Study quality on groin injury management remains low: a systematic review on treatment of groin pain in athletes

Andreas Serner,1,2 Casper H van Eijck,3 Berend R Beumer,3 Per Hölmich,1,2 Adam Weir,1 Robert-Jan de Vos4

ABSTRACT
Background Groin pain in athletes is frequent and many different treatment options have been proposed. The current level of evidence for the efficacy of these treatments is unknown.

Objective Systematically review the literature on the efficacy of treatments for groin pain in athletes.

Methods Nine medical databases were searched in May 2014. Inclusion criteria: treatment studies in athletes with groin pain; randomised controlled trials, controlled clinical trials or case series; n>10; outcome measures describing number of recovered athletes, patient satisfaction, pain scores or functional outcome scores. One author screened search results, and two authors independently assessed study quality. A best evidence synthesis was performed. Relationships between quality score and outcomes were evaluated.

Review registration number CRD42014010262.

Results 72 studies were included for quality analysis. Four studies were high quality. There is moderate evidence that, for adductor-related groin pain, active exercises compared with passive treatments improve success, multimodal treatment with a manual therapy technique shortens the time to return to sports compared with active exercises and adductor tenotomy improves treatment success over time. There is moderate evidence that for athletes with sportsman’s hernia, surgery results in better treatment success than conservative treatment. There was a moderate and inverse correlation between study quality and treatment success (p<0.001, r=−0.41), but not between study quality and publication year (p=0.09, r=0.20).

Conclusions Only 6% of publications were high quality. Low-quality studies showed significantly higher treatment success and study quality has not improved since 1985. There is moderate evidence for the efficacy of conservative treatment (active exercises and multimodal treatments) and for surgery in patients with adductor-related groin pain. There is moderate evidence for efficacy of surgical treatment in sportsman’s hernia.

INTRODUCTION
Acute and long-standing groin pain are frequent problems in sports involving rapid directional changes,1,2 and frequently lead to absence from sporting activities. It is estimated that 5–18% of all sports injuries are groin-related.3

The groin region has a complex anatomy with a large number of potential pain-generating structures. Symptoms may arise from systemic, gynaecological, urogenital, gastrointestinal, neurological and musculoskeletal structures.4 This can make groin pain terminology confusing, resulting in difficulties with interpretation of research results.

The natural history of most groin injuries in sport is favourable after a short period of relative rest.3 However, some injuries can result in longer rehabilitation time and may even become long-standing. It is known that long-standing groin pain can be resistant to many treatment options and can have slow recovery times.6

Three systematic reviews have been published on the treatment of groin pain in athletes.7 8 In 2008, the first review included all types of treatment, but a quality assessment was not performed for 39 out of 45 (87%) studies, due to a subjective consensus on sufficient level of evidence based on individual study design.4 The authors were not able to provide clear recommendations based on the available evidence, instead they described that conservative management was usually tried initially, and surgery might be indicated following unsuccessful treatment.

Two further systematic reviews, from 2009 and 2013, only included studies on the effectiveness of conservative treatment.7 8 A thorough evaluation of exercise interventions, aiming to strengthen the hip and abdominal musculature, was performed in one review.7 All study designs were eligible for inclusion, but only five studies were included and assessed with a modified generic quality appraisal tool. Although the authors conclude that exercise should be a key component in the treatment of groin pain in athletes, the overall evidence base was poor. A recent Cochrane review focused on randomised controlled trials (RCTs) and quasi-RCTs only. This limited the inclusion to two studies, which were evaluated with a seven-point bias assessment. The authors concluded that the two studies provided insufficient evidence to advise a specific conservative treatment for exercise-related groin pain.9

The methodology used in the previous reviews has proven insufficient to provide a clear overview including quality considerations of all available literature on the treatment of the wide spectrum of groin pain in athletes.

We examined the currently available literature on the efficacy of conservative and surgical treatment options for groin pain in athletes. It assesses studies of all levels of evidence, with a focus on high study quality, to provide recommendations for clinical practice and guide further research. A secondary aim was to correlate the study quality with treatment success, percentage of athletes returning to play, time to return to play (RTP) and publication year.
METHODS
Registration in the PROSPERO International prospective register of systematic reviews was performed prior to study initiation (registration number CRD42014010262).

Literature search
The databases PubMed, EMBASE, CINAHL, Medline OvidSP, Scopus, Google Scholar, Web of Science, Sportdiscus and Cochrane Library were searched without time limits in May 2014. The complete electronic search is shown in online supplementary table S1. Manual screening of the reference lists of the eligible studies was performed to include other potential eligible studies. The literature search was assisted by a biomedical information specialist (WM Bramer).

Study selection
Two independent reviewers (R-JdV and BB) assessed all potentially eligible studies identified by the search strategy. The eligibility criteria were:
1. Athletes with a diagnosis of groin pain which was treated either conservatively or surgically;
2. A quantitative outcome measure in terms of treatment success, recovery rate, percentage of athletes returning to play after treatment, pain scores, functional outcome scores or patient satisfaction;
3. Study design was a RCT, prospective or retrospective controlled study, case–control study, or case series with n>10;
4. The article was written in English.

Studies on intra-articular hip pathologies (eg, osteoarthritis and femoroacetabular impingement) and isolated nerve injuries were excluded. All titles and/or abstracts were assessed by two independent reviewers (R-JdV and BB) and, subsequently, relevant articles were acquired. If online access to the articles was unavailable, authors of these articles were contacted for further information. All relevant articles were read in full text by the reviewer to assess whether eligibility criteria were met.

Data extraction
One reviewer (R-JdV), blinded from the quality assessment, recorded publication data, number of participants, study design, diagnosis, intervention and, if applicable, control group(s), duration of follow-up from baseline (for primary outcome measure or, if not applicable, the last follow-up time point) and outcome, using standardised data extraction forms. Primary outcomes were extracted from the published articles to assess the treatment success of the interventions.

If the outcome was not defined as primary or secondary, the most relevant outcome was extracted. The treatment success was hierarchically defined in terms of the percentage of recovered athletes, percentage of excellent or good patient satisfaction, improvement in pain scores, improvement in functional outcome scores or percentage of athletes returning to play. Improvement in pain scores or functional scores was measured as percentage of athletes with predefined successful outcome or as a fraction of the improvement compared with the baseline measure.9

Quality assessment
For assessment of the studies we used a modified Downs and Black (D&B) scale (see online supplementary table S2). The D&B scale is suitable to assess RCTs and non-randomised trials, and has shown good reliability.10 A higher score on the D&B scale is indicative of better methodological quality. The original published tool comprises 27 items with a maximum score of 32; the maximum score for item 5, regarding principal confounders, is 2, and the last item evaluating the power of the study is scored from 0 to 5. However, in line with previous studies, the multiple score on a single item was omitted due to its potential ambiguity.11 12 The tool in our review, therefore, consists of 27 questions with a maximum score of 27.

We judged each study as having a high (≥19/27) or low (<19/27) quality as modified from a previous study.12 The quality assessments of the included studies were used to categorise the level of evidence. Studies with high quality (D&B score ≥19/27) were included in the final analysis for determining the efficacy of treatment in athletes with groin pain.

We also used the quality scores to evaluate the relationships with treatment success, percentage of athletes returning to play, time to RTP and publication year in all initially included studies. The Pearson’s correlation coefficient analysis was used to examine the correlation between these variables if data were not skewed. The correlation coefficient (r) was interpreted as no association when 0.0, weakly positive when 0.2, moderately positive when 0.5, strongly positive when 0.8 and perfectly positive when 1.0.13 Statistics were performed using SPSS V20.0.0 (SPSS Science Inc, Chicago, Illinois, USA), and significance was considered for p values less than 0.05.

The types of treatment (conservative/surgical) and injury (acute groin injury/overuse groin injury) were analysed separately. When possible, we also evaluated subgroups of patients with adductor-related, iliotibial related, inguinal-related and pubic-related groin pain.2

Two authors (AS and AW) independently assessed the quality of included studies using the modified D&B forms. If there was disagreement on an item, it was discussed between the two reviewers. A consensus was reached in all cases, which precluded the need for a decisive independent third reviewer (R-JdV).

Best evidence synthesis
The heterogeneity of the data was evaluated after assessing the number of included high-quality studies. Data could be pooled if there was methodological homogeneity and I² statistics would be performed if there was homogeneity of data. If data could not be pooled because of heterogeneity, a best evidence synthesis was carried out consisting of a qualitative analysis with five levels of evidence, whereas only the highest two levels of evidence were attainable due to the quality criteria.9 14

1. Strong evidence: provided by two or more studies with high quality and by generally consistent findings in all studies (≥75% of the studies reported consistent findings).
2. Moderate evidence: provided by one study with high quality and/or two or more studies with low quality and by generally consistent findings in all studies (≥75% of the studies reported consistent findings).
3. Limited evidence: provided by only one study with low quality.
4. Conflicting evidence: inconsistent findings in multiple studies (<75% of the studies reported consistent findings).
5. No evidence: when no studies could be found.

RESULTS

Literature search
The initial search yielded 5380 records and, after removing duplicates, 2216 articles were screened using the title and/or abstract. Ninety-five studies were identified as potentially relevant, for which we aimed to retrieve full-text articles. Two articles could not be retrieved, even after contacting the authors,
who did not have copies of their own publications. Citation tracking did not lead to any additional relevant articles. After reviewing the full text of 93 articles, 21 articles were excluded and 72 articles met the inclusion criteria (figure 1).

**Description of included studies**

Supplementary table S3 presents the characteristics of the included studies. Data extraction was performed in the 72 studies included, and a detailed description of the studies is provided regarding year of publication, study design, participants, diagnosis, intervention groups, control groups, duration of follow-up and outcomes.

Owing to heterogeneity of the established diagnoses, interventions, outcome measures, follow-up times and methodological quality, it was not possible to perform statistical pooling of the data.

**Study design**

Sixty-five of the 72 studies were case series, of which 52 were retrospective and 13 prospective. Two studies were controlled clinical trials and five were RCTs. Two of the RCTs reported concealing their allocation and blinding of the assessors of key outcomes.

None of the RCTs reported blinding of the patients. Publication dates ranged from 1985 to 2014.

**Participants**

The median number of athletes included in the studies was 41 (IQR 24–73) and 95% were male. The mean athlete age was 27.3 years (SD 4.6, range 18–43 years). The majority of the athletes in the studies included were football players (61% of the studies). Other sports included ice hockey (7%), Australian rules football (6%) and rugby (6%). In 14% of the studies the type of sport was not reported. The level of sports was reported in 56% of the studies with a mean of 61% professional and 39% of amateur athletes. The mean symptom duration was 10.9 months (SD 4.7, range 3–21 months).

**Diagnostic terminology**

Thirty-three different diagnoses were used for groin pain in athletes in the 72 included studies (see online supplementary table S3). One study included acute groin injuries and 71 were on long-standing groin pain. Diagnostic criteria were frequently not reported and, if reported, many different diagnostic criteria were used (see online supplementary table S4). It should be emphasised that diagnostic criteria were very clear in some studies, but very non-specific in most of the studies. This difference could not be addressed in the online supplementary table and the criteria presented are in some cases inferred data. Seventy-one studies evaluated the treatment effect in long-standing groin pain, and one study in acute groin injuries. The following diagnoses were most frequently used: sportsman’s hernia (31%), chronic groin pain (10%), osteitis pubis (10%) and adductor-related groin pain (10%). Iliopsoas-related pain (diagnosed as ‘iliopsoas syndrome’ or ‘iliopsoas tendinitis’) was diagnosed in 3% of the studies. Multiple diagnoses were established in 14% of the studies.

**Interventions**

The interventions were conservative in 18 (25%) and surgical in 54 (75%) studies. The conservative treatment studies included...
Review

passive physical therapy modalities and/or exercise therapy (10 studies), or injection therapy (corticosteroids or dextrose, 9 studies). There were no studies focusing on the conservative treatment of sportsman’s hernia with a well-described treatment protocol. The surgical studies examined open hernia repair (12 studies), laparoscopic hernia repair (10 studies) and adductor tenotomy (9 studies). Many surgical treatments were combined (16 studies), and additional neurotomy of the ilioinguinal, genitofemoral and/or iliohypogastric nerve was often performed (12 studies).

For controlled studies (n=7), the control group intervention was a passive physical therapy modality or exercise therapy in three studies (43%), local corticosteroid injection in two studies (29%), and surgical adductor repair and wait and see in one study (14% each).

Primary outcome measures

Many different outcome measures were used, and frequently these were not defined as being primary or secondary. Forty-three per cent of the studies described their main outcome as percentage of patients without symptoms, 21% as percentage of patients who returned to play, 17% as patient satisfaction, 14% as a pain score and 6% as a function score.

The percentage of athletes returning to play was described in 81% of the articles and the time to RTP in 38% of the articles.

Outcomes

There was a wide range in follow-up time in the 55 studies that contained these data. The mean follow-up time was 27.7 months (SD 32.1) with a range from evaluation directly after treatment to 156 months postintervention.

All studies reported a treatment success in the intervention groups (using definitions related to the percentage of recovered athletes, percentage of excellent or good patient satisfaction, improvement in pain scores, improvement in functional outcome scores, or percentage of athletes returning to play) with a mean of 84.1% of athletes (SD 16.8, range 27–100%). A mean of 90.6% of the patients returned to play in the intervention groups (SD 11.2, range 49–100%) and the mean reported time to RTP was 11.3 weeks (SD 8.1, range 1–38 weeks).

The mean treatment success in the control groups was 48.7% (SD 29.9, range 8–93%). A mean of 45.8% (SD 21.9, range 14–64%) returned to play and the mean time to RTP was 25.6 weeks (SD 5.9, range 2–17 weeks).

Complications

Forty-two articles (58%) reported on the occurrence of complications. There were no complications in 15 of these studies (36%) and in 27 studies (64%) complications were mentioned. Most frequently reported were wound infections, which were reported in 13 (31%) studies with a mean occurrence of 3.0% (SD 3.5, range 1.0–14.0%), haematomas needing evacuation (5 studies, 12%) with a mean of 2.3% (SD 1.7, range 0.6–4.9%), seroma formation (5 studies, 12%) with a mean of 3.9% (SD 3.6, range 1.0–10.0%) and neuralgia with variable durations after leaving the hospital (5 studies, 12%) with a mean of 3.4% (SD 2.9, range 0.3–7.0%).

Quality assessment

The quality assessment scores of all included studies are shown in table 1. There was initial disagreement between the two reviewers in 205 of the 1944 item scores (11%). In two of the 72 studies (3%), this resulted in a difference between low and high quality after agreement was reached (one from high to low quality74 and one from low to high quality81). The percentage of agreement was lowest in items 9 (74%), 11 (79%), 13 (79%) and 20 (74%). The included studies scored worst on items 14 (blinding participants, 100% absent), 15 (blinding outcome assessors, 97% absent) and 24 (concealment treatment allocation in case of a RCT, 97% absent).

The scores ranged from 2 to 24 points with an average of 10.3 (SD 4.6). Four studies (6%) were considered high quality (table 2). The high-quality studies were performed in patients with long-standing adductor-related groin pain (n=3)66 68 81 and sportsman’s hernia with and without adductor tendinitis (n=1).69 One RCT evaluated the effect of active exercise therapy in the intervention group,6 one RCT evaluated the effect of multimodal treatment including a manual therapy technique66 and one RCT assessed the effect of laparoscopic surgery.6 Two RCTs used exercise therapy as control group66 69 and one study used passive physical therapy modalities as control.6 One prospective case series evaluated the effect of surgical adductor release.81

There was a significant moderate and inverse correlation between study quality and treatment success (p<0.001, r=−0.41). There was a weak, but non-significant correlation with quality and the percentage of athletes returning to play (p=0.09, r=−0.23) and no correlation with the time to RTP (p=0.94, r=−0.01; figure 2). There was a non-significant weak correlation between publication year and the D&B quality score (p=0.09, r=0.20), so over time there was no significant improvement in the methodological quality of the studies included.

Level of evidence

The four high-quality studies showed a significant improvement after intervention at the final follow-up or predefined primary outcome time. Table 2 shows the outcomes of the high-quality studies, which all included football players.

There is moderate evidence that:

Active physical training (consisting of adductor and abdominal strengthening, and coordination exercises) is superior to passive physical therapy modalities (consisting of laser, transverse frictions, adductor stretching and electric nerve stimulation) for long-standing adductor-related groin pain.6

Multimodal treatment (consisting of adductor warming, a specific manual adductor stretch, static adductor stretches and a return to running programme) enables a quicker return to sports than active physical training (consisting of adductor and abdominal strengthening and coordination exercises, and a running programme) for long-standing adductor-related groin pain.66

Partial adductor longus release reduces pain and enables RTP over time for athletes with long-standing adductor-related groin pain.68

Laparoscopic inguinal surgery (totally extraperitoneal repair) with or without surgical adductor release is more effective than conservative treatment (consisting of various types of adductor and abdominal strengthening and coordination exercises, corticosteroid injections and oral anti-inflammatory analgesics) for long-standing sportsman’s hernia with or without ‘adductor tendinitis’.69

There was limited evidence for all other treatment options that were evaluated in the included studies, as all low-quality studies showed an improvement in time in the intervention groups.

DISCUSSION

A total of 72 studies were suitable for inclusion in this systematic review on the treatment of groin pain in athletes. Only
| Study                        | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | Total D&B score | High/low quality |
|-----------------------------|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|--------------|-----------------|
| Mozes et al                 | - | + | + | - | + | - | + | + | - | + | - | - | + | + | - | - | + | + | - | - | + | - | + | - | - | 12 | Low            |
| Smedberg et al              | + | - | + | - | - | + | - | + | - | + | - | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 7 | Low            |
| Martens et al               | + | - | + | - | - | + | - | + | - | + | - | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 8 | Low            |
| Fricker et al               | + | + | + | - | - | - | - | - | - | + | - | - | - | - | - | - | - | - | + | - | - | - | - | + | - | 9 | Low            |
| Polglase et al              | + | - | + | - | - | + | - | + | - | + | - | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 6 | Low            |
| Shaker et al                | + | - | + | - | - | + | - | + | - | + | - | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 5 | Low            |
| Akerman and Johansson      | + | + | + | - | + | - | + | - | + | - | - | - | + | - | + | - | + | - | - | - | - | + | - | - | - | 9 | Low            |
| Malcha and Lovell          | - | + | + | + | - | - | + | - | - | + | - | - | + | - | - | + | - | + | - | - | - | - | - | + | + | 13 | Low            |
| Holt et al                  | + | - | + | - | - | + | - | + | - | + | - | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 12 | Low            |
| Simonet et al               | - | + | + | - | - | + | - | + | - | + | - | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 5 | Low            |
| Urquhart et al             | + | - | + | - | - | + | - | + | - | + | - | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 5 | Low            |
| Ingoldby                   | + | - | + | - | - | + | - | + | - | + | - | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 9 | Low            |
| Micheli and Solomon        | - | + | + | + | - | - | + | - | - | + | - | - | + | - | + | - | + | - | - | - | - | + | - | - | - | 6 | Low            |
| Evans                      | - | - | + | - | - | + | - | + | - | + | - | - | + | - | + | - | + | - | - | - | - | + | - | - | - | 8 | Low            |
| Lacroix et al              | - | + | + | - | - | + | - | + | - | + | - | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 7 | Low            |
| Holmich et al              | + | + | + | + | - | - | + | - | - | + | - | - | + | - | - | + | - | + | - | - | - | + | - | - | - | 23 | High           |
| Brannigan et al            | + | - | + | - | - | + | - | + | - | + | - | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 11 | Low            |
| Meyers et al               | + | - | + | - | - | + | - | + | - | + | - | - | + | - | + | - | + | - | - | - | - | + | - | - | - | 9 | Low            |
| McKim and Tauntoun         | + | + | + | + | - | - | + | - | - | + | - | - | + | - | - | + | - | + | - | - | - | + | - | - | - | 16 | Low            |
| Ekstrand and Ringborg      | + | + | + | + | - | - | + | - | - | + | - | - | + | - | - | + | - | + | - | - | - | + | - | - | - | 9 | Low            |
| Irshad et al               | + | - | + | - | - | + | - | + | - | + | - | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 11 | Low            |
| Kumar et al                | - | + | + | - | - | + | - | + | - | + | - | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 12 | Low            |
| O‘Connell et al            | - | - | + | - | - | + | - | + | - | + | - | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 6 | Low            |
| Srinivasan and Schuricht   | - | + | + | - | + | - | + | - | - | + | - | - | + | - | + | - | + | - | - | - | - | + | - | - | - | 9 | Low            |
| Biedert et al              | + | + | + | - | - | + | - | + | - | + | - | - | + | - | + | - | + | - | - | - | - | + | - | - | - | 11 | Low            |
| Van Der Donckt et al       | + | - | + | + | + | - | - | + | - | - | + | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 7 | Low            |
| Genetsaris et al           | + | - | + | + | + | - | - | + | - | - | + | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 8 | Low            |
| Klun et al                 | + | - | + | + | + | - | - | + | - | - | + | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 12 | Low            |
| Paajanen et al             | - | + | + | - | + | - | + | - | - | + | - | - | + | - | + | - | + | - | - | - | - | + | - | - | - | 10 | Low            |
| Steele et al               | + | - | - | + | - | - | + | - | - | + | - | - | + | - | + | - | + | - | - | - | - | + | - | - | - | 6 | Low            |
| Susmalian et al            | + | - | - | + | - | - | + | - | - | + | - | - | + | - | + | - | + | - | - | - | - | + | - | - | - | 5 | Low            |
| Ahumada et al              | + | - | + | - | - | + | - | + | - | - | + | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 6 | Low            |
| Diaco et al                | + | - | - | + | - | - | + | - | - | + | - | - | + | - | + | - | + | - | - | - | - | + | - | - | - | 6 | Low            |
| Topol et al                | + | + | + | - | + | - | + | - | - | + | - | - | + | - | + | - | + | - | - | - | - | + | - | - | - | 16 | Low            |
| Edelman and Selesnick      | + | - | - | + | - | - | + | - | - | + | - | - | + | - | + | - | + | - | - | - | - | + | - | - | - | 8 | Low            |
| Canonico et al             | + | + | + | - | + | - | + | - | - | + | - | - | + | - | - | + | - | + | - | - | - | + | - | - | - | 14 | Low            |
| Schlenz et al              | + | - | + | - | - | + | - | + | - | + | - | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 14 | Low            |
| Van Veen et al             | + | - | + | - | - | + | - | + | - | + | - | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 12 | Low            |
| Verrall et al              | + | + | + | - | + | - | - | + | - | + | - | - | - | + | - | - | + | - | - | - | - | + | - | - | - | 13 | Low            |
| Brown et al                | - | - | + | - | - | + | - | - | + | - | - | + | + | - | - | - | + | - | - | - | - | + | - | - | - | 4 | Low            |
| Lloyd et al                | + | + | + | - | - | - | + | - | - | - | + | - | - | - | + | - | + | - | - | - | - | + | - | - | - | 10 | Low            |
Table 1  Continued

| Study                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | Total | D&B score | High/low quality |
|----------------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Meyers et al **65**        | – | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | – | 2 | Low   |
| Radic and Anner **56**     | + | + | + | + | – | – | – | – | – | – | – | – | – | + | + | – | – | – | + | + | + | – | – | – | – | – | 10 | Low  |
| Topol and Reeves **57**    | + | – | – | + | + | + | + | – | – | – | – | – | – | – | – | – | – | + | + | – | – | – | – | – | – | – | 11 | Low  |
| Ziprin et al **68**        | – | + | + | + | – | – | – | – | – | – | – | – | – | + | – | – | – | + | + | + | – | + | – | – | – | – | 7  | Low   |
| Atkinson et al **69**      | – | + | – | + | + | + | + | – | – | – | – | – | – | – | – | – | – | + | + | – | – | – | – | – | – | – | 13 | Low  |
| Jansen et al **66**        | + | + | + | + | – | – | – | + | + | – | – | – | – | – | – | – | – | + | + | + | + | – | – | – | – | – | 14 | Low  |
| Mann et al **51**          | + | + | + | + | – | + | – | – | + | – | – | – | – | – | – | – | – | + | + | + | + | – | – | – | – | – | 14 | Low  |
| Schilders et al **62**     | + | – | – | + | + | + | + | – | – | + | + | + | – | – | + | + | – | + | + | + | – | – | – | – | – | – | 16 | Low  |
| Schlegel et al **63**      | + | – | – | + | + | + | + | – | – | – | – | – | – | + | – | – | – | + | + | + | + | – | – | – | – | – | 16 | Low  |
| Weir et al **64**          | + | + | + | + | + | + | + | – | – | – | – | – | – | + | + | – | + | – | + | + | + | + | – | – | – | – | 21 | High |
| Muschaweck and Berger **57** | + | + | + | + | – | + | – | + | – | – | + | – | – | – | – | – | – | + | + | + | + | – | – | – | – | – | 13 | Low  |
| Weiner et al **68**        | + | – | + | + | + | + | + | – | – | – | – | – | – | + | + | – | – | + | + | + | + | – | – | – | – | – | 4  | Low   |
| Chernysky et al **65**     | – | – | – | + | – | – | – | – | + | – | – | – | – | – | – | – | – | + | + | + | + | – | – | – | – | – | 4  | Low   |
| Paajanen et al **62**      | + | + | + | + | + | + | + | – | – | – | – | – | – | + | + | – | + | – | + | + | + | + | – | – | – | – | 9  | Low   |
| Preskitt **70**            | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | + | + | + | – | – | – | – | – | – | 11 | Low  |
| Robertson et al **71**     | + | – | – | + | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 9  | Low   |
| Wein et al **64**          | + | + | + | + | + | + | + | – | – | – | – | – | – | + | + | + | + | + | + | + | + | – | – | – | – | – | 24 | High |
| Dojcinovic et al **72**    | – | – | + | + | + | + | + | – | – | – | – | – | – | + | + | – | – | – | – | – | – | – | – | – | – | – | 7  | Low   |
| Jans et al **63**          | + | – | – | + | + | + | + | – | – | – | – | – | – | + | + | – | + | – | + | + | + | – | – | – | – | – | 9  | Low   |
| Maffulli et al **74**      | + | + | + | + | + | + | + | – | – | – | – | – | – | + | + | + | + | + | + | + | + | – | – | – | – | – | 17 | Low   |
| Messaoudi et al **75**     | + | – | – | + | + | + | + | – | – | – | – | – | – | + | + | – | + | – | + | + | + | – | – | – | – | – | 7  | Low   |
| Comin et al **76**         | + | + | + | + | + | + | + | – | – | – | – | – | – | + | + | + | + | – | + | + | + | – | – | – | – | – | 18 | Low   |
| Economopoulos et al **77** | + | + | + | + | + | + | + | – | – | – | – | – | – | + | + | – | + | – | + | + | + | – | – | – | – | – | 14 | Low   |
| Garvey and Hazard **78**   | – | – | + | + | + | + | + | – | – | – | – | – | – | + | + | – | + | – | + | + | + | – | – | – | – | – | 2  | Low   |
| Jakoi et al **79**         | + | + | – | – | – | – | – | – | – | – | – | – | – | + | + | – | – | – | – | – | – | – | – | – | – | – | 8  | Low   |
| Mei-Dan et al **80**       | + | – | – | + | + | + | + | – | – | – | – | – | – | + | + | + | – | – | – | – | – | – | – | – | – | – | 12 | Low  |
| Schilders et al **81**     | + | – | – | + | + | + | + | – | – | – | – | – | – | + | + | + | + | – | – | – | – | – | – | – | – | – | 19 | High |
| Bernhardt et al **82**     | + | + | – | – | + | + | + | – | – | – | – | – | – | + | + | + | – | – | – | – | – | – | – | – | – | – | 9  | Low   |
| Cavalli et al **83**       | + | – | – | – | – | – | – | – | – | – | – | – | – | + | + | + | – | – | – | – | – | – | – | – | – | – | 6  | Low   |
| de Queiroz et al **84**    | + | + | – | – | – | – | – | – | – | – | – | – | – | + | + | + | – | – | – | – | – | – | – | – | – | – | 9  | Low   |
| Sansone et al **85**       | + | + | – | – | + | + | + | – | – | – | – | – | – | + | + | – | – | – | – | – | – | – | – | – | – | – | 11 | Low  |

Percentage of agreement/item: 94, 81, 82, 97, 86, 81, 94, 94, 74, 96, 79, 82, 79, 100, 100, 92, 93, 85, 96, 74, 85, 94, 99, 99, 99, 82, 100.

D&B, Downs and Black.
Table 2. Outcomes of the high-quality studies per diagnosis

| Study Type | Diagnosis | Duration of symptoms (months) | Intervention treatment group(s) | Time to RTP (weeks) | D&B quality score (points) |
|------------|-----------|-------------------------------|---------------------------------|---------------------|-----------------------------|
| RCT        | Football  | 28.1                          | Exercise therapy (ET)           | 24                  | 24                          |
| RCT        | Football  | 30                            | Standard passive physical therapy (PT) | 23                  | 23                          |
| PCS        | Football  | 26.4                          | Surgical laparoscopic hernia repair with or without an adductor tenotomy (LR) | 21                  | 19                          |

*Significant improvement in favour of treatment group and control group, D&B, Downs and Black; NA, not applicable; NL, not listed; PCS, prospective case series; RCT, randomised controlled trial; RTP, return to play.

Low-quality studies result in better outcome

This is the first review on groin pain in athletes that demonstrated a relationship between study quality and treatment success—lower quality studies showed significantly higher treatment success. This is an important finding and highlights the fact that caution is needed when drawing conclusions based on low-quality studies. Previous studies on the management of tendinopathy also showed this inverse relationship, which is known as the ‘Coleman effect’. No significant relationship was found between either the percentage of athletes returning to play or the time to RTP and study quality. This is probably due to the fact that fewer studies could be included in these analyses, as these data were not reported in all studies, and that this type of data is more objective than treatment success, which is often defined according to a threshold set by the individual authors.

Quality assessment

We used the modified D&B quality assessment tool to evaluate the study quality, as it is a suitable tool for controlled trials as well as for case series and has good reliability. After modification of the original tool, there were still 27 items to assess, making it a complete assessment tool. The cut-off of 19 points, to discriminate high-quality and low-quality studies, is a dichotomous approach, but was deemed necessary to perform a reasonable best evidence synthesis. The cut-off used was modified from the existing literature. We did not perform a separate ‘risk of bias’ assessment as the D&B quality assessment tool examines the major sources of bias in its items. This is, in our opinion, a large improvement of the previous quality assessments in reviews on this topic, which have omitted a large number of studies from the quality assessment and have only used a subjectively determined evidence level cut-off, a modified generic quality appraisal tool or a seven-point bias-risk assessment.

The lack of high-quality studies in the field is highlighted in this systematic review. Only 6% were assessed as being high quality. The most frequent methodological flaws were the lack of a suitable control group, randomisation (including allocation concealment), and blinding of participants and those involved in

4 (6%) studies were high quality. Three of these studies were on athletes with long-standing adductor-related groin pain. According to the best evidence synthesis of this systematic review, there is currently moderate evidence that: (1) active exercise therapy improves treatment success when compared with passive treatments, (2) multimodal treatment with a manual therapy technique shortens the time to return to sports when compared to active exercise therapy and (3) adductor tenotomy improves treatment success over time.

For athletes suffering from sportsman’s hernia with or without ‘adductor tendinitis’, there is moderate evidence that surgery results in better treatment success compared with conservative therapy. There was limited evidence for all other treatment options that were evaluated in the included studies.

An important secondary finding in this systematic review is the inverse relationship between study quality and treatment success; the higher the study quality, the lower the treatment success. Over time, the quality of studies has not improved significantly. Notably, only one study included acute groin injuries. As this study was not considered high quality, no definite conclusions can be made regarding the treatment of this type of injury.
the treatment. Future studies should, therefore, use these features in the study design. There has been no significant improvement in the studies from 1985 to 2014. Even in recent publications many authors fail to report on basic information, and could have benefited from following reporting guidelines such as STROBE and CONSORT. This demonstrates that the current review process is not succeeding in enforcing these guidelines in new publications.

Many different diagnoses for groin pain
A major problem in the field of groin pain in athletes is the lack of consensus on diagnostic criteria. Our systematic review revealed that 33 different diagnoses were used for groin pain in athletes (see online supplementary table S3). Clear diagnostic criteria were frequently not reported and, if they were, many different diagnostic criteria were used (see online supplementary table S4). Consensus on diagnostic criteria in the field of groin pain in athletes would help to decrease heterogeneity between studies, and it would aid in interpreting and comparing studies for clinical decision-making. In a recent position statement, an expert group aimed to improve terminology for groin injuries in the inguinal region by adding a new term, ‘inguinal disruption’. This was defined but only covers one location of groin pain in athletes. While this systematic review is not designed to propose diagnostic criteria, we would like to emphasise the need for this.

Potential limitations of this systematic review
There are a few potential limitations of this systematic review. One limitation is that we analysed the results of the predefined outcome measures, or the final follow-up measurements if there was no predefined primary outcome, which was frequently the case. This may have resulted in a bias towards shorter follow-up times, and this fact is not obvious in some cases after the data extraction. For this reason we also extracted data of the time to RTP enabling readers to estimate the time of recovery. While only 38% of the included articles reported on the time to RTP the mean was 11 weeks across these studies. This could be helpful for clinicians when discussing prognosis with athletes in general. The large SD of 8 weeks should also be considered in this regard.

A second limitation may be the relatively high number of disagreements between the authors in the quality assessment. There was initial disagreement in 11% of the item scores, and in 3% this resulted in a difference between low and high quality after reaching agreement. There are two possible reasons for this result. First, a few items on the D&B assessment form are not optimally described, especially for case series. The questions on describing the patients lost to follow-up, those on external validity and the main outcome measures had the lowest level of agreement. Interpretation of the items is difficult in some cases. For example, we chose to award a point if estimates of the random variability in the data (item 7 of the D&B tool) were displayed for the extracted outcome measures. As we extracted multiple outcome measures, it was complex to evaluate this item in some cases. Second, the writing quality of the eligible articles was disappointing, and many authors did not follow the CONSORT or STROBE guidelines for their methods and results. The level of description in the articles makes it consequently challenging to find and interpret the requested data.
information. Failure to report according to the existing guidelines will probably result in more disagreements, as reviewers are forced to rely on assumptions. A clear description of the methods and results containing all relevant information makes assessing the quality much easier.

A third potential limitation of this systematic review is the fact that we were not able to pool data for a quantitative analysis. As stated in the methods, we would only do this if there was homogeneity of data. Owing to the obvious heterogeneity of the diagnoses, interventions, outcome measures, follow-up times and methodological quality, we refrained from statistical pooling of the data. A quantitative analysis has been performed using the calculated percentages of improvement in pain and/or function scores, which has also been carried out in previous systematic reviews. As this percentage improvement is dependent on the baseline score, it is less optimal. However, it was the best available measure we could apply to enable us to explore correlations between study quality and treatment success.

A fourth limitation is the fact that we excluded all low-quality studies before performing the best evidence synthesis. Another approach could be that we only included all RCTs in the best evidence synthesis, which is a common method. However, we wanted to stress the importance of the quality assessment. We are aware that even multiple low-quality studies may provide useful information, but on the other hand, this systematic review highlights the high risk of bias when evaluating treatment success with methodologically flawed studies. We feel this inverse relationship between methodological quality and reported success validates our choice not to pool many low-quality studies into the evidence synthesis. Our methods were predefined and documented in the PROSPERO International prospective register of systematic reviews (registration number CRD42014010262).

**Recommendations for future studies**

Future studies in this field should use appropriate control groups with blinding of patients and treatment assessors, if possible. Authors should follow the CONSORT or STROBE guidelines when reporting their studies to allow better evaluation of the quality. Although only RCTs will have the possibility for the optimal quality score, this study shows that the outcome in case series can also be relevant if performed and reported well. There is also a need for high-quality studies on acute groin injuries.

**CONCLUSION**

There are many publications on the effect of treatments in athletes with long-standing groin pain, but very limited information on acute groin injuries. Only 6% of the included studies were high quality. These studies include different treatments, so there is no strong evidence to support any single treatment option. There is currently moderate evidence for surgical and conservative treatment of athletes with long-standing adductor-related groin pain, and for surgical treatment of athletes with sportsman’s hernia. There was limited evidence for all other treatment options that were evaluated in the included studies.

Lower quality studies reported significantly higher treatment success, and study quality has not improved significantly over the past 30 years. There is a clear need for well-designed studies in this field with adequate reporting following the appropriate guidelines.

**What is already known?**

- Groin pain in athletes is difficult to treat and can result in prolonged absence from sporting activities.
- The best available evidence from two previous systematic reviews on treatment of groin pain in athletes was exercise therapy, but the evidence could be regarded as limited.
- A recent Cochrane review only included randomised controlled trials and concluded that there is insufficient evidence to advise a specific conservative treatment for exercise-related groin pain.

**What are the new findings?**

- Only 6% of the studies on treatment of athletes with groin pain are of high quality.
- There was a significant correlation between lower study quality and higher treatment success.
- For athletes with long-standing adductor-related groin pain there is moderate evidence that: (1) active exercises improve treatment success compared with passive treatments, (2) multimodal treatment with a manual therapy technique shortens the time to return to sports compared with active exercises and (3) adductor tenotomy improves treatment success over time.
- For athletes suffering from sportsman’s hernia with/without adductor tendinitis, there is moderate evidence that surgery results in better treatment success compared with conservative therapy.

**REFERENCES**

1. Bradshaw C, McCory P, Bell S, et al. Obturator nerve entrapment. A cause of groin pain in athletes. *Am J Sports Med* 1997;25:402–8.
2. Brukner P, Khan K, Brukner P, Brukner & Khan’s clinical sports medicine. 4th edn. Sydney; New York: McGraw-Hill, 2012.
3. Morelli V, Smith V. Groin injuries in athletes. *Am Fam Phys* 2001;64:1405–14.
4. Jansen JA, Mens JMC, Backx FJ, et al. Treatment of longstanding groin pain in athletes: a systematic review. *Scand J Med Sci Sports* 2008;18:263–74.
5. Amaon A, Sigurdsson SB, Gudmundsson A, et al. Risk factors for injuries in football. *Am J Sports Med* 2004;32(Suppl. 1):S5–16S.
6. Holmich P, Uhrskou P, Ulitski L, et al. Effectiveness of active physical training as treatment for long-standing adductor-related groin pain in athletes: randomised trial. *Lancet* 1999;353:439–43.

**Acknowledgements**

The authors would like to thank WM Bramer (biomedical information specialist in the Erasmus University medical centre, Rotterdam, the Netherlands) for assistance in the search strategy.

**Contributors**

R-vD performed the search strategy, data extraction and summary, analysed and interpreted the data, and wrote the first draft of the paper. BB performed the search strategy. AS and AV performed quality assessment, interpreted the data and revised the paper. CHvE and PH interpreted the data and revised the paper. All authors gave final approval for the version to be published.

**Competing interests**

None.

**Patient consent**

Obtained.

**Provenance and peer review**

Not commissioned; externally peer reviewed.

**Open Access**

This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/
7 Machorza Z, Kumar S, Perraton LG. A systematic review of the literature on the effectiveness of exercise therapy for groin pain in athletes. *Sports Med Arthrosc Rehabil Ther Tech* 2009;1:5.

8 Almeida MO, Silva BN, Andriolo RB, et al. Conservative interventions for treating exercise-related musculoskeletal, ligamentous and osseous groin pain. Cochrane Database Syst Rev 2013;6:CD009565.

9 de Vos RJ, Wind J, Weer A. Strong evidence against platelet-rich plasma injections for chronic lateral epicondylar tendinopathy: a systematic review. *Br J Sports Med* 2015;49:852–6.

10 Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *J Epidemiol Community Health* 1998;52:377–84.

11 Langham S, Langham J, Goertz HP, et al. Management of severe lower abdominal or inguinal pain. *J Bone Joint Surg Am* 2011;93:32–42.

12 Samocha D, Bruneljs DJ, Elbers NA, et al. Effectiveness of web-based interventions on patient empowerment: a systematic review and meta-analysis. *J Med Internet Res* 2010;12:e23.

13 Zou KH, Tuncali K, Silverman SG. Correlation and simple linear regression. *Radiology* 2003;227:617–22.

14 van Tulder M, Furlan A, Bombardier C, et al. Guideline for the management of chronic low back pain. *Spine* (Phila Pa 1976) 2003;28:1290–9.

15 Mozes M, Papa MZ, Zweig A, et al. Lower abdominal pain syndrome in soccer players. *Br J Sports Med* 2001;35:17–20.

16 Martens MA, Hansen L, Mulier JC. Adductor tendinitis and musculus rectus abdominis tendinopathy. *Am J Sports Med* 1987;15:353–6.

17 Martens MA, Hansen L, Mulier JC. Adductor tendinitis and musculus rectus abdominis tendinopathy. *Am J Sports Med* 1987;15:353–6.

18 Fricker PA, Taunton JE, Ammann W. Osteitis pubis in athletes. *Infection, inflammation or injury?* *Sports Med* 1991;12:266–9.

19 Polglaze AL, Frydman GM, Farmer KC. Inguinal surgery for debilitating chronic groin pain in athletes. *Med J Aust* 1991;155:674–7.

20 Shaker AM, El-Kader Shaheen MA, O’Neil PJ, et al. Traumatic aseptic osteitis pubis. *Ann Saudi Med* 1991;11:205–8.

21 Akermark C, Johansson C. Tenotomy of the adductor longus tendon in the treatment of chronic groin pain in athletes. *Am J Sports Med* 1992;20:640–3.

22 Malycha P, Lovell G. Inguinal surgery in athletes with chronic groin pain: the ‘sportmen’s’ hernia. *Aust N Z J Surg* 1992;62:123–5.

23 Holt MA, Keene JS, Graf BK, et al. Treatment of osteitis pubis in athletes: results of corticosteroid injections. *Am J Sports Med* 1995;23:601–6.

24 Simonet WT, Saylor IHL, Sim L. Abdominal wall muscle tears in hockey players. *Int J Sports Med* 1995;16:126–8.

25 Urquhart DS, Packer GJ, McLaughie GR. Return to sport and patient satisfaction levels after surgical treatment for groin disruption. *Sports Med* 1996;2:37–42.

26 Ingoldby CJH. Laparoscopic and conventional repair of groin disruption in sportmen. *Br J Surg* 1997;84:213–15.

27 Micheli LJ, Solomon R. Treatment of recalcitrant iliotibial bands in athletes and dancers with corticosteroid injection under fluoroscopy. *J Dance Med Sci* 1997;1:7–11.

28 Evans DS. Sports hernia: the diagnosis and laparoscopic management. *Sports Med* 1998;4:28–31.

29 Lacroix VJ, Kinnear DG, Mulder DS, et al. Lower abdominal pain syndrome in National Hockey League players: a report of 11 cases. *Clin J Sport Med* 1998;8:5–9.

30 Brannigan AE, Kerin MJ, McEntee GP. Gilmore’s groin repair in athletes. *J Orthop Sports Phys Ther* 2000;30:329–32.

31 Meyers WC, Foley DP, Garrett WE, et al. Management of severe lower abdominal or inguinal pain in high-performance athletes. *Am J Sports Med* 2000;28:2–8.

32 McKim KR, Taunton JE. The effectiveness of compression shorts in the treatment of athletes with osteitis pubis. *N Z J Sports Med* 2001;29:70–5.

33 Ekstrand J, Ringborg S. Surgery versus conservative treatment in soccer players with chronic groin pain: a prospective randomised study in soccer players. *Eur J Sports Med* 2001;31:141–5.

34 Irshad K, Feldman LS, Lavoie C, et al. Operative management of “hockey groin syndrome”: 12 years of experience in National Hockey League players. *Surgery* 2001;130:759–66.

35 Kumar S, Wilson G, Nixon SJ, et al. Chronic pain after laparoscopic and open mesh repair of groin hernia. *Br J Surg* 2002;89:1476–9.

36 O’Connell MJ, Powell T, McCaffey NM, et al. Symphysis clef injection in the diagnosis and treatment of osteitis pubis in athletes. *Am J Roentgenol* 2002;179:955–9.

37 Srinivasan A, Schurtz A. Long-term follow-up of laparoscopic preperitoneal hernia repair in professional athletes. *J Laparoendosc Adv Surg Tech A* 2002;12:1–10.

38 Biedert RM, Warnke K, Meyer S. Symphysis syndrome in athletes: surgical treatment for chronic lower abdominal, groin, and adductor pain in athletes. *Clin J Sport Med* 2003;13:278–84.
Chernyavsky VS, Davydov T, Trozskin SZ, et al. Athlete’s hernia—a true, early direct inguinal hernia: diagnosis, pathophysiology, and surgical treatment. *Am Surg* 2011;77:1472–6.

Pajanen H, Brinck T, Hermunen H, et al. Laparoscopic surgery for chronic groin pain in athletes is more effective than nonoperative treatment: a randomized clinical trial with magnetic resonance imaging of 60 patients with sportsman’s hernia (athletic pubalgia). *Surgery (USA)* 2011;150:99–107.

Preskitt JT. Sports hernia: the experience of Baylor University Medical Center at Dallas. *Bayl Univ Med Cent Proc* 2011;24:89–91.

Robertson IJ, Curran C, McCaffrey N, et al. Adductor tenotomy in the management of groin pain in athletes. *Int J Sports Med* 2011;32:45–8.

Dojcinovic B, Sebecic B, Staresinic M, et al. Laparoscopic surgery for chronic groin pain in athletes. *Int J Sports Med* 2012;36:2361–5.

Jans C, Messaoudi N, Pauli S, et al. Results of surgical treatment of athletes with sportsman’s hernia. *Acta Orthop Belg* 2012;78:35–40.

Maffulli N, Loppini M, Longo UG, et al. Bilateral mini-invasive adductor tenotomy for the management of chronic unilateral adductor longus tendinopathy in athletes. *Am J Sports Med* 2012;40:1880–6.

Messaoudi N, Jans C, Pauli S, et al. Surgical management of sportsman’s hernia in professional soccer players. *Orthopedics* 2012;35:e1371–5.

Comin J, Obaid H, Lammers G, et al. Radiofrequency denervation of the inguinal ligament for the treatment of ‘Sportsman’s Hernia’: a pilot study. *Br J Sports Med* 2013;47:380–6.

Economopoulos KJ, Milewski MD, Hanks JB, et al. Sports hernia treatment: modified Bassini versus minimal repair. *Sports Health* 2013;5:463–9.

Garvey JF, Hazard H. Sports hernia or groin disruption injury? Chronic athletic groin pain: a retrospective study of 100 patients with long-term follow-up. *Hernia* 2013 Published Online First: 12 October 2013.

Jakoi A, O’Neill C, Damsgaard C, et al. Sports hernia in National Hockey League players: does surgery affect performance? *Am J Sports Med* 2013;41:107–10.

Mei-Dan O, Lopez V, Carmont MR, et al. Adductor tenotomy as a treatment for groin pain in professional soccer players. *Orthopedics* 2013;36:e1189–e97.

Schilders E, Dimitrakopoulou A, Cooke M, et al. Effectiveness of a selective partial adductor release for chronic adductor-related groin pain in professional athletes. *Am J Sports Med* 2013;41:603–7.

Bernhardt GA, Gruber G, Molderings BS, et al. Health-related quality of life after TAPP repair for the sportsman’s groin. *Surg Endosc* 2014;28:439–46.

Cavalli M, Bombini G, Campanelli G. Pubic inguinal pain syndrome: the so-called sports hernia. *Surg Technol Int* 2014;24:189–94.

de Queiroz RD, de Carvalho RT, Szeles PR, et al. Return to sport after surgical treatment for puhlalgia among professional soccer players. *Rev Bras Ortop* 2014;49:233–9.

Sansone M, Ahlden M, Jonasson P, et al. Can hip impingement be mistaken for tendon pain in the groin? A long-term follow-up of tenotomy for groin pain in athletes. *Knee Surg Sports Traumatol Arthrosc* 2014;22:786–92.

Crowther M, Lim W, Crowther MA. Systematic review and meta-analysis methodology. *Blood* 2010;116:3140–6.

Tallon C, Coleman BD, Khan KM, et al. Outcome of surgery for chronic Achilles tendinopathy. A critical review. *Am J Sports Med* 2001;29:315–20.

de Vos RJ, van Veldhoven PL, Moen MH, et al. Autologous growth factor injections in chronic tendinopathy: a systematic review. *Br J Med Bull* 2010;95:63–77.

Schulz KF, Altman DG, Moher D, et al. CONSORT 2010 statement: updated guidelines for reporting parallel group randomized trials. *Ann Intern Med* 2010;152:726–32.

von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Lancet* 2007;370:1453–7.

Weir A. From disruption to consensus: the thousand mile journey. *Br J Sports Med* 2014;48:1075–7.

Sheen AJ, Stephenson BM, Lloyd OM, et al. ‘Treatment of the Sportsman’s groin’: British Hernia Society’s 2014 position statement based on the Manchester Consensus Conference. *Br J Sports Med* 2014;48:1079–87.

Serner A, et al. *Br J Sports Med* 2015;49:813. doi:10.1136/bjsports-2014-094256
### Supplementary table 1 - Search strategy

| Database                  | Records | Duplicates removed |
|---------------------------|---------|--------------------|
| Embase.com                | 1289    |                    |
| Medline (ovidSP)          | 838     |                    |
| Web-of-science            | 726     |                    |
| Scopus                    | 1317    |                    |
| CINAHL                    | 436     |                    |
| PubMed publisher          | 46      |                    |
| Cochrane                  | 20      |                    |
| Google Scholar            | 200     |                    |
| Sportdiscus               | 508     |                    |
| **Total**                 | **5380**| **2216**           |

Duplicates removed: 3164

**Embase.com - 1289**

('inguinal pain'/de OR ((pain/exp OR injury/exp OR tendinitis/de OR osteitis/de OR 'tendon injury'/exp OR 'muscle strain'/exp OR 'cumulative trauma disorder'/de) AND ('inguinal region'/exp OR 'inguinal hernia'/de OR 'pubis symphysis'/de OR 'iliopsoas muscle'/de OR 'rectus abdominis muscle'/de OR 'abdominal wall'/exp OR 'pubic bone'/de)) OR (((Athlet* OR Incipient OR sport* OR hockey OR soccer* OR football* OR rugby) NEAR/3 (Pubalgia* OR herni* OR groin*)) OR ((gilmore* OR disrupt* OR pain OR injur* OR pain* OR symphysit* OR tendinit* OR tendonit* OR tendinopat* OR tendinos* OR tenonit* OR tenontit* OR tenosit* OR rupture* OR Osteit* OR avuls* OR fracture* OR tear*) NEAR/6 (groin* OR inguin* OR pubic OR pubis OR iliopsoa* OR psoas* OR adductor* OR pubi* OR 'rectus abdominis' OR 'abdominal rectus' OR 'rectus abdominal' OR 'abdominal wall')):ab,ti) AND (athlete/de OR sport/exp OR 'sport injury'/exp OR 'sports medicine'/de OR (athlet* OR sport* OR football* OR soccer* OR rugb* OR hockey* OR cycli* OR runner* OR running* OR basketball* OR baseball* OR cricket* OR tennis* OR racquet*):ab,ti)

**Medline (ovidSP) - 838**

(((exp pain/ OR exp "Wounds and Injuries"/ OR injuries.xs. OR osteitis/) ) AND ("groin"/ OR "Inguinal Canal"/ OR "Hernia, Inguinal"/ OR "Pubic Symphysis"/ OR "Rectus Abdominis"/ OR "Abdominal Wall"/ OR "Pubic Bone"/) OR ((Athlet* OR Incipient OR sport* OR hockey OR soccer* OR football* OR rugby) ADJ3 (Pubalgia* OR herni* OR groin*)) OR ((gilmore* OR disrupt* OR pain OR injur* OR
sport* OR football* OR soccer* OR rugby* OR hockey* OR cycling* OR runner* OR running* OR basketball* OR baseball* OR cricket* OR tennis* OR racquet*)

**PubMed publisher - 46**

((((Athlet*[tiab] OR Incipient[tiab] OR sport*[tiab] OR hockey[tiab] OR soccer*[tiab] OR football*[tiab] OR rugby) AND (Pubalgia*[tiab] OR herni*[tiab] OR groin*[tiab]))) OR ((gilmore*[tiab] OR disrupt*[tiab] OR pain*[tiab] OR injur*[tiab] OR pain*[tiab] OR symphysit*[tiab] OR tendinit*[tiab] OR tendonit*[tiab] OR tendinopat*[tiab] OR tendinos*[tiab] OR tenonit*[tiab] OR tenontit*[tiab] OR tenosit*[tiab] OR rupture*[tiab] OR Osteit*[tiab] OR avuls*[tiab] OR fracture*[tiab] OR tear*[tiab]) AND (groin*[tiab] OR inguin*[tiab] OR pubic OR pubis OR iliopsoa*[tiab] OR psoas*[tiab] OR adductor*[tiab] OR pubi*[tiab] OR rectus abdominis*[tiab] OR abdominal rectus*[tiab] OR rectus abdominal*[tiab] OR abdominal wall*[tiab]))) AND (((Athlet*[tiab] OR sport*[tiab] OR football*[tiab] OR soccer*[tiab] OR rugby) AND (groin*[tiab] OR inguin*[tiab] OR pubic OR pubis OR iliopsoa*[tiab] OR psoas*[tiab] OR adductor*[tiab] OR pubi*[tiab] OR rectus abdominis*[tiab] OR abdominal rectus*[tiab] OR rectus abdominal*[tiab] OR abdominal wall*[tiab])))

**Cochrane - 20**

((((Athlet* OR Incipient OR sport* OR hockey OR soccer* OR football* OR rugby) NEAR/3 (Pubalgia* OR herni* OR groin*)) OR ((gilmore* OR disrupt* OR pain OR injur* OR pain* OR symphysit* OR tendinit* OR tendonit* OR tendinopat* OR tendinos* OR tenonit* OR tenontit* OR tenosit* OR rupture* OR Osteit* OR avuls* OR fracture* OR tear*) NEAR/6 (groin* OR inguin* OR pubic OR pubis OR iliopsoa* OR psoas* OR adductor* OR pubi* OR 'rectus abdominis' OR 'abdominal rectus' OR 'rectus abdominal' OR 'abdominal wall'))):ab,ti) AND (((Athlet* OR sport* OR football* OR soccer* OR rugby* OR hockey* OR cycling* OR runner* OR running* OR basketball* OR baseball* OR cricket* OR tennis* OR racquet*):ab,ti)

**Google Scholar - 200**

pains|injury|tendinitis|tendinopathy|osteitis|strain|trauma|inguinal|"pubis symphysis"|iliopsoas|"rectus abdominis"|"abdominal wall"|"pubic bone"|groin

**Athlete|Athletes|Incipient|sport|sportsmen|hockey|soccer|football|soccer|rugby|basketball|baseball**

**Sportdiscus - 508**

(MH "Groin Pain" OR MH "Sports Hernia" OR ((MH pain+ OR MH "WOUNDS & injuries+" OR MH osteitis+)) AND (MH "groin+" OR MH "Rectus Abdominis Muscles+" OR MH "Pubic Bone+"))) OR (((Athlet* OR Incipient OR sport* OR hockey OR soccer* OR football* OR rugby) N3 (Pubalgia* OR herni* OR groin*)) OR ((gilmore* OR disrupt* OR pain OR injur* OR pain* OR symphysit* OR...)}
tendinit* OR tendonit* OR tendinopat* OR tendinos* OR tenonit* OR tenontit* OR tenosit* OR rupture* OR Osteit* OR avuls* OR fracture* OR tear*) N6 (groin* OR inguin* OR pubic OR pubis OR iliopsoa* OR psoas* OR adductor* OR pubi* OR "rectus abdominis" OR "abdominal rectus" OR "rectus abdominal" OR "abdominal wall"))) AND (MH athletes+ OR MH sports+ OR MH "sports Injuries+" OR MH "sports medicine+" OR (athlet* OR sport* OR football* OR soccer* OR rugb* OR hockey* OR cycli* OR runner* OR running* OR basketball* OR baseball* OR cricket* OR tennis* OR racquet*)))
### Supplementary table 2 - Quality Assessment Tool: Modified Downs and Black scale

| Reporting                                                                 | YES (published) | No / Unable to Determine |
|--------------------------------------------------------------------------|-----------------|--------------------------|
| 1) Is the hypothesis/aim/objective of the study clearly described?       |                 |                          |
| 2) Are the main outcomes to be measured clearly described in the Introduction or Methods section? |                 |                          |
| 3) Are the characteristics of the patients included in the study clearly described? |                 |                          |
| 4) Are the interventions of interest clearly described?                   |                 |                          |
| 5) Are the distributions of principal confounders in each group of subjects to be compared clearly described? |                 |                          |
| 6) Are the main findings of the study clearly described?                  |                 |                          |
| 7) Does the study provide estimates of the random variability in the data for the main outcomes? |                 |                          |
| 8) Have all important adverse events that may be a consequence of the intervention been reported? |                 |                          |
| 9) Have the characteristics of patients lost to follow-up been described? |                 |                          |
| 10) Have actual probability values been reported?                         |                 |                          |
| **External validity**                                                    |                 |                          |
| 11) Were the subjects asked to participate in the study representative of the entire population from which they were recruited? |                 |                          |
| 12) Were those subjects who were prepared to participate representative of the entire population from which they were recruited? |                 |                          |
| 13) Were the staff, places, and facilities where the patients were treated, representative of the treatment the majority of patients receive? |                 |                          |
| **Internal validity - Bias**                                             |                 |                          |
| 14) Was an attempt made to blind study subjects to the                    |                 |                          |
| Question                                                                 | Answer |
|-------------------------------------------------------------------------|--------|
| intervention they have received?                                        |        |
| 15) Was an attempt made to blind those measuring the main outcomes of the intervention? |        |
| 16) If any of the results of the study were based on “data dredging”, was this made clear? |        |
| 17) In trials and cohort studies, do the analyses adjust for different lengths of follow-up of patients? |        |
| 18) Were the statistical tests used to assess the main outcomes appropriate? |        |
| 19) Was compliance with the interventions reliable?                     |        |
| 20) Were the main outcome measures used accurate (valid and reliable)?  |        |
| **Internal validity – Confounding (selection bias)**                    |        |
| 21) Were the patients in different intervention groups (trials and cohort studies) recruited from the same population? |        |
| 22) Were study subjects in different intervention groups (trials and cohort studies) recruited over the same period of time? |        |
| 23) Were study subjects randomised to intervention groups?              |        |
| 24) Was the randomised intervention assignment concealed from both patients and health care staff until recruitment was complete and irrevocable? |        |
| 25) Was there adequate adjustment for confounding in the analyses from which the main findings were drawn? |        |
| 26) Were losses of patients to follow-up taken into account?            |        |
| 27) Did the study have sufficient power to detect a clinically important effect? |        |
### Supplementary table 3 - Data extraction of the included articles listed according to diagnostic category

#### Inguinal-related

| Ref                  | Study type | N   | Mean Age (year) | Type of Sports | Diagnosis                      | Mean Duration symptoms (months) | Intervention treatment group                                             | Intervention control group(s)                                      | Mean follow-up (months) | Treatment success (%) | Athletes RTP (%) | D&B Quality score (points) |
|----------------------|------------|-----|-----------------|----------------|-------------------------------|--------------------------------|--------------------------------------------------------------------------------|---------------------------------------------------------------------|------------------------|-----------------------|-------------------|--------------------------|
| Comin et al. (2013)  | RCT        | 36  | 43.2            | Football       | Sportman’s hernia              | 9.1                            | Radiofrequency denervation of the ilioinguinal nerve and inguinal ligament (RF) | Corticosteroid injection inguinal ligament (CI)                       | 6                      | RF: 77%† CI: 8%         | RF: NL            | 18                       |
| Muschawek and Berger (2010) | PCS   | 87  | 29              | NL             | Sportman’s hernia              | 3                              | Surgical open hernia repair with or without partial removal of the genito-femoral nerve | NA                                                                         | 1                      | 79%                   | 84%               | 16                       |
| Canonico et al. (2007) | PCS     | 16  | 19              | Football       | Chronic inguinal pain         | NL                             | Surgical open hernia repair                                             | NA                                                                         | 12                     | 100%                  | 100%              | 14                       |
| Economopoulos et al. (2013) | CCT | 28  | 23.5            | NL             | Sportman’s hernia              | NL                             | Surgical open hernia repair (HR)                                        | Surgical minimal repair technique (MR)                               | 41                     | HR: 93% ¥ MR: 78%      | HR: 93%† MR: 64% | 14                       |
| Malycha and Lovell (1992) | RCS    | 44  | 25.4            | Football       | Sportman’s hernia              | 9                              | Surgical open hernia repair                                             | NA                                                                         | 6                      | 98%                   | 93%               | 13                       |
| Kumar et al. (2002)  | RCS       | 25  | 30              | Football       | Sportman’s hernia              | NL                             | Surgical external oblique repair and hernia repair                        | NA                                                                         | 6                      | 82%                   | 93%               | 12                       |
| Van Veen et al. (2007) | PCS     | 55  | 25              | Football       | Sportman’s hernia              | NL                             | Surgical laparoscopic hernia repair                                     | NA                                                                         | 3                      | 88%                   | 88%               | 12                       |
| Brannigan et al. (2000) | RCS     | 85  | 24              | Irish football  | Gilmore’s groin hernia         | 13.6                           | Surgical open hernia repair                                             | NA                                                                         | NL                     | 96%                   | 96%               | 11                       |
| Irshad et al. (2001)  | RCS       | 22  | 26              | Ice hockey     | Hockey groin syndrome          | 6                              | Surgical external oblique repair with neurotomy of the ilioinguinal nerve | NA                                                                         | 31.2                   | 82%                   | 100%              | 11                       |
| Paajanen et al. (2004) | RCS     | 41  | 27              | Football       | Sportman’s hernia              | 9.2                            | Surgical laparoscopic hernia repair                                     | NA                                                                         | 51                     | 95%                   | 95%               | 10                       |
| Lloyd et al. (2010)   | RCS       | 28  | 38.5            | NL             | Inguinal                      | 18                              | Surgical laparoscopic hernia repair                                     | NA                                                                         | 6                      | 57%                   | 92%               | 10                       |
| Study                          | Study Design | Country | Sport               | Hernia Type                        | Treatment                                                                 | N  | Outcome 1 | Outcome 2 | Outcome 3 | Notes |
|-------------------------------|--------------|---------|---------------------|------------------------------------|--------------------------------------------------------------------------|----|------------|------------|------------|-------|
| al. (2008)                    | RCS          | NL      | Rugby               | Inguinal ligament pathology        | Surgical open hernia repair                                             | NA | NL         | 100%       |           | 9     |
| Ingoldby (1997)               | RCS          | NL      | Rugby               | Inguinal ligament pathology        | Surgical open hernia repair                                             | NA | NL         | 100%       |           | 9     |
| Ekstrand and Ringborg (2001)  | RCT          | NL      | Football            | Chronic groin pain due to incipient hernia and/or nerve entrapment | Surgical open hernia repair with neurotomy of the ilio-inguinal and ilio-hypogastric nerves (OR) | 13 | OR: 94% (PT) 19% (ET) 39% (WS) | NL         | 9     |
| Srinivasan and Schuricht (2002) | RCS         | 15      | Football            | Sportman’s hernia                 | Surgical laparoscopic hernia repair                                      | NA | 12.1       | 100%       |           | 87%   |
| Bernhardt et al. (2014)       | PCS          | 28      | Football            | Sportman’s hernia                 | Surgical laparoscopic hernia repair                                      | NA | 94         | 88%        |           | 9     |
| Evans (1998)                  | RCS          | 154     | Football            | Sportman’s hernia                 | Surgical laparoscopic hernia repair                                      | NA | NL         | 99%        | 93%       | 8     |
| Edelman and Selesnick (1985)  | RCS          | 10      | Football and Basketbal | Sportman’s hernia                 | Surgical laparoscopic hernia repair                                      | NA | 12         | 80%        |           | 8     |
| Jakoi et al. (2013)           | RCS          | 43      | Ice Hockey          | Sportman’s hernia                 | Surgical treatment (not specified)                                      | NA | 24         | 27%        | 80%       | 8     |
| Smedberg et al. (1985)        | RCS          | 53      | Football            | Athletic groin hernia             | Surgical open hernia repair                                             | NA | 41         | 90%        | 98%       | 7     |
| Lacroix et al. (1998)         | RCS          | 11      | Ice hockey          | Lower abdominal pain syndrome     | Surgical external oblique repair with neurectomy of the ilio-inguinal nerve | NA | NL         | 91%        | 91%       | 7     |
| Ziprin et al. (2008)          | RCS          | 17      | NL                  | Sportman’s hernia                 | Surgical laparoscopic hernia repair                                      | NA | 6          | 94%        | 94%       | 7     |
| Messaoudi et al. (2012)       | RCS          | 71      | Football            | Sportman’s hernia                 | Surgical open hernia repair with bilateral percutaneous adductor release | NA | 48         | 100%       | 94%       | 7     |
| Steele et al. (2004)          | RCS          | 47      | Football and Australia football | Posterior inguinal wall deficiency | Surgical open hernia repair                                             | NA | NL         | 81%        | 77%       | 6     |
| Ref                      | Study type | N  | Mean Age (year) | Type of Sports | Diagnosis                      | Mean Duration symptoms (months) | Intervention treatment group | Intervention control group(s) | Mean follow-up (months) | Treatment success (%) | Athletes RTP (%) | D&B Quality score (points) |
|-------------------------|------------|----|-----------------|----------------|-------------------------------|---------------------------------|-----------------------------|--------------------------|------------------------|------------------------|---------------------|-----------------------------|
| Ahumada et al. (2005)   | RCS        | 12 | 25              | Running        | Sportman’s hernia             | 9                               | Surgical open hernia repair with or without adductor release | NA                       | 4                      | 100%                | 100%                | 6                   |
| Diaco et al. (2005)     | RCS        | 96 | NL              | NL             | Sportman's hernia             | NL                              | Surgical open hernia repair or laparoscopic repair with or without adductor release | NA                       | NL                     | 98%                 | 96%                 | 6                   |
| Cavalli et al. (2014)   | RCS        | 80 | 34.7            | NL             | Sportman's hernia             | NL                              | Surgical open hernia repair with neurectomy and with or without adductor/rectus abdominis release | NA                       | NL                     | 100%                | 100%                | 6                   |
| Simonet et al. (1995)   | RCS        | 10 | 25.5            | Ice hockey     | Sportman’s hernia             | 9.6                             | Surgical open hernia repair     | NA                       | NL                     | 100%                | 100%                | 5                   |
| Urquhart et al. (1996)  | RCS        | 24 | 31.8            | Football       | Groin disruption              | 6                               | Surgical open hernia repair     | NA                       | 12                     | 72%                 | 72%                 | 5                   |
| Susmailla et al. (2004) | RCS        | 35 | 24.3            | Football       | Sportman’s hernia             | NL                              | Surgical open hernia repair     | NA                       | 14.6                   | 97%                 | 97%                 | 5                   |
| Chernyavsky et al. (2011)| RCS        | 96 | 22.6            | Football       | Athlete’s Hernia             | NL                              | Surgical muscle repair with neurectomy of the affected nerves | NA                       | 1.5                    | 98%                 | 98%                 | 4                   |
| Preskitt (2011)         | RCS        | 100| NL              | NL             | Sportman’s hernia             | NL                              | Surgical open hernia repair     | NA                       | NL                     | 98%                 | 98%                 | 4                   |

### Public-related

| Ref                      | Study type | N  | Mean Age (year) | Type of Sports | Diagnosis                      | Mean Duration symptoms (months) | Intervention treatment group | Intervention control group(s) | Mean follow-up (months) | Treatment success (%) | Athletes RTP (%) | D&B Quality score (points) |
|-------------------------|------------|----|-----------------|----------------|-------------------------------|---------------------------------|-----------------------------|--------------------------|------------------------|------------------------|---------------------|-----------------------------|
| McKim and Taunton (2001)| PCS        | 11 | 38.9            | Football       | Osteitis pubis               | 20.6                            | Compression short             | NA                       | 0                      | 33%                  | NL                  | 16                   |
| Verrall et al. (2007)   | PCS        | 27 | 23              | Australia       | Pubic bone stress injury     | 4.5                             | Exercise therapy              | NA                       | 24                     | 74%                  | 100%                | 13                   |
| Holt et                 | RCS        | 11 | NL              | NL             | Osteitis                      | NL                              | Corticosteroid injection      | NA                       | NL                     | 91%                  | NL                  | 12                   |
| Study                                | Ref.          | N   | Mean Age (year) | Type of Sports | Diagnosis                  | Mean Duration symptoms (months) | Intervention treatment group                                                                 | Intervention control group(s) | Mean follow-up (months) | Treatment success (%) | Athletes RTP (%) | D&B Quality score (points) |
|--------------------------------------|---------------|-----|-----------------|----------------|----------------------------|--------------------------------|-------------------------------------------------------------------------------------------|-------------------------------|----------------------|----------------------|------------------|-----------------------------|
| Sansone et al. (2014)                | RCS 32 24     | Football | Pubalgia        | NL  | Surgical adductor and/or rectus abdominis tenotomy | NA                            | 72                                                                                       | 75%                           | 72%                  | 11                  |                 |                             |
| Radic and Annear (2008)              | RCS 23 27     | Australia n football | Osteitis pubis | 13.2 | Surgical curettage of the pubic symphysis | NA                            | 24.3                                                                                      | 74%                           | 70%                  | 10                  |                 |                             |
| Shaker et al. (1991)                 | RCS 78 22     | Football | Osteitis pubis  | 3   | NSAIDs and physical therapy. Corticosteroid injection pubic bone if non-response | NA                            | NL                                                                                       | 75%                           | 75%                  | 9                   |                 |                             |
| de Queiroz et al. (2014)             | RCS 30 24.4   | Football | Pubalgia        | 18.6 | Surgical adductor tenotomy                      | NA                            | 36                                                                                       | 100%                          | 100%                 | 9                   |                 |                             |
| O'Connel et al. (2002)               | RCS 16 28.4   | NL   | Osteitis pubis  | NL  | Corticosteroid injection symphysis              | NA                            | 6                                                                                         | 69%                           | 100%                 | 6                   |                 |                             |
| Fricker et al. (1991)                | RCS 45 30.3   | Running | Osteitis pubis  | 10.1 | NSAIDs and physical therapy                     | NA                            | 16.5                                                                                     | 75%                           | 49%                  | 5                   |                 |                             |
| Meyers et al. (2008)                 | RCS 546 0     | NL   | Football        | Athletic pubalgia | Surgical open muscle reattachments and/or releases | NA                            | NL                                                                                       | 95%                           | 95%                  | 2                   |                 |                             |

### Adductor-related

| Ref                  | Study type | N   | Mean Age (year) | Type of Sports | Diagnosis               | Mean Duration symptoms (months) | Intervention treatment group                  | Intervention control group(s) | Mean follow-up (months) | Treatment success (%) | Athletes RTP (%) | D&B Quality score (points) |
|----------------------|------------|-----|-----------------|----------------|-------------------------|--------------------------------|---------------------------------------------|--------------------------------|----------------------|----------------------|------------------|-----------------------------|
| Weir et al. (2011)   | RCT 48     | 28.1 | Football        | Long-standing adductor-related groin pain | 8                       | Exercise therapy and manual therapy (MM) | Exercise therapy (ET)                      | 5                             | MM: 50% † ET: 55%                 | MM: 50% † ET: 55% | 24                           |
| Holmich et al. (1999)| RCT 68     | 30   | Football        | Long-standing adductor-related groin | 9.9                     | Exercise therapy (ET) | Standard physical therapy (PT) | 6.5                           | ET: 74% † PT: 30%                  | ET: 79% † PT: 14% | 23                           |
| Study                | Year | Subjects | Sport                  | Condition                             | Treatment                          | Time to Return | Success Rate | Rate | References |
|---------------------|------|----------|------------------------|---------------------------------------|------------------------------------|----------------|--------------|------|------------|
| Schilders et al. (2013) | 2013 | 43       | Football               | Long-standing adductor-related groin pain | Surgical adductor tenotomy         | NA             | 40.2         | 81% | 98%        | 19 |
| Maffulli et al. (2012) | 2012 | 29       | Football               | Adductor longus tendinopathy          | Surgical bilateral percutaneous adductor tenotomy | NA             | 36           | 46% | 90%        | 17 |
| Weir et al. (2009)   | 2009 | 30       | Football               | Long-standing adductor-related groin pain | Manual therapy technique           | NA             | 9            | 84% | 90%        | 16 |
| Schilders et al. (2007) | 2007 | 24       | Football               | Adductor-related groin pain           | Corticosteroid injection symphysis | NA             | 12           | 33% | NL         | 14 |
| Schilders et al. (2009) | 2009 | 28       | Football               | Adductor longus dysfunction           | Corticosteroid injection symphysis | NA             | 12           | 68% | NL         | 14 |
| Atkinson et al. (2009) | 2009 | 48       | Australia football     | Long-standing adductor-related groin pain | Surgical percutaneous adductor tenotomy | NA             | 36           | 67% | 81%        | 13 |
| Weir et al. (2010)   | 2010 | 44       | Football               | Long-standing adductor-related groin pain | Exercise therapy and passive joint mobilisation | NA             | 22           | 71% | 77%        | 13 |
| Robertsson et al. (2011) | 2011 | 109      | Gaelic football        | Adductor tendinopathy                 | Surgical open adductor tenotomy    | NA             | 26           | 72% | 92%        | 11 |
| Schlegel et al. (2009) | 2009 | 19       | Rugby                  | Proximal adductor tendon rupture      | Exercise therapy (ET)              | Surgical adductor repair (SR)      | NL            | ET: 100% | SR: NA (n<10) | 10 |
| Akerman and Johansson (1992) | 1992 | 16       | Football and ice hockey | Chronic groin pain at the origin of the adductor longus muscle | Surgical adductor tenotomy         | NA             | 34.8         | 100%| 94%        | 9  |
### Iliopsoas-related

| Ref                | Study type | N  | Mean Age (year) | Type of Sports | Diagnosis                  | Mean Duration symptoms (months) | Intervention treatment group                     | Intervention control group(s) | Mean follow-up (months) | Treatment success (%) | Athletes RTP (%) | D&B Quality score (points) |
|--------------------|------------|----|-----------------|----------------|----------------------------|---------------------------------|---------------------------------|---------------------------|----------------------|----------------------|----------------------|-----------------------------|
| Mozes et al. (1985)| RCS        | 40 | 24              | Football       | Iliopsoas syndrome         | NL                              | Corticosteroid injection iliopsoas | NA                        | NL                   | 100%                 | 88%                 | 12                           |
| Micheli and Solomon (1997) | RCS | 13 | 17.7            | Dancers        | Iliopsoas tendinitis       | NL                              | Corticosteroid injection iliopsoas | NA                        | 13                   | 76%                  | NL                   | 6                             |

### Chronic groin pain

| Ref                | Study type | N  | Mean Age (year) | Type of Sports | Diagnosis                  | Mean Duration symptoms (months) | Intervention treatment group                     | Intervention control group(s) | Mean follow-up (months) | Treatment success (%) | Athletes RTP (%) | D&B Quality score (points) |
|--------------------|------------|----|-----------------|----------------|----------------------------|---------------------------------|---------------------------------|---------------------------|----------------------|----------------------|----------------------|-----------------------------|
| Mann et al. (2009) | PCS        | 73 | 30              | Football       | Chronic groin pain         | 5                               | Surgical laparoscopic hernia repair | NA                        | NL                   | 73%                  | 99%                 | 16                           |
| Jansen et al. (2009) | PCS | 21 | 24.8            | Football       | Chronic groin pain         | 9.3                             | Exercise therapy                 | NA                        | 14                   | 79%                  | NL                   | 14                           |
| Kluij et al. (2004) | RCS        | 14 | 36              | Football       | Chronic groin pain         | NL                              | Surgical laparoscopic hernia repair | NA                        | 12                   | 86%                  | 93%                 | 12                           |
| Genitsari et al. (2004) | RCS | 131 | 23.5           | Football       | Chronic groin pain         | 4.5                             | Surgical laparoscopic hernia repair | NA                        | 60                   | 99%                  | NL                   | 8                             |
| Van Der Donckt et al. (2003) | RCS | 41 | 27              | Football       | Chronic groin pain         | 15.2                            | Surgical open hernia repair with adductor release | NA                        | 150                  | 98%                  | 100%                | 7                             |
| Polglase et al. (1991) | RCS | 63 | 24              | Australiaan Football | Chronic groin pain         | 9.2                             | Surgical open hernia repair with or without division of the iliinguinal nerve | NA                        | NL                   | 95%                  | 95%                 | 6                             |

### Combined diagnoses

| Ref                | Study type | N  | Mean Age (year) | Type of Sports | Diagnosis                  | Mean Duration symptoms (months) | Intervention treatment group                     | Intervention control group(s) | Mean follow-up (months) | Treatment success (%) | Athletes RTP (%) | D&B Quality score (points) |
|--------------------|------------|----|-----------------|----------------|----------------------------|---------------------------------|---------------------------------|---------------------------|----------------------|----------------------|----------------------|-----------------------------|

**Notes:**
- RCS: Refereeing Centre Study
- PCS: Purely Clinical Study
- NL: Not listed
| (year)  | (months) | symptoms (months) | (months) |
|---------|----------|-------------------|----------|
| Paajanen et al. (2011) | RCT | 60 | 31 | Football | Sportman’s hernia and/or adductor tendinitis | 12.5 | Surgical laparoscopic hernia repair with or without an adductor tenotomy (LR) | Exercise therapy (ET) | 12 | LR: 97% † ET: 50% | LR: 97% † ET: 50% | 21 |
| Topol et al. (2005) | PCS | 24 | 25 | Rugby | Osteitis pubis and/or adductor tendinopathy | 15.5 | Dextrose injections painful sites | NA | 17.2 | 85% | 92% | 16 |
| Mei-Dan et al. (2013) | RCS | 140 | 23 | Football | Chronic groin pain with or without lower abdominal pain | 5 | Surgical adductor tenotomy with or without laparoscopic hernia repair | NA | NL | 80% | NL | 12 |
| Biedert et al. (2003) | RCS | 24 | 25.8 | Football | Chronic symphysis syndrome | 17 | Surgical rectus abdominis and/or adductor tenotomy | NA | 79.2 | 85% | 96% | 11 |
| Topol and Reeves (2008) | PCS | 72 | NL | Rugby | Chronic groin/abdominal pain | 11 | Dextrose injections adductors | NA | 26 | 80% | 92% | 11 |
| Meyers et al. (2000) | RCS | 157 | NL | Football | Lower abdominal pain syndrome or inguinal pain | 14.4 | Surgical reattachment rectus abdominis with or without adductor release | NA | 46.8 | 95% | 95% | 9 |
| Martens et al. (1987) | RCS | 81 | 26.3 | Football | Adductor tendinitis and/or | 10 | Surgical adductor and/or rectus abdominis tenotomy | NA | 24 | 88% | NL | 8 |
| Study                          | Design | Patients | Football | Diagnosis                                      | Treatment                                                                 | N  | Success 1 | Success 2 | Review |
|-------------------------------|--------|----------|----------|------------------------------------------------|---------------------------------------------------------------------------|----|-----------|-----------|--------|
| Dojcinović et al. (2012)      | PCS    | 99       | 23.9     | Football Sportsman’s hernia and/or adductor tendinosis | Surgical open hernia repair with neurectomy and with or without adductor release | NA | 12        | 96%       | 97%    | 7      |
| Brown et al. (2008)           | RCS    | 98       | 27.1     | Ice hockey Intractable lower abdominal and groin pain | Surgical external oblique repair with neurectomy of the ilio-inguinal nerve | NA | NL        | 99%       | 99%    | 4      |
| Garvey and Hazard (2013)      | CCT    | 66       | 33       | NL Multiple diagnoses related to groin pain         | Surgical treatment (various) (ST) Standard physical therapy and corticosteroid injection (PT) | 156| ST: 94% ¥ | PT: 93%   | ST: NL | 2      |

RCT = Randomised Controlled Trial, PCS = Prospective Case Series, RCS = Retrospective Case Series, N = Number, NA = Not Applicable, NL = Not Listed. † = significant improvement in favour of treatment group, ¥ = no significant difference in outcome between treatment groups.
### Supplementary table 4 – reported diagnostic criteria

| Reference          | Diagnosis                                      | Described diagnostic criteria                                                                                                                                                                                                 |
|--------------------|------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mozes et al. (1985) | Clinically diagnosed “Iliopsoas syndrome”     | Lower abdominal pain, lateral to the rectus abdominis muscle and above the inguinal ligament. Pain provocation with hip flexion and forward kicking of the ball. X-ray and US for exclusion of other pathologies.                                          |
| Smedberg et al.    | Athletic groin hernia confirmed by herniography| Groin pain with positive herniography. After positive herniography re-examination was performed to confirm if pain was a result of the hernia.                                                                                                                                       |
| Martens et al. (1987) | Clinically diagnosed adductor tendinitis and/or rectus abdominis tendopathy | Adductor tendinitis: Pain when sprinting, pivoting, and shooting. Pain increases with fatigue and after sports activity. Stiffness the following day. Pain is situated in the groin. On PE there is local tenderness on deep pressure over the gracilis and adductor brevis muscles near the insertion. A painful active adduction in extension is noted. Rectus abdominis tendopathy: pain in the lower abdominal region when sprinting and on sudden movements. Pain after sports and also upon coughing. Local tenderness is primarily located at the insertion on the superior pubic ramus on PE. Pain in the lower abdominal region upon lifting both legs from the examination table. X-ray in both diagnoses negative. |
| Fricker et al. (1991) | Clinical and radiological diagnosis of osteitis pubis in medical record | Clinical: gradually increasing discomfort in the pubic area, adductor area or the area of the lower rectus abdominis muscle. Movements such as kicking, running and pivoting on one leg typically aggravates the pain. Signs of osteitis pubis include tenderness of the symphysis pubis and adjacent pubic bodies and rami, and pain on adductor muscle stretch. Radiological: X-ray shows rarefaction and/or cystic changes of the symphysis margins with widening of the joint. A bone scan with 99mTc-methylenedi-phosphonate shows increased tracer uptake in the region of the symphysis. |
| Polglase et al. (1991) | Clinically diagnosed chronic groin pain       | Lower abdominal wall pain, radiating to the medial thigh. Pain aggravated by running, kicking, coughing, sneezing and jumping. X-rays were normal, bone scans and peritoneography could be positive.                                                                 |
| Shaker et al. (1991) | Clinically diagnosed traumatic aseptic osteitis pubis | Pain in the leg, hip, groin, symphysis or lower abdomen in relation to sports activity. PE may show local palpation tenderness and/or pain on adductor squeeze. Radiological examinations may be normal or show a wide range of abnormalities.                                                                 |
| Akermark and Johansson (1992) | Clinically diagnosed long-standing groin pain at the origin of the adductor longus muscle | Long-standing groin pain on exertion, clinically localized to the proximal adductor longus muscle. Pain had to be refractory to conservative treatment. On PE active and passive muscle testing and palpation of the different adductor muscles. Negative PE of the rectus femoris and rectus abdominis muscles, hernias, entrapment neuropathies, tumours in the groin area, urogenital diseases and injuries in the lumbar region or sacroiliac joint. X-rays were performed. |
| Malycha and Lovell | Chronic undiagnosed                           | Chronic groin pain which did not respond to conservative treatment and had negative clinical                                                                                                                                         |
| Reference          | Diagnosis/Description                                           | Clinical Findings/Investigations                                                                 |
|--------------------|------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| (1992)             | Groin pain (consistent with diagnosis of sportman's hernia)     | Examination and investigations (X-ray, and in some cases bone scan and/or herniography) for other pathology. All athletes had local tenderness above the inguinal ligament, lateral and superior to the pubic tubercle. Athletes had either ceased playing sport or had marked impairment of performance. |
| Holt et al. (1995) | Clinically diagnosed osteitis pubis                              | An insidious onset of pain in the adductor musculature, which aggravates with activities like kicking, running and pivoting. Pain located on the pubic symphysis and lower abdominal musculature. On PE tight adductors that are painful on resisted contraction tests and there tenderness on palpation of the pubic symphysis. Standard radiographs and bone scans confirm the diagnosis. |
| Simonet et al. (1995) | Clinically diagnosed sportman’s hernia (radiological exclusion of other diagnoses) | Pain in the lower abdominal area, increasing during sport activities. On PE localised pain on palpation internal inguinal ring. X-ray, ultrasound, MRI or bone scan was performed and did not show abnormality. |
| Urquhart et al. (1996) | Clinically diagnosed groin disruption                           | Well-localised pain in the groin region which eventually results in inability to participate in sports. Radiation of pain is possible. Conservative treatment is frequently ineffective. On PE, there is a dilated external ring which is tender on palpation. Palpation pain may also be present on the pubic tubercle and mid-inguinal region. A cough impulse can be palpated. A CT-herniogram can be positive. |
| Ingoldby (1997)    | Clinically diagnosed inguinal canal-related pain                 | Persistent pain located at the inguinal canal which prevented regular activities for 3 months or more. Patients with a hernia or pelvic pain were excluded. |
| Micheli and Solomon (1997) | Clinically diagnosed iliopsoas tendinitis            | A slow progressive onset of an initially painless snap that occurs in performing the manoeuvre of dévelopé to the side. In particular, this snap occurs as the leg is brought down from the elevated, abducted, and externally rotated position of the hip and aligned with the standing leg. Subsequently there is pain accompanying the snap, and this pain progresses to the point where dancing must be discontinued. On PE, there is a positive provocative hyper-flexion test, pain on resisted adduction in "frog" position and an iliopsoas stress test. |
| Evans (1998)       | Clinically diagnosed sports hernia                              | Lower abdominal pain which increased during sports activity. The pain could be present during coughing or sneezing and radiation can be present. Conservative treatment fails and patients have to stop sports activities. On PE, the direct stress examination test (lower abdomen painful on palpation during sit-up) must be positive. |
| Lacroix et al. (1998) | Clinically diagnosed lower abdominal pain syndrome (radiological exclusion of other diagnoses) | Pain in the lower abdominal area, which prevented athletes from sport activities. On PE no signs of hernia. X-ray, ultrasound, CT, MRI or bone scan was performed and did not show abnormalities. |
| Study                  | Diagnosis                                                                 | Clinical Criteria                                                                                                                                                                                                 |
|-----------------------|---------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Holmich et al. (1999) | Clinically and/or radiologically diagnosed adductor-related groin pain    | Pain on palpation of the adductor tendons or the insertion on the pubic bone, or both, and groin pain during active adduction against resistance. Moreover, a minimum of 2 of the following 4 criteria had to be met: (1) a characteristic history of, for instance, groin pain and stiffness in the morning, groin pain at night, groin pain with coughing or sneezing; (2) pain at palpation of the symphysis joint; (3) increased scintigraphic activity in the pubic bone; (4) radiographic signs of osteitis pubis around the symphysis joint. Other causes (hernia, neurogenic, hip-related, malignancy, bursitis of systemic disorders) were excluded. |
| Brannigan et al. (2000)| Clinically diagnosed Gilmore’s groin hernia                                | Chronic pain in the area around the pubic tubercle of the affected groin. Increasing pain after sports and during increased intra-abdominal pressure (e.g. coughing). On PE, the pubic tubercle is the site of maximum pain. In addition, the superficial inguinal ring is typically dilated upon scrotal invagination, easily admitting the tip of the index finger. |
| Meyers et al. (2000)  | Clinically diagnosed lower abdominal pain syndrome or inguinal pain        | Chronic inguinal or pubic-area pain in athletes, that is exertional only and not explainable preoperatively by a palpable hernia or other medical diagnosis. Pain can be bilateral and located on the medial thigh. The pain negatively influenced athletic activity. Radiological examination was performed in many cases, but not structurally. |
| McKim et al. (2001)   | Clinically diagnosed Osteitis pubis                                       | The diagnosis of osteitis pubis was made by PE, which included tenderness over the symphysis, tenderness of the inferior pelvic rami, positive squeeze test and possible pain centrally on single leg hop. This was confirmed by the finding of increased tracer uptake in the region of the symphysis pubis on a delayed view bone scan. |
| Ekstrand and Ringborg  | Chronic groin pain due to incipient hernia and/or nerve entrapment, diagnosed with herniography and/or nerve block test | More than 3 months of pain in the groin area with positive herniography and/or nerve block test of the ilio-inguinal or ilio-hypogastric nerve.                                      |
| Irshad et al. (2001)  | Clinically diagnosed hockey groin syndrome                                 | Pain exacerbated by pushing off the skates or taking a slap-shot. Gradual onset of pain and exacerbation by ipsilateral hip extension and contralateral torso rotation. PE reveals tenderness in the affected groin and absence of a clinically apparent inguinal hernia. No standardised radiological work-up, but in many cases the additional diagnostics were performed and negative. |
| Kumar et al. (2002)   | Clinically diagnosed Sports hernia                                        | Chronic groin pain which was exacerbated by sports activity or coughing/sneezing. No effect of conservative treatment, including stretching and strengthening exercises. On PE a painful palpation of the inguinal canal and pubic tubercle which increased during a sit-up or coughing. Radiological |
| Reference | Description |
|-----------|-------------|
| O’Connell et al. (2002) | Clinically and radiologically diagnosed Osteitis pubis |
| O’Connell et al. (2002) | Debilitating groin pain in combination with a radiological sign of osteitis pubis: (1) Radiographic visualisation of an articular surface irregularity, erosion, sclerosis and osteophyte formation. Symphysal joint laxity or disruption was diagnosed in patients with widening of the joint space > 7 mm and malalignment of the upper margins of the superior pubic rami of > 2 mm on flamingo views. (2) Scintigraphic criteria for the diagnosis of osteitis pubis were focal accumulation of radionuclide at or adjacent to the symphysis pubis on delayed scans. (3) The MRI criteria for the diagnosis of osteitis pubis were visualisation of an articular surface irregularity on coronal T1-weighted images and axial T2-weighted images and para-articular marrow edema on fat-suppressed coronal images. |
| Srinivasan and Schuricht (2002) | Clinically diagnosed Sports hernia |
| Srinivasan and Schuricht (2002) | Pain worsening with athletic activity. Hernias were classified according to the grading system developed by Nyhus. |
| Biedert et al. (2003) | Clinically diagnosed chronic symphysis syndrome |
| Biedert et al. (2003) | Chronic pain during sports activities in the lower abdominal area, which may be accompanied by pain in the adductor region. Pain on palpation was located in all patients in the inguinal canal, at the lateral border of the sheath of the rectus abdominis muscle, in the insertion area on the pubis and along the adductor muscles near the pubis. |
| Van Der Donckt et al. (2003) | Clinically diagnosed chronic groin pain |
| Van Der Donckt et al. (2003) | Groin pain for > 6 months which did not improve after conservative treatment for at least 6 months. Patients were selected after careful screening of all the differential diagnostic possibilities. |
| Genitsaris et al. (2004) | Clinically diagnosed chronic groin pain |
| Genitsaris et al. (2004) | Persistent groin pain, despite initial conservative treatment for 6 months. Physical signs could include a dilated external ring, hernia or PE could be normal. Other causes of groin pain were excluded (not specified). |
| Kluin et al. (2004) | Undiagnosed chronic groin pain |
| Kluin et al. (2004) | Undiagnosed groin pain for at least 3 months that does not respond well to conservative measures including prolonged rest. The pain must be related to sport and must make sport on the patient’s desired level impossible. Imaging (X-ray, ultrasound and bone scan) must be negative. |
| Paajanen et al. (2004) | Clinically diagnosed sportman’s hernia (radiological exclusion of other diagnoses) |
| Paajanen et al. (2004) | A typical history associated with deep palpation pain at pubic tubercle was considered diagnostic. Other causes of groin pain were clinically or radiologically excluded. |
| Steele et al. (2004) | Clinically diagnosed posterior inguinal wall deficiency |
| Steele et al. (2004) | A history of chronic groin pain in the inguinal region with or without radiation to the testicle or upper medial thigh, and worse with cough or sit-up. The tenderness was located at the superficial inguinal ring or conjoint attachment to the pubic tubercle. Patients with tenderness at the pubic symphysis, a direct inguinal hernia or adductor origin pain were considered to have coexistent pathology and were not included. |
| Author(s)               | Diagnosis/Description                                                                 | Description                                                                                                                                                                                                 |
|------------------------|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Susmallian et al. (2004) | Sportman's hernia                                                                      | A history of > 1 year chronic groin pain with conservative treatment that had failed.                                                                                                                       |
| Ahumada et al. (2005)  | Clinically diagnosed sportman's hernia                                                  | Groin pain that did not respond to physical therapy. Symptoms exacerbated by activity and temporarily relieved with rest. The pain manifests as point tenderness over the pubis at the rectus abdominus muscle origin. Exclusion of other causes: prostatitis, epididymitis, urethritis, hydrocele, inguinal hernia, osteitis pubis, bursitis, gynaecologic disorders and arthritis of the hip. |
| Diaco et al. (2005)    | Clinically diagnosed sportman's hernia                                                  | Groin pain associated with running, cutting, or bending. No pain with rest, but, increased pain after activity. Groin pain for 3 months or longer and no other causes.                                                |
| Topol et al. (2005)    | Clinically diagnosed osteitis pubis and/or adductor tendinopathy                        | Chronic groin pain that blocked full performance in sports and occurred with activities of daily living. No effect of physiotherapy modalities.                                                             |
| Canonico et al. (2006) | Clinically and radiologically diagnosed chronic inguinal pain                          | The presence of a groin hernia or a wide internal ring and peritoneal dimple as assessed using inguinal dynamic ultrasound. Absence of adductor muscle injury and skeletal changes. |
| Edelman and Selesnick (2006) | Sportman's hernia, diagnosed as a tear in the transversalis fascia during surgery    | A tear in the transversalis fascia that was not evident on preoperative physical exam, but present during surgery. No response to conservative treatment. Radiological exams negative. |
| Schilders et al. (2007) | Clinically diagnosed adductor-related groin pain                                       | An athlete with tenderness localized to the adductor longus origin, pain on passive stretching of the adductors, and pain on adduction of the thigh against resistance, and failure to respond to non-operative treatment. Absence of a clinical diagnosis of osteitis pubis or a sports hernia, or clinical and/or radiological evidence of hip joint pathology. |
| Van Veen et al. (2007) | Clinically diagnosed sportman's hernia, radiological exclusion of other causes         | Groin pain related to sports activities. The pain existed for at least 3 months and did not respond to conservative therapy. Radiological (radiograph, ultrasound, bone scan or MRI) exclusion of other causes. |
| Verrall et al. (2007)  | Clinically and radiologically diagnosed pubic bone stress injury                      | Chronic groin pain that had been present for longer than 6 weeks in duration, with impaired training and/or playing performance, and a diagnosis of non–hip-related cause for their groin pain. Pain located at the anterior groin, adductor region or lower abdominal region central. PE showed tenderness on the pubic symphysis, superior pubic ramus, and/or pubic bone at the adductor origin and positive pubic pain provocation tests: squeeze and bilateral adductor. MRI criteria was extensive pubic bone marrow edema |
| Study                          | Diagnosis                                      | Clinical Symptoms                                                                                           | Imaging/Exam Findings                                                                                     |
|-------------------------------|-----------------------------------------------|-------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| Brown et al. (2008)           | Clinically diagnosed "intractable lower abdominal and groin pain" | Pain increasing in intensity during ice hockey with acceleration or changing direction. Dramatic reduction of performance. Pain on coughing or sneezing and arising out of bed. On PE, all patients exhibited varying degrees of tenderness on palpation of the inguinal region, especially over the external inguinal ring. Radiological examinations were frequently negative. |
| Lloyd et al. (2008)           | Clinically diagnosed "inguinal ligament pathology" | Chronic groin pain for 8 weeks or longer with no improvement after rest, limitation of sports activity, or physiotherapy. On PE, there had to be localized tenderness over the insertion of the inguinal ligament and superficial ring with no overt evidence of a hernia. In addition, the pain had to be reproduced on straining with the Valsalva manoeuvre of sitting up against resistance. |
| Meyers et al. (2008)          | Clinically diagnosed "athletic pubalgia"       | Diagnosis of the various clinical entities were made by a combination of history and physical examination, and in more recent years supported by new MRI techniques. |
| Radic and Annear (2008)       | Clinically diagnosed "osteitis pubis"          | A typical history of gradually increasing unilateral or bilateral discomfort or pain in the pubic area, 1 or both groins (adductor areas), and the area of the lower rectus abdominis muscle. Additional signs of osteitis pubis include tenderness of the symphysis pubis and adjacent pubic bodies and rami, as well as pain on adductor muscle stretch. Various imaging techniques such as plain radiographs, bone scans, and MRI have been used to augment this diagnosis but these may be normal. |
| Topol and Reeves (2008)       | Clinically diagnosed "chronic groin/abdominal pain" with a positive local anaesthetic injection test | Athletes were required to be both “elite” and “impaired.” Reproduction of the athlete’s pain was required by palpation of the pelvic rim and/or ischiopubic ramus with abdominal or thigh adductor contraction against manual resistance by the examiner. No response after conservative treatment program of at least 2 months. > 90% of pain relief after a local anaesthetic injection on the most painful location. |
| Ziprin et al. (2008)          | Clinically diagnosed sportman’s hernia         | Groin pain not present at rest and increased on sudden movement, on coughing, and came on after participation in sports activity. A slow onset of pain over a period of time. On PE, there had to be tenderness in the midinguinal region, and a positive stress test (i.e., tenderness over the affected inguinal region on coughing or straining) and the absence of a true hernia. Each patient had failed with non-operative treatment. Investigations included radiographs of the pelvis, ultrasonography, bone scan and MRI. All these investigations were found to be normal in all patients. |
| Atkinson et al. (2009)        | Clinically diagnosed chronic adductor-related groin pain | Chronic sports-related groin pain that did not respond to physiotherapy. On PE there was tenderness at the adductor longus origin and a positive ‘squeeze’ test. |
| Jansen et al. (2009)          | Clinically diagnosed longstanding groin         | Groin pain that restricted athletes from sports participation for at least 4 weeks, with motivation to return to sports. On PE, the groin pain needed to be provoked during a squeeze test. Other causes (acute |
| Reference | Diagnosis/Description |
|-----------|---------------------|
| Mann et al. (2009) | Clinically diagnosed chronic groin pain |
| Schilders et al. (2009) | Clinically diagnosed adductor longus dysfunction |
| Schlegel et al. (2009) | Clinically diagnosed and radiologically confirmed proximal adductor tendon rupture |
| Weir et al. (2009) | Clinically diagnosed chronic adductor-related groin pain |
| Muschaweck and Berger (2010) | Clinically and ultrasonographically diagnosed Sportman’s groin |
| Chernyavsky et al. (2011) | Clinically diagnosed Athlete’s Hernia |

Pain associated with resisted hip adduction, trauma, indications of fracture, hip arthritis, inguinal and/or femoral hernia, bursitis, referred pain, organ-related symptoms, psychopathology, systemic disease, earlier surgery in the groin region, visually abnormal anatomy of the hip, back, or pelvis) were excluded.

Groin pain with no improvement following rest or limitation of sporting activity, physiotherapy, injection or previous surgery. Symptoms had to be present for at least 6 weeks. On PE, there had to be localised tenderness over the insertion of the inguinal ligament and superficial ring with no overt evidence of a hernia. Increased pain on coughing while the inguinal ligament attachment was palpated. Pain on pubic tubercle palpation and ipsilateral hip flexion with adduction against resistance. The pain had to be reproduced on straining with the Valsava manoeuvre of sitting up against resistance. Imaging was not routinely used in preoperative assessment.

A recreational athlete with clinical adductor dysfunction, diagnosed as pain reproduced by (1) palpation of enthesis, (2) passive stretching of adductors, and (3) active resisted adduction. There had to be failure of conservative treatment. Patients were excluded if there was any clinical evidence of sports hernia or osteitis pubis or any clinical or radiological evidence of hip joint pathology.

A proximal adductor injury confirmed by MRI.

A minimum of 2 months of pain in the groin during or after sport together with pain during or after sports at the proximal insertion of the adductors; together with pain on palpation at the proximal insertion of the adductors and a positive-resisted adduction test. Athletes with suspicion of inguinal or femoral hernias, prostatitis or urinary tract infections, lumbar spine pathology, hip arthritis or impingement, bursitis, nerve entrapment or knee ligament instability were excluded.

Groin pain, often with radiation down the inner thigh, the scrotum, the testicles, and the pubic bone. On PE, no inguinal hernia was found, but there was a localised bulge in the posterior wall of the groin canal during the Valsalva manoeuvre. On ultrasonography, a convex anterior bulge of the posterior inguinal wall was observed during stress.

Groin pain with an insidious onset and superomedial thigh pain without a specific inciting event. The pain is frequently intense, especially while trying to participate in physical activity, and subsides with rest. On PE, there is tenderness, especially deep and
inferior to the inguinal ligament. The external ring is often palpably widened, especially when compared with the asymptomatic side. There is no true hernia. Radiological examinations are frequently negative.

| Authors          | Diagnosis                                                                 | Description                                                                                                                                 |
|------------------|---------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Paajanen et al. (2011) | Clinically diagnosed Sportman's hernia and/or adductor tendinitis    | Sportman's hernia: Groin symptoms that had persisted for 3-6 months. The location of pain had to be rostral to the inguinal ligament in the deep inguinal ring on palpation, with or without tenderness over the pubic symphysis or tubercle, or at the insertion of adductor tendons. A dull, diffuse pain in the groin, often radiating to the perineum and inner thigh or across the mid-line could be present. Imaging studies only were not decisive, but exclusion criteria were isolated adductor tendinitis, avulsion fractures of the pelvic bone, obvious inguinal hernias, suspicion of inguinal nerve entrapment, referred spinal pain, disorders of the hip joint or bursitis, and any gynecologic, urologic, or suspected bowel pathology. Adductor tendinitis: distinct pain at the proximal origin of the adductor longus muscle and tendon and provocation of pain at exertion to the proximal part of the adductor longus muscle. |
| Preskitt (2011)   | Clinically diagnosed sports hernia                                        | A deep lower abdominal or groin pain, exacerbated with sport-specific activities and relieved with rest. The most specific signs are tenderness over the medial inguinal floor and pain in the inguinal floor with a resisted sit-up. Other causes of pain must be ruled out: genitourinary, intra-abdominal, gynaecological, hip/lumbar, or other muscular strains and sprains. |
| Robertson et al. (2011) | Clinically diagnosed adductor tendinopathy. Radiological exclusion of other causes in case of suspicion | Pain and tenderness of the adductor longus origin of greater than 3 months duration with a positive squeeze test. MRI was reserved for those patients where coexistent pathologies such as osteitis pubis or hip joint pathology were suspected, which were excluded. |
| Weir et al. (2011-Phys Ther) | Clinically diagnosed longstanding adductor-related groin pain | A minimum of 1 month of pain in the groin during or after sport together with pain during or after sports at the proximal insertion of the adductors; together with pain on palpation at the proximal insertion of the adductors and a positive-resisted adduction test. Athletes with suspicion of inguinal or femoral hernias, pain above the inguinal ligament, prostatitis or urinary tract infections, lower back pain, hip arthritis, bursitis or nerve entrapment were excluded. |
| Weir et al. (2011 - Man Ther) | Clinically diagnosed chronic adductor-related groin pain | A minimum of 2 months of pain in the groin during or after sport together with pain during or after sports at the proximal insertion of the adductors; together with pain on palpation at the proximal insertion of the adductors and a positive-resisted adduction test. Athletes with suspicion of inguinal or femoral hernias, pain above the inguinal ligament, prostatitis or urinary tract infections, lower back pain, hip arthritis, bursitis, nerve entrapment or knee ligament instability were excluded. |
| Dojcinovic et al. (2012) | Clinically diagnosed Sports hernia and/or                              | Sports hernia: chronic pain of varying intensity in the region of lower abdominal wall, resistant to conservative treatment. Ultrasonography was performed. Adductor tendinosis: in case of clinical |
| Authors             | Diagnoses                                      | Description                                                                                                                                                                                                 |
|---------------------|------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Jans et al. (2012)  | Clinically diagnosed sportman's hernia.        | A painful palpation of the conjoint tendon and the pubic tubercle. In some cases the experienced clinician can find a dilated and hypersensitive outer inguinal ring. Resisted forceful sit-ups and hip adduction are painful. Furthermore, PE was done to exclude Femoroacetabular Impingement, a true hernia and intra-abdominal pathology. Radiology (X-ray, ultrasonography, MRI or bone scan) was performed to exclude other causes of pain. |
| Maffulli et al. (2012) | Clinically diagnosed unilateral adductor longus tendinopathy | Presence of groin pain and functional limitation which did not respond to 6-month non-operative treatment. The clinical diagnosis was made if 3 tests were positive: tenderness localised to the adductor longus origin, pain on passive stretching of the adductors, and pain on adduction of the thigh against resistance. Other causes (hip pathology, osteitis pubis, hernia or urological disorders) were excluded with PE and/or imaging and/or referral to a specialist. |
| Messaoudi et al. (2012) | Clinically diagnosed Sportman's hernia | A dull, chronic groin pain, with an insidious onset which is intensified by running and sudden accelerations. Passing or kicking may elicit pain. PE reveals point tenderness over the conjoined tendon or medial inguinal canal, distal rectus insertion, pubic tubercle or adductor. Valsava maneuvers often worsen the pain, but no hernia is palpated. There is discomfort when palpating the groin during forceful resisted sit-ups and hip adduction is often a classic finding. Radiology (X-ray, ultrasonography, MRI or bone scan) was performed to exclude other causes of pain. |
| Comin et al. (2013) | Clinically diagnosed Sportman's hernia | Chronic groin pain of no readily identifiable structural cause and of greater than 6 months duration which did not respond to conservative treatment. Extensive clinical assessment and MRI scans were used to exclude alternate diagnoses (such as inguinal hernia, hip joint disorders, iliopsoas bursitis, symphyseal degeneration, adductor tears and stress fracture). |
| Economopoulos et al. (2013) | Clinically diagnosed Sports hernia | Disabling groin pain associated with exertion, along with the clinical examination of pain with Valsalva and partial sit-up. Other physical findings included pain over the pubis and inguinal area on palpation. Imaging studies used to evaluate the patients included MRI and ultrasound of the groin. |
| Garvey and Hazard (2013) | Clinically diagnosed Sports hernia, Conjoint tendinopathy, groin disruption injury, Classical hernia, Adductor tendinopathy, Rectus abdominis syndrome, | Undiagnosed chronic groin or lower abdominal pain, with either negative or equivocal physical examination findings. Athletes with a clinically obvious hernia were also included. MRI and/or ultrasonography was frequently performed and the result was negative or inconclusive. |
| Authors (Year) | Diagnosis | Description |
|---------------|-----------|-------------|
| Jakoi et al. (2013) | Diagnosis of Sports hernia | Players who were reported to have had a sports hernia who were treated with surgical repair, as described in the medical file on a website. |
| Mei-Dan et al. (2013) | Clinically diagnosed recalcitrant groin pain (with or without lower abdominal pain) | Groin pain that failed to resolve with non-operative therapy. Athletes were unable to compete at the desired competitive level due to the pain. On PE there had to be adductor tendon insertion pain, a positive squeeze test (with or without pubic bone tenderness), and/or tenderness of the surrounding aponeurosis. |
| Schilders et al. (2013) | Clinically diagnosed chronic adductor-related groin pain and radiological exclusion of other causes | Chronic adductor longus dysfunction for more than 3 months that was not responsive to non-operative treatment. Groin pain while sprinting, during side-to-side movements, or with long kicks. Clinically, there had to be pain over the proximal adductors and on resisted adduction. Athletes with PE and/or radiological (radiograph and/or MRI) signs of an acute avulsion, femoroacetabular impingement, osteitis pubis or sports hernia were excluded from the study. |
| Bernhardt et al. (2014) | Clinically diagnosed Sportmen’s groin. Ultrasonography was used to exclude true hernias | Groin pain that did not respond to conservative treatment/rest for 3 months. Existence of a hernia was ruled out preoperatively by clinical examination and/or sonography. If a true hernia was visualised during the laparoscopic procedure, the patient was excluded. Other reasons for groin pain were excluded by urological, gynaecological, neurological and orthopaedic examinations and additional radiological studies (X-ray, CT scan, MRI). |
| Cavalli et al. (2014) | Clinically diagnosed Sportman’s hernia. Radiological exclusion (MRI) of other causes (osteitis pubis). | Chronic groin pain without a clinically evident hernia that did not respond to conservative treatment. The pain had to be 6 points or more on a VAS scale or disabling physical activity. On PE there was frequently bulging of the posterior wall and pain on valsalva. There had to be a positive abdominal crunch test and adductor test. MRI was used to exclude osteitis pubis. |
| de Queiroz et al. (2014) | Clinically and radiologically diagnosed pubalgia | Groin pain in the pubic symphysis that did not respond to conservative treatment for at least 12 months. Players had to be moved out of the main team with a decline in performance. There had to be pain when standing up on one leg and pain on flexing the trunk. PE had to show a positive squeeze test and lateral compression test, pain on palpation of the symphysis and adjacent structures, pain on flexing the trunk and pain on resisted adduction. There had to be an abnormal radiograph (Irregularity of the margin of the pubic symphysis, Bone reabsorption, Bone sclerosis, Bone avulsion, Alterations at the sacroiliac joint and Vertical instability) and/or MRI (bone marrow edema). |
| Sansone et al. (2014) | Clinically diagnosed pubalgia | Long-standing groin pain and the inability to participate in sport because of pain over the adductor origin and/or the pubic attachment of the rectus abdominis. All athletes failed conservative treatment including unspecified physiotherapy |