with this information will we better understand sports hernia pathogenesis, verify superior surgical approaches, develop evidence-based screening and prevention strategies, and more effectively direct both conservative and post-surgical rehabilitation.

Introduction

Among professional sportsmen the estimated incidence of groin pain is 0.5% - 6.2% and it is more common among ice hockey and soccer players.¹⁻⁵ Among male soccer players the incidence of chronic groin pain is 10-18% per year.^{6,7} In sports such as soccer, ice and field hockey, tennis, and Australian Rules football groin injuries may represent 5-7% of all injuries.^{8,9} Injury data from the National Hockey League reveals that 13-20 out of 100 players per year sustain a groin injury.¹⁰

Sports hernia has been described as a common diagnosis in otherwiseunexplained chronic groin pain.¹¹ Some believe that it is the most common cause of chronic groin pain in athletes, whereas others consider it to be quite rare.¹²⁻¹⁷ Gilmore¹⁸ suggested that the incidence of chronic groin injury has increased with the greater intensity of modern athletic play. Others however have suggested that the increased injury frequency is more likely attributed to the heightened awareness of athletic trainers and physicians.^{5,19} The sports hernia is one of the least understood, poorly defined, and under researched maladies to affect the human body. The media had popularized the use of this diagnostic term, and actual injury characteristics are poorly identified.²⁰ The sports hernia reflects a compilation of diagnoses lumped together with a wide range of other pathologies that need to be excluded before it ever should be considered as a diagnosis.²⁰ There is a paucity of sports hernia verification through surgical textbooks, anatomic drawings or pictures.^{20,21}

The etiology, onset (chronic vs. acute), anatomy involved, and terminology used to define a sports hernia varies widely in the literature.^{22,23} Geographical and sports-specific differences seem to exist for the over- or under-diagnosis of a sports hernia with

European soccer players with chronic groin pain more often diagnosed with a sports hernia, and Australian Rules Football players with chronic with chronic groin pain more often diagnosed with osteitis publis.^{22,24-26} Fredberg et al²⁷ suggested that proper evidence does not exist for the theory that a sports hernia constitutes a credible explanation for chronic groin pain, calling for greater restraint prior to surgical intervention.

The groin disruption syndrome described by Gilmore including injury to the internal oblique aponeurosis, conjoined tendon-pubic tubercle attachment, and dehiscence between the conjoined tendon-inguinal ligament have been grouped together as inguinal wall and superficial inguinal ring disorders.^{2,18,20,28} Posterior inguinal wall deficiency occurs as a result of injury to the transversalis fascia or conjoined tendon which is formed by the medial portion of the internal oblique and transverses abdominis muscles.^{8,19,21,29}

Many reports define a sports hernia as a bulge or incipient posterior inguinal wall hernia that creates lower abdominal or groin pain leading to loss of inguinal canal integrity without the presence of a true hernia.^{4,8,30-32} Other sports hernia descriptions have included abnormalities of the rectus abdominis muscle, avulsion of part of the internal oblique muscle fibers from the pubic tubercle, tearing within the internal oblique muscle, or abnormality in the external oblique muscle and aponeurosis³³⁻³⁵ since each of these conditions may also dilate or weaken the inguinal wall or ring.¹¹ Anterior inguinal wall defects have also been identified via surgical exploration in up to 80% of athletes who experience chronic groin pain.^{2,36,37}

Most sports hernias occur in males, although they may also occur in females.^{32,38} Harmon³⁸ may have provided the most accurate sports hernia definition describing it as "the phenomena of chronic activity-related groin pain that is unresponsive to conservative therapy and significantly improves with surgical repair". Surgical success however is usually interpreted as return to sports activity timing.^{9,29} Verrall et al⁹ reported how misleading return to sports activity timing can be to assess patient outcome following sports hernia treatment intervention. Slavotinek et al²⁹ reported that only a small proportion of athletes with groin pain miss games due to their high motivation to maintain position within a team. The purpose of this systematic literature review paper is to summarize sports hernia pathogenesis, differential diagnosis, conservative treatment, surgical treatment, and post-surgical rehabilitation.

Methods

We performed a comprehensive Medline literature search to identify all English language papers regarding the sports hernia between 1950 and the second week of April 2008. Review articles and case series were included to help define the nature of the sports hernia diagnosis and because of the limited number of clinical studies concerning this topic. Search terms included all combinations for "sports or sportsman's hernia", "chronic groin pain", "chronic groin injury" and "athlete". Retrospective and nonrandomized studies were included since they comprise the majority of literature on the topic of sports hernias. The search term "sports or sportsman's hernia with or without the term "athlete" generated a total of 33 papers. The search term "chronic groin pain" with or without the term "athlete" generated at total of 75 papers. The search term "chronic groin injury" with or without the term "athlete" generated a total of 39 papers. Papers that focused on tendon conditions or that were based primarily on true hernias were not included in this review. Following correction for redundancies a total of 104 papers were identified that contributed to this review.

Pathogenesis

Chronic groin injury may develop from overuse, increased shear forces across the hemipelvis, lumbopelvic and lower extremity muscle strength, endurance, extensibility, and coordination imbalances, loss of dynamic abdominal wall rotational stability or congenital inguinal wall weakness.^{7,40} The close proximity of numerous anatomical structures in the region where sports hernias develop results in the strong likelihood of co-existing conditions⁷ (Fig. 1). Alternatively, an initial musculoskeletal groin injury may alter delicate hip and groin region musculoskeletal biomechanics leading to sports hernia onset as a secondary injury.^{7,23,26}

Repetitive or excessive shear forces applied through the pelvis from the hip adductor muscles pulling against a fixed lower extremity may weaken or injure internal oblique or transversalis fascia attachments from the inguinal ligament. The transverses abdominis muscle and fascia normally functions as an inguinal canal "shutter" mechanism when the muscle contracts and the activation onset of this muscle may be delayed in athletes who experience chronic groin pain.^{20,41}

Reduced hip abduction and internal-external rotation range of motion has been associated with chronic groin injury and also with transversalis fascia and conjoined tendon attenuation.^{38,42,43} Verrall et al^{42,43} hypothesized that hip joint capsular twisting from Australian Rules Football participation may create motion restrictions similar to those that repetitious throwing creates at the glenohumeral joint. The same mechanisms that create sports hernias however may also lead to osteitis pubis, pubic bone edema, or hip adductor tendinosis, supporting the likelihood of co-existing injuries whether or not a sports hernia exists.³⁸

The pubic symphysis is the center of rotation between the compression strut that links the posterior pelvis and lumbosacral spine with the femur.⁴²⁻⁴⁴ Restricted hip range of motion or muscle group strength, endurance, coordination or extensibility imbalances may further increase the stress/unit area in this region. This places excessive loads on the inguinal wall tissue that lies perpendicular to the transversalis fascia causing pain and/or defects at the inguinal rings.^{11,42-46} Non-contractile tissue injury from these shearing forces may be particularly problematic for athletes who have developed imbalances between the comparatively stronger hip adductor muscles, and the comparatively weaker lower abdominal muscles.^{11,33} The hip adductor muscles (particularly adductor longus and gracilis) are important pelvis stabilizers during single leg support. Effective dynamic hip motion control in sports such as soccer, Australian Rules Football, or ice hockey requires synergistic abdominal and hip region muscle co-activation to maintain appropriate lumbo-pelvic alignment.³³ Weakness, poor endurance, reduced extensibility, or poor coordination of these muscular synergists may precipitate functional instability, overuse and injury at comparatively weaker non-contractile structures.³³ Subsequent attenuation or tearing of the transversalis fascia or conjoined tendon^{5,47}, rectus abdominis insertion^{13,15}, internal oblique muscle at the pubic tubercle⁴⁸, external oblique muscle and aponeurosis⁴⁸, nerve entrapment at the external oblique aponeurosis⁴⁹, entrapment of the genital branches of the ilioinguinal or genitofemoral nerves⁵⁰, or entrapment of the obturator nerve¹⁹ have all been reported.

Balduini et al⁵¹ suggested that the tenuous nature of the internal and external oblique muscle origins and insertions predisposes them to strain injury. In males these muscles extend to form the cremaster (internal oblique) and internal and external (internal and external oblique) spermatic fascia which is the likely reason why lower abdominal injuries may precipitate scrotal pain.^{38,51} Others have theorized that increasingly rigorous, and perhaps misguided off-season conditioning programs contribute to a strength, endurance, coordination and/or an extensibility imbalance between the stronger lower extremity muscles and the weaker abdominal muscles increasing shear forces across the pubic symphysis and subsequently tearing of the transversalis fascia, conjoined tendon, inguinal canal, or overlying musculature.^{2,5,6,10,11,16,22,35,38,52,58} Hip adductor strains occur 20 times more frequently during professional hockey training camp compared to the regular season suggesting that off-season de-conditioning or inappropriate off-season conditioning practices may both be contributing factors.^{10,52}

Direct trauma, intense abdominal muscle training, or the stresses associated with repetitious rotational trunk forces transmitted to the abdominal wall during a hockey slapshot could lead to ilioinguinal nerve entrapment in a similar condition known as hockey groin syndrome.³⁴ Hypertrophied internal oblique muscles may increase the shearing forces that are transmitted to the external oblique aponeurosis leading to fascial tears or thinning.³⁴ Ziprin et al⁴⁹ in studying 25 male athletes (mainly soccer players) identified external oblique aponeurosis defects through which the neurovascular bundles passed. After surgical division of these bundles and primary repair of the aponeurosis tears, chronic groin pain was largely eliminated.

Differential Diagnosis

Sports hernias are characterized by insidious onset, gradually worsening, diffuse, unilateral groin pain that may radiate to the perineum and upper medial thigh.^{11,20,22,35,38,51,54-57} Pain radiation across the midline into the scrotum and testicles is present in approximately 30% of symptomatic individuals.^{16,17,47} While the signs and symptoms of chronic groin injury are well described, how they contribute to the differential diagnosis of a sports hernia is less clear.^{5,11,22,35} A detailed history, focused questioning, and clinical examination are the most important aspects of the patient encounter.^{48,58,59-61} The average patient who has a sports hernia is a male in his mid-20s, but sports hernias have been diagnosed across a wide age range³² and they are more common in females than previously thought.^{32,38,62} Between 27-90% of athletes with sports hernia type symptoms have multiple pathologies^{5,7,26,34,40,63-66} making accurate diagnosis difficult, and supporting the need for a multi-disciplinary examination.^{7,23,62,65,68}

The underlying etiology of musculoskeletal chronic groin pain in general is usually attributed to one of four broad categories: 1. adductor longus dysfunction, 2. osteitis pubis, 3. sports hernia (sportsman's hernia, pre-hernia complex, Gilmore's groin), or 4. a pathological condition of the hip joint (femoroacetabular impingement, capsulolabral injuries, and chondral defects).^{25,69,70} Holmich et al²³ described three musculotendinous causes for chronic groin injury in sportsmen: 1. hip adductor-related dysfunction with palpatory pain at the pubic bone attachment and pain with resisted hip adduction; 2. iliopsoas-related dysfunction with palpatory pain of the muscle at the lower lateral abdomen or immediately distal of the inguinal ligament in addition to pain during the Thomas test; and 3. rectus abdominis-related dysfunction with palpatory pain at the distal tendon or pubic bone attachment, and pain with a resisted sit-up.²³

Acknowledgment of groin pain during the performance of sport specific movement patterns is considered to be unequivocal for the sports hernia diagnosis.³³ Biedert et al³³ reported a specific chronic groin pain and "weakness" combination for "symphysis syndrome" consisting of: 1. posterior inguinal wall deficiency with an open external inguinal ring and weak external oblique muscle aponeurosis and transversalis fascia without clinical hernia signs; 2. a small rectus abdominus muscle attachment area on the pubis; and 3. chronic hip adductor pain. With symphysis syndrome pain is generally located lateral to the rectus abdominus muscle sheath, medial to the inguinal ligament, and immediately proximal to the pubis where a smaller than normal rectus abdominus attachment does not adequately cover the weak groin region. They described the pain mechanism as increased intra-abdominal pressure during sports activity that thrusts the peritoneum into the weak groin region.³³

Before arriving at a sports hernia diagnosis one must also rule out other musculoskeletal etiologies such as referred synovitis, lumbosacral pain, femoral capital avascular necrosis or slipped epiphysis, femoral neck and shaft stress fracture, degenerative hip disease, rheumatic arthritis, sacroiliac or iliolumbar ligament injury, pelvic joint inflammatory conditions, pubic bone stress reactions, disruption of muscle or tendon and enthesopathy, bursitis (13 in the region), and snapping hip syndrome.^{62,66,69}

Other conditions such as an "true" hernias, nerve entrapment or irritation, tumors, regional inflammatory or infection conditions (prostate conditions, urinary infections, gynecologic disorders, rheumatoid arthritis, intra-abdominal disorders, genitourinary abnormalities, anklylosis, spondylitis, Legg Calve Perthes disease, sero-negative arthropathy, Reiter's syndrome, gout, osteomyelitis, tuberculosis) must also be ruled out, further contributing to the diagnostic dilemma.^{7,14,31,46,66,71}

First and foremost, the physical examination of a patient with a sports hernia reveals no detectable inguinal hernia. Unless there are multiple causes, patients can often identify the exact site of pain.^{12,56,58,72} With a sports hernia the following elements are consistently found on physical examination: 1. inguinal canal tenderness; 2. dilated superficial inguinal ring; 3. pubic tubercle tenderness; and 4. hip adductor origin tenderness.²⁰ The key physical examination finding is pubic tubercle tenderness and an inguinal floor tear that can occasionally be palpated, creating pain inside the external inguinal ring.²¹ The pain may radiate to a testicle or laterally to the upper thigh.^{16,17,47} The pain is usually aggravated by sudden movement such as athletic effort, a Val salva maneuver, sneezing, coughing, sexual activity, and during a resisted sit-up or hip adduction.^{11,21,73} Verrall et al⁷⁴ described three pain provocation tests that if positive demonstrated a high likelihood for an athlete having MR-detected parasymphyseal pubic bone marrow edema: 1. having the patient squeeze their knees together while in supine with 45° hip flexion and 90° knee flexion; 2. having the patient squeeze their feet together while in supine with 30° hip flexion and slight abduction-internal rotation; and 3. hip flexion-abduction-external rotation (FABER) or Quadrant tests. Mens et al⁷⁵ however reported that isometric hip adduction is not a hallmark for hip adductor muscle group injury as pain levels decrease and muscle force levels increase in patients with pelvic ring instability who wear a pelvic belt.

Entrapment of the genital branch of the genitofemoral, ilioinguinal, lateral femoral cutaneous, or obturator nerves may also create symptoms that resemble those of a sports hernia.^{19,76,77} Bradshaw et al^{50,78} stated that the course of the obturator nerve placed it at increased risk for entrapment between poorly described fascia and the obturator externus and adductor brevis muscles. Adductor magnus and adductor longus receive partial innervation from the sciatic and femoral nerves, explaining why obturator entrapment may create only subtle weakness on physical examination, and possibly making the adductor brevis ideal for specific insertional EMG examination of obturator nerve entrapment.⁷ When sensory nerve compression or entrapment is the cause of groin pain or paresthesia the pattern tends to closely follow the sensory distribution of the particular nerve that is entrapped or compressed.¹⁹ However, there is considerable anatomic variation in the origin and course of the ilioinguinal, genitofemoral and iliohypogastric nerves.⁷ For effective treatment of the patient with groin pain of neural origin, it is essential to have a thorough knowledge of regional cutaneous nerve anatomic variability, an appreciation of the pathophysiology of neuroma formation, and a specific surgical approach strategy.⁷⁹

Hemingway et al⁶⁴ reported that the hip flexors on the affected side of randomly selected individuals with posterior inguinal wall insufficiency were significantly weaker than the non-involved side prior to surgical repair, possibly due to pain-inhibition. Additionally, only 12.5% of patients compared to 100% of non-impaired control subjects could effectively perform a transverse abdominal muscle test to control pelvic tilt during crook lying and only 13% of patients compared to 80% of control subjects could effectively perform an external oblique muscle test to control hip abduction and external

rotation while simultaneously controlling pelvic tilt.⁶⁴ Tests such as these may be useful both as screens to identify individuals who are at risk for sports hernia development or for individuals who may have a symptomatic sports hernia.

Diagnostic imaging does not generally reveal a sports hernia, but it is useful to rule out other conditions.³⁵ Standard radiographs may reveal pubic symphysis widening or erosion, fractures, healing stress fractures or skeletal disease.²¹ The "flamingo x-ray view" with the patient in alternating one leg stance may ascertain pelvic movement shifts across the pubic symphysis.²¹ Bone and/or CT scans can effectively rule out stress reactions or inflammatory processes. MRI is useful in detecting the location, extent and characteristics of pelvic and/or hip injury such as strains, labral tears, stress reactions, osteitic pubis, iliopsoas bursitis, true hernias, or occult stress fractures and is somewhat useful to predict recovery time and in defining treatment,^{7,16,60,69,80-82} however it may not be a useful tool for deciding between operative or conservative chronic groin injury treatment.⁸³

The secondary cleft sign on MRI may imply adductor longus, gracilis, or conjoined tendon dysfunction.⁸⁴ This sign should be sought on coronal short inversion time inversion-recovery (STIR) images in athletes who present with chronic groin pain. The presence of the secondary cleft sign on MRI may obviate an extensive search for other chronic groin pain causes, thereby reducing the number of unnecessary diagnostic imaging interventions.⁸⁴

If the patient has a painful hip Quadrant or FABER test⁷⁴, MR arthrography should be considered. If the MR arthrography is positive, hip arthroscopy evaluation should be considered.⁷⁰ Patients with pre-existing femoroacetabular dysplasia are more

susceptible to capsulolabral tears secondary to altered hip joint biomechanics.⁸ Patients with labral tears often give a history of a sharp, catching pain that is poorly localized radiating to the groin where it may be the only area of reported symptoms.⁸ Narvani et al⁸⁵ reported that MR arthrography demonstrated an acetabular labrum tear in four out of 18 (22.2%) consecutive athletes who presented with chronic groin pain.

Diagnostic imaging to identify sports hernias has not been particularly useful with the exception of ultrasonography, which enables a dynamic assessment.^{7,60,69} As the patient actively strains during the procedure a real time convex anterior bulge and ballooning of the inguinal canal can be observed at the superficial inguinal ring.^{11,86} Posterior inguinal wall deficiency is demonstrated when anterior abdominal wall muscle contraction reveals a loss of the normal valve-like action on the inguinal canal as the posterior inguinal wall is displaced anteriorly rather than becoming taut.⁸ There features however are very subtle and this test is highly operator dependent.^{8,86,87} Although this finding is also associated with a varicocele, a spermatic cord lipoma, and increasing patient age, the presence of a progressive convex anterior bulge increases the diagnostic specificity for a sports hernia.⁸⁶ Future advancements in the use of ultrasound imaging during rehabilitation exercises and physical task performance may enable more accurate, functionally relevant assessment and evaluation of soft tissue inguinal region injuries and treatment effectiveness.⁸⁸

Herniography (injecting a contrast material into the abdominal or peritoneal cavity) provides an anatomical outline of the pelvic floor and its peritoneal reflections and can identify small inguinal canal tears.^{60,69,73,89,90,92} Herniography is an invasive procedure however that lacks specificity, and has a high false positive

rate.^{20,21,35,59,65,81,87,91} Potential risks from herniography include hollow viscous perforation, vasovagal reactions, infections, abdominal wall hematomae, and contrast agent reactions. Herniography for the differential diagnosis of a sports hernia is rarely used in the United States.¹¹

In summary, sports hernia is a diagnosis made from a comprehensive physical examination that requires ruling out numerous other musculoskeletal and nonmusculoskeletal conditions. Typical symptoms before diagnosis can range in duration from 6 weeks to 5 years with an average of 20 months.^{47,68,92} Essentially it is a diagnosis that can only be confirmed at surgery.¹¹ The chronic groin region pain and tenderness that athletes who have a sports hernia display is more directly related to their inability to effectively compete in sports activity than are imaging findings.³⁹

Conservative Treatment

Traditionally employed conservative sports hernia treatment has low success rates.^{16,63,66,98} Conservative treatment generally includes 6-8 weeks of rest followed by focused progressive resistance hip adductor strengthening and stretching exercises, sports specific functional tasks and gradual return to full activities.^{40,63,66,92} At approximately 10-12 weeks following conservative treatment initiation and when the athlete is pain-free, return to sports competition is generally attempted.³³

Like most other chronic groin injuries sports hernias are also initially treated with non-steroidal anti-inflammatory medication, heat or ice, and massage.^{5,66} Electrical modalities such as transcutaneus electrical nerve stimulation or interferential current may be used for pain control at any time during the treatment progression. An active program

designed to improve strength, endurance, coordination, and appropriate hip and abdominal muscle synergistic balance (including isometric and progressive resistance hip abduction, adduction, flexion, extension exercises, sit-ups, wobble board, sliding board, and Fitter exercises) has been shown to achieve better patient outcomes than a conventional more passive treatment intervention.⁶ Only recently have conservative rehabilitation programs been developed that address the power, endurance, and coordination of trunk and hip stabilizing muscles.^{5,64,93-95} The rehabilitation emphasis should be on placed on resolving core strength, endurance, coordination, and extensibility deficiencies and imbalances at the hip and abdominal muscles and dynamically stabilizing the pelvic ring.^{5,11,35,75,93-95}

Tyler et al⁹³ reported that preseason hip adductor strength was 95% of hip abductor strength for uninjured hockey players, but only 78% of hip abductor strength for injured players. Development of a hip adductor injury prevention plan including stationary cycling, hip adductor stretching, sumo squats, side lunges, kneeling pelvic tilts, ball squeezes, concentric progressive resistance hip adduction exercises, sliding board, unilateral lunges with reciprocal arm movements, "on ice" kneeling adductor "pull togethers", slide skating, cable column crossover pulls significantly decreased hip adductor injuries among this group of athletes.^{94,95}

Ashby⁷² identified entheseopathy at the pubic insertion of the rectus abdominis or adductor longus tendons of 49 patients with chronic groin pain and reported pain relief at 3-15 months following local injection of a long-acting steroid (1% triamcinolone) and local anaesthetic (2% lignocaine). Prolotherapy injection of 12.5% dextrose solution into the hip adductor pelvic attachments, at the conjoined tendon on the pelvic rim, and at the symphysis pubis may facilitate the natural repair process.⁶⁷ A single entheseal injection of bupivacaine (3 mL of a 0.5% solution) mixed with triamcinolone actetonide (80 mg in 2 mL) provided hip adductor-related groin pain relief for at least one year in competitive rugby and soccer athletes.²⁵ In summary, conservative treatment as it applies specifically to a sports hernia diagnosis is poorly described and evidence of successful conservative treatment intervention is lacking.^{6,11,20,22}

Surgery

Unlike most other causes of groin pain, the literature suggests that sports hernias rarely improve without surgery.^{11,35,38,98} Surgical exploration and repair should only be considered when rest and non-surgical treatment over a minimum of 6-8 weeks has failed and when careful history and multi-disciplinary clinical examination has ruled out other potential pain sources.^{21,55,65}

When the surgical option is selected, either an open or a laparoscopic approach can provide good results.³⁸ Most sports hernia surgical procedures reinforce the abdominal muscles or fascia near the inguinal ligament in a manner similar to conventional hernia surgery.^{2,18,28} Meyers et al¹³ in performing successful open procedures on numerous athletes suggested that laparoscopic or "incorrect" open repairs that did not effectively address the causative pathology were each unlikely to have a successful outcome. Many sports hernia surgical techniques do not provide sufficient detail and several "anatomic" repairs do not incorporate the appropriate anatomic layers.²⁰ A wide variety of open repair techniques are described to reinforce the inguinal canal by placating the existing tissue layers without mesh^{2,4,13,14,15,28,33,37,49,55,97} or with mesh.^{21,30,34,58,87,96,98,104} A growing number of surgeons are using laparoscopic techniques to repair sports hernias.^{3,29,31,36,54,58,96,99,100,103} Regardless if the surgical intervention is laparoscopic or open, success rates reportedly vary from 63-97% for both symptom relief and for return to previous sports activity levels.^{4,11,13,35,47,96,97} Meyers et al¹² reported that a success rate of 95% should be expected with carefully selected patients. Our review reveals very good and comparable results between open (92.8 \pm (9.9%) (Table 1.) and laparoscopic $(96.0 \pm 4.5\%)$ (Table 2.) repairs based solely on the criterion of return to sports activity. Two reports were not included in these estimates since both open and laparoscopic techniques were used.^{58,96} Some have suggested that at least part of the success with either sports hernia surgical approach can be attributed to the inflammatory reaction and general tissue healing fibrosis that occurs at the repair site.^{12,13,44} Additionally, surgery appears to be quite effective regardless of whether the technique that is used is open or laparoscopic used when return to sports activity is used as the sole criteria for evaluating patient outcome. Basing surgical success on return to sports activity alone however is insufficient to truly determine the efficacy of treatment intervention.^{9,39} As with other areas of surgery, improved, more frequent, patient directed outcome measurements are needed.

Most patients do well with sports hernia repair in the absence of definitive MRI or diagnostic ultrasound findings.^{12,83,87} Additionally, surgical release of a portion of the hip adductor muscle group from the pubic bone may help restore the balance between abdominal and hip adductor muscle forces at the pubic bone.^{13,33,54,55}

Several reports suggest that ideally, the injured tissue should first be normalized with an anatomic surgical repair and then be reinforced with mesh.^{1-3,21,29,30,58,96,98-100} Our

review found that on average, 35% of open and 100% of laparoscopic procedures used mesh. Concerns exist that laparoscopic repair may not completely repair the lesion since it does not enable direct visualization, potentially contributing to greater failure over time.^{12,13,38,60} A laparoscopic approach may however provide better posterior inguinal canal wall exposure enabling easier bilateral reinforcement of the lower abdominal wall from the pubic bone to the anterior superior iliac spine.³¹ The relatively "tension-free" laparoscopic technique described by Genitsaris et al³¹ may enable earlier strenuous exercise performance in contrast to an open repair in which a new inguinal floor is constructed by suturing mobile muscles and non-contractile (aponeurotic elements) structures together under tension.³¹ Meyer et al¹² however suggested that the tension-free repair provided by the laparoscopic repair does not adequately stabilize the anterior pelvis. Neumayer et al¹⁰¹ reported that laparoscopic repair yielded a significantly higher recurrence rate (10.1%) following direct inguinal hernia repair compared to an open repair technique with mesh reinforcement (4.9%) concluding that the open mesh repair was superior. Conceivably, an open technique with sufficient anatomic sports hernia repair and mesh reinforcement might provide the most durable repair, however it is difficult directly extrapolate the findings of Neumayer et al¹⁰¹ to the strictly sports hernia condition. Canonico et al¹⁰² reported good preliminary results for using human fibrin glue to secure mesh to achieve tension-free open inguinal hernia repair in soccer athletes with chronic groin pain.

Laparoscopic repair may enable athletes to progress more quickly during rehabilitation and ultimately to return to unrestricted sports activities faster than open repair.^{38,53} Srinivasan & Shuricht et al¹⁰³, reported that approximately 87% (13 of 15

patients) of sports hernia patient cases that were treated with laparoscopic repair could initiate training within four weeks of surgery, return to full activity within six weeks, and did not have recurrent symptoms at a mean 12.1 month follow-up (range = 6-60 months). In a similar report, Ingoldby et al⁹⁶ reported that 13 of 14 (92.9%) athletes who underwent laparoscopic surgery for sports hernia repair returned to training in four weeks.

In using open repair to treat a group of 12 recreational athletes with sports hernias Ahumada et al¹⁰⁴ reported that 83.3% (10 of 12 patients) had excellent results at four month follow-up. Open repair however required athletes to be relatively inactive over the initial four post-operative weeks. Only after the initial four post-operative weeks were athletes allowed to begin even mild activities such as walking in a swimming pool and gentle stretching. Athletes who underwent open repair were generally returned to full activity at six months postsurgery.¹⁰⁴ Kumar et al³⁰ reported that open inguinal wall repair was associated with a marked improvement in patient median pain scores and approximately 93% (25 of 27 patients) returned to full activity by 14 weeks.

Malycha and Lovell⁴ reported an approximately 93% (41 of 44 survey respondents) return to pre-injury sports activity level at six months follow-up among sports hernia cases that were treated with open repair. Therefore it appears that both laparoscopic and open repair techniques for sports hernias can be effective, however laparoscopic repair offers the advantage of a faster rehabilitation progression, earlier return to unrestricted activities of daily living, and earlier return to pre-injury sports activity levels. Part of the difficulty in assessing the superiority of a particular surgical approach is the heterogeneity of the patient populations.^{20,22} Well designed prospective,

randomized, controlled studies are greatly needed to establish the true efficacy of these different surgical approaches.^{11,20,66}

Post-Surgical Rehabilitation

Post-surgical rehabilitation has been described to varying extents by several reports.^{2,4,30,33,34,37,47,49,54,55,63,64,104} Detailed descriptions however are generally lacking. Early post-surgery, sharp, sudden movements are avoided and core and lower extremity musculoskeletal inflexibility, weakness, poor endurance, or poor coordination are identified and corrected. Walking is encouraged early post-surgery with progression to jogging or running by 3-4 weeks.^{4,47,63} Straight ahead running while avoiding cutting movements and select sport specific activities may be started after post-operative day 21.⁶³ Sprinting without cutting can generally be initiated by the third post-operative week and runners subsequently return to full activity within 2-4 months.³⁵ Recovery following laparoscopic repair generally takes 6-8 weeks before full return to competition is permitted.^{30,47,54,64,104}

Hemingway et al⁶⁴ described a six week post-open sports hernia repair rehabilitation program: (Week 1) isometric abdominal and hip exercises, walking increased by 5 min/day, and stair climbing; (Week 2) active hip exercises, active transverse and oblique abdominal exercises, and stationary cycling; (Week 3) flexibility work, resistance band hip exercises, active transverse and oblique abdominal exercises, jogging, and swimming; (Week 4) forward running, abdominal training with progressive resistance, upper body exercise with light resistance; (Week 5) sprinting, multidirectional running, light ball skills, kicking, progressive resistance abdominal exercises, and gradual return to sports; and (Week 6) unrestricted exercise training, and return to competitive sports.

van Veen et al⁵⁴ described a 6 week duration post-laparoscopic sports hernia repair rehabilitation program: (Weeks 0-1) walking 5 km/h; (Weeks 1-2) aquatic training, 20 min power walking adding 5 min each session to a 50 min maximum, 4 sets of 10 min duration stationary cycling (80-90 RPM, 2 min break between sets to a maximum of 15 min), isometric rectus abdominus training, and step-ups with knee flexed 60°; (Weeks 2-3) sit-ups, progressive interval and speed running, and lunges; (Weeks 3-5) weight training, normal activities within pain-free limits; and (Week 6) normal, unrestricted training.

Overall we found that post-surgical recovery time (based on return to sports activity) for patients who underwent open repair was 17.7 ± 13.1 weeks, compared to 6.1 ± 4.5 weeks for laparoscopic repairs. Developing evidence based post-surgical rehabilitation and conditioning progressions and more standardized patient outcome and activity level assessments (with patient generated items and item weight) are needed. Serial measurements should be made at key functional time periods and milestones based on specific criteria such as pain, strength, and function levels. This needs to take place in addition to the extremely limited and often misinterpreted "return to play" factor and widely varying follow-up periods. Well-designed studies are greatly needed. 9.11.20.66.68

Conclusion

Sports hernias most often occur in males who participate in sports that involve cutting, pivoting, kicking, and sharp turns, and although their onset is usually insidious,

with focused questioning a specific incident or "onset mechanism" may be recalled.^{13,58} We currently do not know the precise sequence of events that lead to sports hernia development, however the combination of abdominal and hip adductor muscle strength, endurance and coordination imbalances, lumbopelvic and hip range of motion deficits, poor tissue extensibility, and intense or high repetition hip adductor muscle shearing forces through their pelvic attachments may be the primary factors.^{5,7,11,13,23,26,33,42-44} Poorly designed off-season conditioning programs that focus on lower extremity muscle strength-power development while neglecting synergistic abdominal and core muscle group strength, endurance, coordination, and extensibility balance may be related to the increasing number of sports hernias that are being reported. Although numerous injuries may contribute to the sports hernia diagnosis, the most common surgical finding is posterior inguinal wall insufficiency that creates an occult hernia that is not apparent on physical examination.¹⁶

Since it can be difficult to make a definitive diagnosis based on conventional physical examination, diagnostic imaging modalities such as MRI, CT scans, and diagnostic ultrasound are recommended. To date the most effective use of various imaging modalities however has been to rule out other groin region injuries. Innovative rehabilitative ultrasound imaging methods may have considerable potential for directing conservative and post-surgical sports hernia treatment.^{66,86,88}

The literature suggests that sports hernia surgery is considerably more effective than conservative treatment.^{11,35,98} Unfortunately, information regarding specific conservative treatment interventions, particularly as they apply to strength, endurance and coordination training and flexibility exercises, manual therapy, and electromodality are

poorly described and well-designed studies are lacking. When the decision is made to proceed with surgery, laparoscopic repair in addition to providing a minimally invasive exploratory diagnostic method also enables a faster rehabilitation progression and potentially a quicker return to unrestricted sporting activities than open repair. However concerns exist regarding the capacity for this surgical method to completely evaluate and repair all sports hernia lesion types.⁶⁰

In summary, sports hernias remain a misunderstood and poorly researched problem that affects many athletes at all levels of competition. There is currently no consensus as to what specifically constitutes its diagnosis. Well designed research studies are needed to better understand sports hernia pathogenesis, to aid in its prevention, and to more effectively direct conservative treatment. The high incidence of groin/abdominal strain injury early in the competitive season for sports like soccer and ice hockey has significant implications for further investigation of risk factors such as non-existent or poorly designed off-season sports training programs.

What is already known about the topic?

The differential diagnosis of a sports hernia is difficult to make from physical examination and it is thereby largely determined only at the time of surgery. Both open and laparoscopic surgical approaches are reported to effectively eliminate symptoms and enable patients to return to previous sporting activity levels.

What this study adds?

Sports hernia anatomy, surgical procedures, and rehabilitation strategies are poorly described. Serial patient outcome measurements are needed to base intervention success on factors other than return to sports activity. Well-designed research studies will help to better elucidate pathogenesis, verify intervention efficacy, develop evidencebased prevention strategies, and more effectively direct conservative and post-surgical rehabilitation.

The Corresponding Author has the right to grant on behalf of all authors and does grant on behalf of all authors, an exclusive licence (or non-exclusive for government employees) on a worldwide basis to the BMJ Publishing Group Ltd and its Licensees to permit this article (if accepted) to be published in BJSM and any other BMJPGL products to exploit all subsidiary rights, as set out in our licence

Competing interests - None

Table 1.

Study	Туре	Patients	Primary	Repair	Mesh	Operative	Follow-	Clinical
0.1 2	D. C.	(male/female)	Sport	0	N	Findings	up	Outcomes
Gilmore	Retrospective	1200 (1176/24)	Soccer	Open	None		Not specified	97% return
							speemea	activity in 6
								weeks
Meyers	Prospective	157 (157/0)	Soccer	Open pelvic	None	1. Loose	3.9 years	96% to full
et al.			(46%), Hockey	floor repair,		(57%)	(range =	activity in
			(17%),	of the		2. External	months –	of 6 months
			Football	inferolateral		oblique	12 years)	
			(13%)	edge of rectus		aponeurosis		
				muscle with		3. "Thin" rectus		
				its fascial		abdominis		
				attachment to		muscle insertion		
				adjacent		(17%)		
				anterior				
				ligament.				
				23% also had				
				release				
Malycha	Prospective	50 (not	Soccer	Open	None	1. Bulge of	6 months	93% to full
& L		reported)		reinforcement		posterior		activity in
Loven				inguinal wall		(80%)		0-8 weeks
				in two layers		2. No		
				using prolene		abnormalities		
				suture		(14%) 3 Small		
						indirect inguinal		
						hernia (2%)		
						4. Lipoma of		
						(2%)		
						5. Posterior		
						inguinal wall		
Kumar et	Retrospective	35 (34/1)	Soccer	Approximatio	Yes	1. Tear in	6 months	93% to full
al ³⁰	1			n of external		external oblique		activity in
				oblique .		aponeurosis		mean 14
				aponeurosis		with or without		weeks
				darn or		inguinal canal		
				Lichenstein		wall bulge		
						(57%) 2 Posterior		
						inguinal wall		
						bulge (28%)		
						3. Conjoined		
						dilated		
						superficial		
						inguinal ring		
						(9%) 4 Small direct		
						hernia (3%)		
						5. Lipoma of		
						spermatic cord		
						inguinal wall		
						bulge (3%)		
Steele et	Retrospective	47 (47/0)	Soccer/	Modified	Yes	Bulging of	6-50	77% to full
al			Rugby	Bassini with mesh		posterior inguinal wall	months	activity in 4 months

Hackney 14	Retrospective	15 (14/1)	Soccer	Parainguinal approach, reconstitution of internal ring, plication of transversalis fascia	None	Weakening of transversalis fascia with separation from conjoined tendon and dilatation of the internal ring (100%), as above with a direct inguinal hernia (7%)	18-60 months	87% return to full activity in 6 weeks
Polglase et al ⁹⁷	Retrospective	64 (62/2)	Australia n Rules Football	Standard Bassini and Tanner Slide, or plication of transversalis fascia	None	 Deranged posterior wall of inguinal canal (85%) Splitting of conjoined tendon (26%) Indirect inguinal hernia (8%) 	8 months	62.5% to full activity; 31% partially satisfied; 4.7% dissatisfied at minimum of 8 months post- surgery
Branniga n et al ³⁷	Retrospective	85 (not reported)	Soccer	Modified Shouldice	None	 Separation of conjoined tendon from inguinal ligament Weakened transversalis fascia 	3-21 months	96% returne d to full activity in 15 weeks
Williams & Foster ²⁸	Retrospective	6 (6/0)	Soccer = 4, Rugby = 1, Cricket = 1	Approximate external oblique aponeurosis	None	Small external oblique aponeurosis tear at the site of emergence of the terminal branch of iliohypogastric neurovascular bundle.	1.5 months	100% returned to full activity in 6 weeks
Joesting ²	Retrospective	45 (not reported)	Not described	Modified Lichtenstein	Yes	Transversalis fascia tear	12 months	90% to full activity (time period not reported)
Taylor et al ¹⁵	Retrospective	9 (7/2)	Soccer = 3, baseball = 2, runners = 2, basketbal l = 1, football = 1.	Modified Bassini	None	 Direct inguinal hernia (56%) Direct or indirect hernia (22%) Indirect inguinal hernia (11%) Avulsion of internal oblique aponeurosis from pubic tubercle (11%) 	3 months	100% returned to full activity in approximat ely 12 weeks
Irshad et al ³⁴	Retrospective	22 (22/0)	Ice hockey	Approximate external oblique, ablate ilioinguinal nerve	86%	External oblique aponeurosis tear with ilioinguinal nerve branches within the	31 months	100% full activity (Time period not reported)

						defect		
Ahumad a et al ¹⁰⁴	Retrospective	12 (11/1)	Running = 4, basketbal l = 3, soccer = 2, football = 2, baseball = 1	Open repair with internal oblique muscle flap. Four patients also had adductor release	75%	Nonspecific inguinal floor attenuation and cord lipomas	Median 4 months (range = 2-13 months)	100% returned to sports; 83.3% excellent, 16.7% satisfactory results at approximat ely 6 months
Simonet et al ⁹⁸	Retrospective	10 (10/0)	Ice hockey	Bassini approximatio n	70%	Tears at the floor of the inguinal ring	6 month - 4 yr	100% returned to hockey with symptom improveme nt (time period not reported)
Van Der Donckt et al ⁵⁵	Prospective	41 (41/0)		Bassini repair and percutaneous adductor tenotomy, 14 bilateral	None	Not described	Mean follow-up was 12 years and 6 months (range = 3 years and 1 month to 16 years and 5 months	90% return to full activity in 6-15 months
Biedert et al ³³	Retrospective	24 (24/0)	Soccer = 17, ice hockey = 3, others = 3	Open, spreading of the lateral border of the sheath of the rectus abdominus and adductor release, denervation of rectus insertion	None	Not described	Mean follow-up was 6.6 years (range = 1.2-12.3 years)	96% return to full activity in 3-4 months
Ziprin et al ⁴⁹	Retrospective	25 (25/0)	Rugby or Soccer = 19, others = 6	Inguinal approach and exploration, repair of external oblique aponeurosis, neurolysis of illiohypogastr ic nerve	None	Single or multiple tears (1-4 cm) in the external oblique aponeurosis at the sites of perforating neurovascular bundles. Occult indirect hernia in 1 patient. Patent processus vaginalis in 1 patient	20.6 months (range = 7-56 months)	100% returned to sports. 32% continued to have mild pain. 1 patient did not improve. Mean resumption of sports was 11.6 weeks (range = 4- 20 weeks)

Table 2.

Study	Туре	Patient	Primary	Repair	Mesh	Operative	Follow-	Clinical
Kluin et al ³ Edelman & Selesnick ²⁹	Prospective	(male/female) 14 (13/1) 10 (9/1)	Sport Soccer and triathletes Soccer = 2, Basketbal 1 = 2, other sports =	Transabdomi nal preperitoneal or extraperitonea l approach, 4 bilateral repairs Laparoscopic repair using extraperitonea l technique with balloon peritoneum discostion	Yes	Findings 50% Hernia inguinalis; 22% hernia femoralis; 16.7% preperitoneal lipoma, 5.6% hernia obturatoria; 5.6% no obvious pathology Tear or laxity of transversalis fascia	up 1 year 1 year	Outcomes 93% returned to full activity in 12 weeks 100% returned to full activity in 4 weeks. One patient did not
Srinivasan	Retrospective	15 (15/0)	Soccer =	Totally	Yes	Small indirect	6-8	after surgery 87% to full
& Schuricht ¹⁰			6, football = 4, hockey = 4, body builder = 1	extraperitonea l procedure		hermas	months	activity in 3-6 weeks
Paajanen et al ⁹⁹	Retrospective	41 (41/0)	Soccer = 58%, ice hockey = 27%	Totally extraperitonea l procedure	Yes	 no macroscopic abnormality (59%) Rupture of conjoined tendon near public ramus (24%) Muscle asymmetry (17%) 	48 months	94% to full activity in 4 weeks
van Veen et al ⁵⁴	Prospective	55 (53/2)	Soccer	Totally extraperitonea l procedure	Yes , occasiona l adductor release	 Weakness of posterior wall (63%, 7% with lymph node near internal ring, and 9% with lipoma) Direct inguinal hernia (6%) Indirect inguinal hernia (31%) 	3 months	100% to full activity at 3 months
Susmallian et al ¹⁰⁰	Prospective	35 (35/0)		Totally extraperitonea l procedure	Yes	 Wide internal ring and peritoneal dimple (80%); Indirect hernia (11%); 	15 months	97% to full activity. Average time to return to full play

						3. No obvious abnormality (9%)		was not reported
Genitsaris et al ³¹	Retrospective	131 (131/0)	Soccer	Transabdomi nal preperitoneal procedure	Yes	Direct hernia (62%); bilateral (31%)	Mean = 5 years (range = 4 months - 10 years)	96.9% returned to full activity within 2-3 weeks
Azurin et al ³⁶	Retrospective	8 (8/0)	Hockey = 3, Football = 3, Soccer = 1, Body Builder = 1	Endoscopic preperitoneal	Yes	100% subtle hernia; bilateral in 7 patients	4 weeks	100% return to full activity in 2-3 weeks

References

- 1. Fon LJ, Spence RA. Sportsman's hernia. Br J Surg. 2000;87:545-52.
- Gilmore OJA. Groin pain in the soccer athlete: fact, fiction and treatment. *Clin* Sports Med. 1998;17:787-93.
- Kluin J, den Hoed PT, van Linschoten R, Ijzerman JC, van Steensel CJ. Endoscopic evaluation and treatment of groin pain in the athlete. *Am J Sports Med.* 2004;32:944-9.
- Malycha P, Lovell G. Inguinal surgery in athletes with chronic groin pain: "Sportsman's" hernia. *Aust NZ J Surg.* 1992;62:123-5.
- Anderson K, Strickland SM, Warren R. Hip and groin injuries in athletes. *Am J Sports Med.* 2001;29:521-33.
- Holmich P, Uhrskou P, Ulnits L, Inge-Lis K, Neilsen MB, Bjerg AM, Krogsgaard K. Effectiveness of active physical training as treatment for long-standing adductorrelated groin pain in athletes: Randomised trial. *Lancet.* 1999;**353**:439-43.
- 7. Morelli V, Weaver V. Groin injuries and groin pain in athletes: Part 1. Prim Care

Clin Office Pract. 2005;**32**:163-83.

- 8. Kavanaugh EC, Koulouris G, Ford S, McMahon P, Johnson C, Eustace SJ. MR imaging of groin pain in the athlete. *Sem Musculoskel Radiol*. 2006;**10**:197-207.
- Verrall GM, Slavotinek JP, Fon GT, Barnes PG. Outcome of conservative management of athletic chronic groin injury diagnosed as pubic bone stress injury. *Am J Sports Med.* 2007;35:467-74.
- Emery CA, Meeuwisse WH, Powell JW. Groin and abdominal strain injuries in the National Hockey League. *Clin J Sports Med.* 1999;9:151-6.
- Farber AJ, Wilckens JH. Sports hernia: Diagnosis and therapeutic approach. J Am Acad Surg. 2007;15:507-14.
- Meyers WC, Lanfranco A, Castellanos A. Surgical management of chronic lower abdominal and groin pain in high-performance athletes. *Curr Sports Med Reports*. 2002;1:301-5.
- Meyers WC, Foley DO, Garrett WE, Lohnes JH, Mandlebaum BR. Management of severe lower abdominal or inguinal pain in high-performance athletes. Performing athletes with abdominal or inguinal neuromuscular pain study group (PAIN). *Am J Sports Med.* 2000;28:2-8.
- Renstrom PAFH. Tendon and muscle injuries in the groin area. *Clin Sports Med.* 1992;11:815-31.
- Taylor DC, Meyers WC, Moylan JA, Lohnes J, Bassett FH, Garrett WE Jr.
 Abdominal musculature abnormalities as a cause of groin pain in athletes. Inguinal hernias and pubalgia. *Am J Sports Med.* 1991;19:239-42.
- 16. Morelli V, Smith V. Groin injuries in athletes. Am Fam Physician. 2001;64:1405-

14.

- Morelli V, Espinosa L. Groin injuries and groin pain in athletes: Part 2. Prim Care Clin Office Pract. 2005;32:185-200.
- 18. Gilmore OJA. Gilmore's groin. *Physiother Sport.* 1995;18:14-15.
- 19. Akita K, Niga S, Yamato Y, Muneta T, Sato T. Anatomic basis of chronic groin pain with special reference to the sports hernia. *Surg Radiol Anat.* 1999;**21**:1-5.
- Nam A, Brody F. Management and therapy for sports hernia. *Am Coll Surg.* 2008;206:154-64.
- Joesting DR. Diagnosis and treatment of sportsman's hernia. *Curr Sports Med Rep.* 2002;1:121-24.
- Swan Jr. KG, Wolcott M. The athletic hernia. A systematic review. *Clin Orthop*. 2006;455:78-87.
- Holmich P. Long-standing groin pain in sportspeople falls into three primary patterns, a "clinical entity approach: A prospective study of 207 patients. *Br J Sports Med.* 2007;41:247-52.
- Gibbon WW. Groin pain in professional soccer players: A comparison of England and the rest of Western Europe [Letter to the Editor]. *Br J Sports Med.* 1999;33:435-6.
- Schilders E, Bismil Q, Robinson P, O'Connor PJ, Gibbon WW, Talbot JC. Adductor-related groin pain in competitive athletes. *J Bone Joint Surg Am*. 2007;89:2173-8
- 26. **Robinson P**, Barron DA, Parsons W, Grainger AJ, Schilders EMG, O'Connor PJ. Adductor-related groin pain in athletes: Correlation of MR imaging with clinical

findings. Skeletal Radiol. 2004;33:451-7

- Fredberg U, Kissmeyer-Nielsen P. The sportsman's hernia fact or fiction? Scan J Med Sci Sports. 1996;6:201-4.
- Williams P, Foster ME. Gilmore's groin or is it? Br J Sports Med. 1995;29:206-8.
- Edelman DS, Selesnick H. "Sports" Hernia: treatment with biologic mesh (Surgisis). Surgical Endoscopy. 2006;20:971-3.
- Kumar A, Doran J, Batt ME, Nguyen-Van-Tam JS, Beckingham IJ. Results of inguinal canal repair in athletes with sports hernia. *J R Coll Edinb*. 2002;47:561-5.
- Genitsaris M, Goulimaris I, Sikas N. Laparoscopic repair of groin pain in athletes. *Am J Sports Med.* 2004;32:1238-42.
- 32. Moeller JL. Sportsman's hernia. Curr Sports Med Reports. 2007;6:111-4.
- 33. Biedert RM, Warnke K, Meyer SRP. Symphysis syndrome in athletes: Surgical treatment for chronic lower abdominal, groin, and adductor pain in athletes. *Clin J Sport Med.* 2003;13:278-84.
- 34. Irshad K, Feldman LS, Lavoie C, Lacroix VJ, Mulder DS, Brown RA. Operative management of "hockey groin syndrome": 12 years of experience in National Hockey League players. *Surg.* 2001;130:759-66.
- Paluska SA. An overview of hip injuries in running. Sports Med. 2005;35:991-1014
- 36. Azurin DJ, Go LS, Schuricht A, McShane J, Bartolozzi A. Endoscopic preperitoneal herniorraphy in professional athletes with groin pain. J Laparoendoscopic & Advanced Surg Tech. 1997;7:7-12.

- Brannigan AE, Kerin MJ, McEntee GP. Gilmore's groin repair in athletes. J Orthop Sports Phys Ther. 2000;30:329-32.
- Harmon KG. Evaluation of groin pain in athletes. *Curr Sports Med Reports*. 2007;6:354-61.
- 39. Slavotinek JP, Verrall GM, Fon GT, Sage MR. Groin pain in footballers. The association between preseason clinical and pubic bone magnetic resonance imaging findings and athlete outcome. *Am J Sports Med.* 2005;33:894-9.
- Macintyre J, Johson C, Schroeder EL. Groin pain in athletes. *Curr Sports Med Reports*. 2006;5:293-9.
- Cowan SM, Schache AG, Brukner P, Bennell KL, Hodges PW, Coburn P, Crossley KM. Delayed onset of transverses abdominus in long-standing groin pain. *Med Sci Sports Exerc*. 2004;36:2040-5.
- 42. Verrall GM, Hamilton IA, Slavotinek JP, Oakeshott RD, Spriggins AJ, Barnes PG, Fon GT. Hip joint range of motion reduction in sports-related chronic groin injury diagnoses as pubic bone stress injury. J Sci Med Sport. 2005;8:77-84.
- 43. Verrall GM, Slavotinek JP, Barnes PG, Esterman A, Oakeshott RD, Spriggins AJ.
 Hip joint range of motion restriction precedes athletic chronic groin injury. *J Sci Med Sport.* 2007;10:463-6.
- 44. **Paajanen H**, Hermunen H, Karonen J. Pubic magnetic resonance imaging findings in surgically and conservatively treated athletes with osteitis pubis compared to asymptomatic athletes during heavy training. *Am J Sports Med.* 2008;**36**:117-21.
- 45. **Yilmazlar T**, Kizil A, Zorluoglu A, Ozguc H. The value of heriography in football players with obscure groin pain. *Acta Chir Belg.* 1996;**96**:115-8.

- Fricker PA. Management of groin pain in athletes. *Br J Sports Med.* 1997;**31**:97-101.
- Hackney RG. The Sports Hernia: a cause of chronic groin pain. *Br J Sports Med.* 1993;27:58-62.
- Lacroix VJ, Kinnear DG, Mulder DS, et al. Lower abdominal pain syndrome in National Hockey League players: A report of 11 cases. *Clin J Sports Med.* 1998;8:5-9.
- 49. **Ziprin P**, Williams P, Foster E. External oblique aponeurosis nerve entrapment as a cause of groin pain in the athlete. *Br J Surg.* 1999;**86**:566-8.
- Bradshaw C, McCrory P, Bell S, Brukner P. Obturator nerve entrapment: A cause of chronic pain in athletes. *Am J Sports Med.* 1997;25:402-8.
- Balduini FC. Abdominal and groin injuries in tennis. *Clin Sports Med.* 1988;7:349-57.
- 52. Tyler T, Zook L, Brittis D, Gleim G. A new pelvic tilt detection device: Roentgenographic validation and application to assessment of hip motion in professional ice hockey players. *J Orthop Sports Phys Ther.* 1996;24:303-8.
- Schuricht A, Haut E, Wetzler M. Surgical options in the treatment of sports hernia. Op Tech Sports Med. 2002;10:224-7.
- van Veen RN, de Baat P, Heijboer MP, et al. Successful endoscopic treatment of chronic groin pain in athletes. *Surg Endosc.* 2007;21:189-93.
- 55. Van Der Donckt K, Steenbrugge F, Van Den Abbeele K, Verdonk R, Verhelst M. Bassini's hernial repair and adductor longus tenotomy in the treatment of chronic groin pain in athletes. *Acta Orthop Belg.* 2003;69:35-41.

- Cetin C, Sekir U, Yildiz Y, Aydin T, Ors F, Kalyon TA. Chronic groin pain in an amateur soccer player. *Br J Sports Med.* 2004;38:223-224.
- 57. Diesen DL, Pappas TN. Sports hernias. Adv Surg. 2007;41:177-87.
- Diaco JF, Diaco DS, Lockhart L. Sports Hernia. Op Tech Sports Med. 2005;13:68-70.
- Lovell G. The diagnosis of chronic groin pain in athletes: A review of 189 cases. *Aust J Sci Med Sport*. 1995;27:76-9.
- 60. Holzheimer RG. Inguinal Hernia: classification, diagnosis and treatment--classic, traumatic and Sportsman's hernia. *Eur J Med Res.* 2005;**10**:121-34.
- Holmich P, Holmich LR, Bjerg AM. Clinical examination of athletes with groin pain: An intraobserver and interobserver reliability study. *Br J Sports Med.* 2004;**38**:446-51.
- 62. Holzheimer RG, Gresser U. Inguinal hernia vs. arthritis of the hip in sporting adolescents, Case report and review of the literature. *Eur J Med Res.* 2007;12:314-9.
- 63. LeBlanc KE, LeBlanc KA. Groin pain in athletes. Hernia. 2003;7:68-71.
- 64. **Hemingway AE**, Herrington L, Blower AL. Changes in muscle strength and pain in response to surgical repair of posterior abdominal wall disruption followed by rehabilitation. *Br J Sports Med.* 2003;**37**:54-8.
- 65. Ekberg O, Persson NH, Abrahamsson PA, et al. Long-standing groin pain in athletes: A multidisciplinary approach. *Sports Med.* 1988;6:56-61.
- 66. Unverzagt CA, Schuemann T, Mathisen J. Differential diagnosis of a sports hernia in a high-school athlete. *J Orthop Sports Phys Ther.* 2008;**38**:63-70.
- 67. Topol GA, Reeves KD, Hassanein KM. Efficacy of dextrose prolotherapy in elite

male kicking-sport athletes with chronic groin pain. *Arch Phys Med Rehabil*. 2005;**86**:697-702.

- Paajanen H, Heikkinen J, Hermunen H, Airo I. Successful treatment of osteitis pubis by using totally extraperitoneal endoscopic technique. *Int J Sports Med.* 2005;26:303-6.
- 69. Armfield DR, Kim DHM, Towers JD, Bradley JP, Robertson DD. Sports-related muscle injury in the lower extremity. *Clin Sports Med.* 2006;25:803-42.
- Mitchell B, McCrory P, Brukner P, O'Donnell J, Colson E, Howells R. Hip joint pathology: Clinical presentations and correlation between magnetic resonance arthrography, ultrasound, and arthroscopic findings in 25 consecutive cases. *Clin J Sports Med.* 2003;13:152-6.
- Karlsson J, Sward L, Kalebo P, Thomee R. Chronic groin injuries in athletes: Recommendations for treatment and rehabilitation. *Sports Med.* 1994;17:141-8.
- 72. Ashby EC. Chronic obscure groin pain is commonly caused by enthesopathy:'tennis elbow' of the groin. *Br J Surg.* 1994;81:1632-4.
- Sutcliffe JR, Taylor OM, Ambrose NS, et al. The use, value and safety of herniography. *Clin Radiol.* 1999;54:468-72.
- 74. Verrall GM, Slavotinek JP, Barnes PG, Fon GT. Description of pain provocation tests used for the diagnosis of sports-related chronic groin pain: Relationship of tests to defined clinical (pain and tenderness) and MRI (pubic bone marrow oedema) criteria. *Scand J Med Sci Sports*. 2005;15:36-42.
- Mens J, Inklaar H, Koes BW, Stam HJ. A new view on adduction-related groin pain. *Clin J Sports Med.* 2006;16:15-9.

- McCrory P, Bell S. Nerve entrapment syndromes as a cause of pain in the hip, groin and buttock. *Sports Med.* 1999;27:261-74.
- 77. Rab M, Ebmer And J, Dellon AL. Anatomic variability of the ilioinguinal and genitofemoral nerve: Implications for the treatment of groin pain. *Plastic & Reconstructive Surg.* 2001;108:1618-23
- Bradshaw C, McCrory P. Obturator nerve entrapment. *Clin J Sport Med.* 1997;**7**:217-9.
- Lee CH, Dellon AL. Surgical management of groin pain of neural origin. J Am Coll Surg. 2000;191:137-42.
- Kunduracioglu B, Yilmaz C, Yorubulut M, Kudas S. Magnetic resonance findings of osteitis pubis. *J Magnetic Resonance Imaging*. 2007;25:535-9.
- Tuite MJ, DeSmet AA. MRI of selected sports injuries: Muscle tears, groin pain, and osteochondritis dissecans. *Seminars in Ultrasound, CT, and MRI*. 1994;15:318-40.
- De Paulis F, Cacchio A, Michelini O, Damiani A, Saggini R. Sports injuries in the pelvis and hip: Diagnostic imaging. *Eur J Radiol.* 1998;27:S49-S59.
- 83. Daigeler A, Belyaev O, Werner H, Pennekamp WH, Morrosch S, Koster O, Uhl W, Weyhe D. MRI findings do not correlate with outcome in athletes with chronic groin pain. J Sports Sci Med. 2007;6:71-6.
- 84. Brennan D, O'Connell MJ, Ryan M, Cunningham P, Taylor D, Cronin C, O'Neil P, Eustace S. Secondary cleft sign as a marker of injury in athletes with groin pain: MR image appearance and interpretation. *Radiol.* 2005;235:162-7.
- 85. Narvani AA, Tsiridis E, Kendall S, Chaudhuri R, Thomas P. A preliminary report

on prevalence of acetabular labrum tears in sports patients with groin pain. *Knee Surg Sports Traumatol Arthrosc.* 2003;**11**:403-8.

- Orchard JW, Read JW, Neophyton J, Garlick D. Groin pain associated with ultrasound finding of inguinal canal posterior wall deficiency in Australian Rules footballers. *Br J Sports Med.* 1998;**32**:134-9.
- Steele P, Annear P, Grove JR. Surgery for posterior inguinal wall deficiency in athletes. *J Sci Med Sport*. 2004;7:415-21.
- Whitaker JL, Teyhen DS, Elliott JM, et al. Rehabilitative ultrasound imaging: Understanding the technology and its applications. *J Orthop Sports Phys Ther*. 2007;**37**:434-9.
- Hamlin JA, Kahn AM. Herniography: A review of 333 herniograms. *Am Surg*. 1998;64:965-9.
- Kesek P, Ekberg O, Westlin N. Herniographic findings in athletes with unclear groin pain. *Acta Radiologica*. 2002;43:603-8.
- 91. Smedberg SGG, Broome AEA, Gullmo A, Roos H. Herniography in athletes with groin pain. *Am J Surg.* 1985;149:378-82.
- Lynch SA, Renstrom P. Groin injuries in sport: Treatment strategies. *Sports Med.* 1999;28:137-44.
- 93. Tyler TF, Nicholas SJ, Campbell RJ, McHugh MP. The association of hip strength and flexibility with the incidence of adductor muscle strains in professional ice hockey players. *Am J Sports Med.* 2001;29:124-8.
- 94. **Tyler TF**, Nicholas SJ, Campbell RJ, Donellan S, McHugh MP. The effectiveness of a preseason exercise program on prevent adductor muscle strains in professional

ice hockey players. Am J Sports Med. 2002;30:680-3.

- 95. Nicholas SJ, Tyler TF. Adductor muscle strains in sport. Sports Med. 2002;32:339-44.
- Ingoldby CJH. Laparoscopic and conventional repair of groin disruption in sportsmen. *Br J Surg.* 1997;84:213-5.
- 97. **Polglase AL**, Frydman GM, Framer KC. Inguinal surgery for debilitating chronic groin pain in athletes. *Med J Aust.* 1991;**155**:674-7.
- Simonet WT, Saylor HL 3rd, Sim L. Abdominal wall muscle tears in hockey players. *Int J Sports Med.* 1995;16:126-8.
- 99. Paajanen H, Syvahuoko I, Airo I. Totally extraperitoneal endoscopic (TEP) treatment of sportsman's hernia. *Surg Laparosc Endosc Percutan Tech*. 2004;14:215-8.
- 100. Susmallian S, Ezri T, Elis M, Warters R, Charuzi I, Muggia-Sullam M. Laparoscopic repair of "sportsman's hernia" in soccer players as treatment of chronic inguinal pain. *Med Sci Monitor*. 2004;10:CR52-4.
- 101. Neumayer L, Giobbie-Hurder A, Jonasson O, Fitzgibbons R, Dunlop D, Gibbs J, Reda A, Henderson W. Open mesh versus laparoscopic mesh repair of inguinal hernia. N Eng J Med. 2004;350:1819-27.
- 102. Canonico S, Benevento R, Della Corte A, Fattopace A, Canonico R. Sutureless tension-free hernia repair with human fibrin glue (tissucol) in soccer players with chronic inguinal pain: Initial experience. *Int J Sports Med.* 2007;28:873-6.
- 103. **Srinivasan A**, Schuricht A. Long-term follow-up of laparoscopic preperitoneal hernia repair in professional athletes. *J Laparoendoscop Adv Surg Tech*.

2002;**12**:101-6.

104. Ahumada LA, Ashruf S, Espinosa-de-los-Monteros A, et al. Athletic pubalgia: Definition and surgical treatment. *Ann Plast Surg.* 2005;55:393-6.

Copyright statement

The Corresponding Author has the right to grant on behalf of all authors and does grant on behalf of all authors, an exclusive licence (or non-exclusive for government employees) on a worldwide basis to the BMJ Publishing Group Ltd and its Licensees to permit this article (if accepted) to be published in BJSM and any other BMJPGL products to exploit all subsidiary rights, as set out in our licence

Competing interests - None

Figure Legend

Fig. 1. Anterior view of the inguino-abdominal regions after the peritoneum and transversalis fascia have been removed.

Downloaded from bjsm.bmj.com on 7 October 2008

