

The conservative treatment of longstanding adductor-related groin pain syndrome: a critical and systematic review

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ABSTRACT: Longstanding (chronic) adductor-related groin pain syndrome is a widely common problem for athletes in many sports activities which often drastically reduces player activity and performance. The first choice in therapeutic treatment is conservative therapy. The objective of this study is to provide a systematic review regarding conservative treatment for longstanding adductor-related groin pain syndrome present in literature today. Furthermore, this study aims to give a critical vision of the current state of the art of the considered topic. After screening 234 articles, 19 studies following the inclusion criteria were included and summarized in this current systematic review and seven different types of therapeutic interventions were described. Compression clothing therapy, manual therapy together with strengthening exercise and prolotherapy were the therapeutic interventions which showed both the greatest level of strength of evidence (Moderate) and grade of recommendation (D). The remaining four types of therapeutic interventions i.e.: corticoid injection, platelet rich plasma therapy, intra-tissue percutaneous electrolysis and pulse-dose radiofrequency, showed both lower levels of strength of evidence (Conflicting) and grade of recommendation (C). In conclusion the literature available on the conservative treatment for longstanding adductor-related groin pain syndrome is limited and characterized by a low level of evidence. Therefore, our recommendation is to refer only to the few studies with higher level of evidence and at the same time to encourage further research in this area. The intervention showing the greater level of strength of evidence, and the greater grade of recommendation are compression clothing therapy, manual therapy and strengthening exercise, and prolotherapy. Other therapeutic interventions such as intra-tissue percutaneous electrolysis and pulse-dose radiofrequency seem promising but require further studies to confirm their efficacy.

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INTRODUCTION

Groin pain syndrome (GPS) is a common problem for athletes in several sports, often reducing the players' activity when chronic [1, 2]. Indeed, its yearly incidence in football (soccer) of 10–18% continues to increase due to many risk factors such as high loads and short recoveries [3]. It is important to note that the majority of injury surveillance studies in football are based on the so called “time loss concept” [4]. Indeed, injuries are recorded only if a player is unable to participate in football training and/or competition [5–9]. Recent studies revealed that the “time loss definition” captured only one-third of the GPS injuries in male football players [10]. Thus, the traditional “time loss injury” approach may be inappropriate and the recorded data may represent only the “tip of the iceberg” of a deeper and most painful issue [10]. Indeed, it is common for players to

continue training despite the pain, in order not to register any time loss injury, yet by doing so the affected structures are subjected to overuse, which is consolidated as an important element in most cases of GPS [11, 12]. For adductor-related GPS (i.e. the GPS caused by adductor tendinopathy or acute adductor injury), overuse etiology is confirmed by a recent study in which football adductor injuries are 49% traumatic and 53% due to overuse [11].

The GPS has a multifactorial etiopathogenesis and the adductor tendinopathy is a common, but not easily recognizable cause of longstanding GPS (i.e. chronic adductor-related GPS) especially in athletes [2]. This could be due to an extremely complex hip anatomy with several structures interacting and contributing to its functioning [13]. For example, a professional football team composed of an

average number of 25 players can expect an average of two long-standing adductor-related GPS per season causing an average 35 days of time-loss injury [14]. The muscles involved in the hip joint adduction movement are: gracilis (the only bi-articular muscle of the group), adductor brevis, adductor longus, adductor magnus, pectineus and obturator externus (all mono-articular muscles) [15]. Long-standing adductor-related GPS can be classified as an overuse condition of an adductor muscle tendon (in the majority of cases located at the adductor longus), which leads to disrepair and further degeneration [16]. This is a common injury in many sports activities, especially in those with sudden cutting/changes of direction and/or high mechanical loads, as they transmit both horizontal and cutting forces to the symphysis during athletic activity [2, 13]. These mechanical loads, when excessive, lead to unhealthy changes in tendon and/or ligament structures [17]. Several studies focusing on a generic longstanding GPS [17–19] are present in literature, but very few investigate the specific longstanding adductor-related GPS [20–21]. There are also different studies on conservative treatments, but with different methodologies and validity of the related studies [20]. In the context of longstanding adductor-related GPS, conservative treatment should be considered as the first line treatment,

and various influencing factors such as symptom severity and duration, experience of physicians and presumptive diagnosis ought to be kept in mind. Several treatments have been proposed and are currently used in clinical practice: rest, reduction and modification of sport activities [22–25], cryotherapy [23], oral medications such as non-steroidal anti-inflammatory drugs [26] manual and physiotherapy exercises together with stretching [22–25], resolution of biomechanical abnormalities of the lower limbs (leg length discrepancy, pes planus or cavus) postural gymnastics, strengthening of hip abductors and external rotators muscles, improving pelvic lumbar control core stability and pelvic stabilizer exercises [22–24], local corticosteroid injection [26, 27], prolotherapy [27, 28], compression garments [29–33], intra-tissue percutaneous electrolysis [34] and Pulse-Dose Radiofrequency [35]. Since the longstanding adductor-related GPS is a common cause of GPS [2–13] and understanding the treatment option may facilitate recovery, it is important to have a clear vision and interpretation of the evidence present in literature to date. This present systematic review of literature aims to report the different conservative treatments proposed for longstanding adductor-related GPS and determine the current evidence in the management of this pathology.

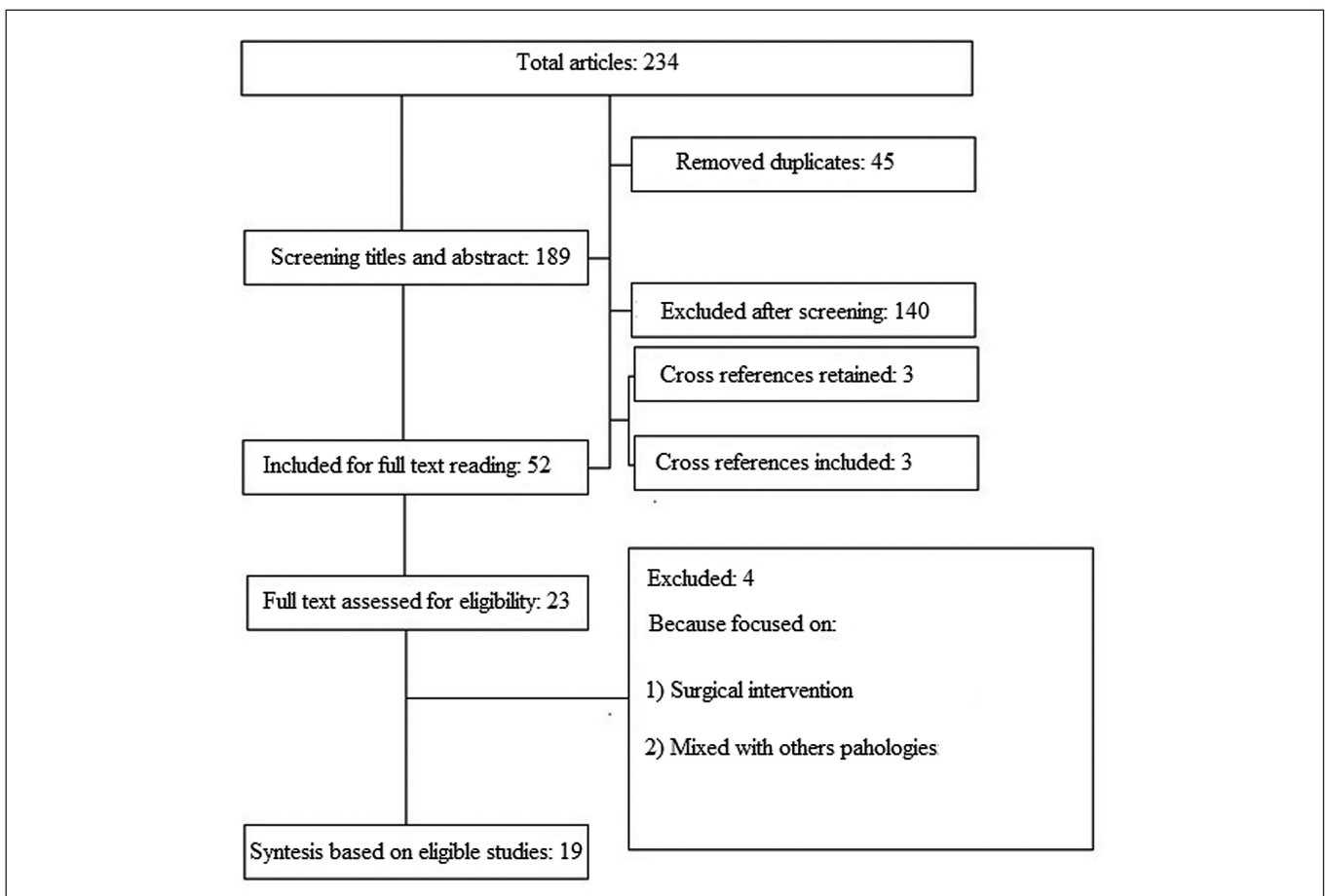


TABLE 1. The PRISMA flow diagram of the study search and selection procedure.

MATERIALS AND METHODS

Aim of the current systematic review

This systematic review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) guidelines [36]. The protocol of this study was registered at the PROSPERO register for systematic reviews (number CRD42019130781).

Data extraction and quality assessment

Prior to this systematic review the PubMed/MEDLINE, Scopus, ISI, Cochrane Database of Systematic Reviews, and PEDro data bases were consulted for systematic reviews on the comparison of different conservative treatments for longstanding adductor-related GPS, in order to ensure that similar systematic reviews were not already present in literature. After this verification, three authors (BGN, CE, GRG) independently screened the literature using a string of keywords: “longstanding adductor-related groin pain syndrome” “adductor-related groin pain syndrome”, “chronic adductor-related groin pain syndrome” “adductor tendinopathy”, “adductor tendinitis”, “adductor tendinosis”, “conservative treatment”, “physiotherapy”, fittingly connected by Boolean operators. When appropriate, medical subject headings (MeSH) and wild-card options were used. Furthermore,

target journals were reviewed, in order to increase the possibility of collecting all the relevant articles. The research started on 20 March 2019 and finished on 30 April 2019. Neither data restriction nor language limitation were applied. “Grey literature” (i.e. conference, abstracts, thesis and unpublished reports) was not taken into account. Cross-references from the selected articles were screened to verify their possible relevance. All double citations were removed. For each article, the relevant information was extracted and recorded on an *ad hoc* Excel spreadsheet. The PRISMA flow diagram of the study search and selection procedure is shown in Table 1. The Methodological Index for Non-Randomized Studies (MINORS) [37] was used to assess the quality of each individual study considered. The score calculated for each study using the MINORS criteria is shown in Table 2. The characteristics of the studies considered are shown in Table 3.

Risk of bias

If the studies satisfied $\geq 75\%$ of the MINORS criteria the risk of bias was considered low; if the MINORS criteria were satisfied by a percentage of 60–74%, the risk of bias was considered moderate; finally, if the MINORS criteria were satisfied for $< 60\%$ the risk of bias was considered high [38–39]. The risk of bias score is shown in Table 2.

TABLE 2. MINORS score [37], risk of bias [38] and OCEBM level [43] of the studies reviewed.

Study	Type of study	MINORS score	Risk of bias	OCEBM level
Otten et al., 2019 [33]	Double blind RCT	20/24	Low (83%)	2
Sawle et al., 2019 [32]	Blind pilot RCT	20/24	Low (83%)	2
Weir et al., 2011 [23]	Blind prospective RCT	19/24	Low (79%)	2
Moreno et al., 2017 [34]	RCT	16/24	Moderate (66%)	2
Hölmich et al., 1999 [22]	RCT	13/24	High (54%)	2
Mens et al 2006 [31]	Cross sectional study	13/16	Low (81%)	4
Topol et al., 2005 [28]	Case series	14/16	Low (78%)	4
Topol and Reves, 2008 [27]	Case series	14/16	Low (78%)	4
Weir et al., 2009 [49]	Retrospective case series	12/16	Moderate (67%)	4
Weir et al., 2010 [50]	Retrospective case series	12/16	Moderate (67%)	4
Masala et al., 2017 [35]	Case series	10/16	High (55%)	4
Schilders et al., 2007 [47]	Case series	10/16	High (55%)	4
Schilders et al., 2009 [26]	Case series	10/16	High (55%)	4
Holt et al., 1995 [45]	Case series	9/16	High (50%)	4
O’Connell et al., 2002 [46]	Case series	9/16	High (50%)	4
Yousefzadeh et al., 2018a ²⁴	Case series	9/16	High (50%)	4
Yousefzadeh et al., 2018a [25]	Case series	9/16	High (50%)	4
McKim et al, 1999 [29]	Case series	8/16	High (44%)	4
Dallaudiere et al., 2014 [48]	Case series	4/16	High (22%)	4

MINORS maximal score: 24 for randomized clinical trials, 16 for non-randomized clinical trials.

TABLE 3. The characteristics of the considered studies.

Reference	Study design and level of evidence	Participants and study setting	Diagnosis	Type of rehabilitation	Follow-up	Time loss injury	Outcome	Complications
Dallauciè <i>et al.</i> , 2014 ⁴⁸	Case series (level of evidence IV)	41 subjects. Age: 44.4 ± 12.4 years, sex and sport activity were not specified	Longstanding adductor-related GPS	PRPt, single intratendinous US-guided PRP injection X3 with no adjuvant	6 weeks and 32 months	Not specified	At 6 weeks follow-up the US residual tendinopathy signs was lower than the baseline signs observed before the PRPt. At 32 months follow-up QuickDASH score and WOMAC was significantly improved	None
Holmich, 1999 ²²	RCT (level of evidence II)	68 athletes. 34 subjects in AT group (age 30 years, range 20–50 years) of which 26 (76%) performed soccer and 8 (24%) other sports. 34 subjects in PT group (age 30 years, range 21–50 years) of which 28 (82%) performed soccer and 6 (18%) performed other sports activity.	Longstanding adductor-related GPS	AT group: active training and physiotherapy (laser, friction massage, stretching of adductor and transcutaneous electrical nerve stimulation). PT group: physiotherapy only. Or both groups the treatment period was compromised between 8 and 12 weeks	4 weeks and 4 months	AT group 18.5 weeks. PT group not specified	In the AT group, 23 (67.6%) subjects return to sport activity at the previous level after in average 18.5 weeks. In PT group, 5 subjects (14.7%) of athletes return to previous sport level without pain (time loss injury was not specified)	None
Holt <i>et al.</i> , 1995 ⁴⁵	Case series (level of evidence IV)	12 athletes (10 males and 2 females, age range 20–35 years). Sport activity was not specified.	Longstanding adductor-related GPS	Corticosteroid injection (1 ml 1% lidocaine, 1 ml 0.25% bupivacaine, and 4 mg dexamethasone) at pubic symphysis level	12 months (range 6–24 months)	10.9 ± 8.3 weeks range 3–24 weeks	3 athletes (27.2%) pain free after 1 injection, 3 (27.2%) pain free after 2 injections and needed between 11 and 16 weeks for the full recovery, 1 (9%) underwent 3 injections and became pain free after 24 weeks, and 1 (9%) received 3 injections and became symptom free after 24 weeks. 1 subject (9%) had no improvement	None
Masala <i>et al.</i> 2017 ³⁵	Case series (level of evidence IV)	32 subjects: 9 (28.1%) soccer players, 7 (21.9%) long-distance runners, 6 (18.7%) high jumpers, 4 (12.5%) swimmers, 2 (6.2%) hockey athletes and 4 (12.5%) other sport activities. Age 26 ± 7.7 years (18.3–33.7), 13 males and 19 females	Longstanding adductor-related GPS	PDRt on the genital branches of obturator nerve, genito-femoral nerve, ilio-inguinal and ilio-hypogastric nerves.	1, 3, 6 and 9 months	Not specified	Follow-up at 9 months showed a decrease (at least 50%) in pain value (VAS scale) in 31 patient over 32 (96.9%).	None
McKim and Taunton 2001 ²⁹	Case series (level of evidence IV)	10 subjects (8 males and 2 female age and sport activity not specified)	Longstanding adductor-related GPS	Effectiveness of a compression short during sport activity.	Not specified	Not specified	Compression shorts significantly reduce groin and pelvic pain during exercises. A quicker return to sport activity may be possible while wearing the compression shorts.	A slight decrement in performance may ensue.

TABLE 3. Continue.

Reference	Study design and level of evidence	Participants and study setting	Diagnosis	Type of rehabilitation	Follow-up	Time loss injury	Outcome	Complications
Mens et al. 2006 ³¹	Cross sectional study	G1 composed by 44 athletes (32 men and 12 women; age: 31.3 years, range: 28.1–34.6) affected by longstanding adductor-related GPS. G2 composed by 44 healthy sports subjects (32 men and 12 women; age: 32.2 years, range:30.0–35.4)	Adductor-related GPS with a duration of at least 1 month with positive squeeze test	Pelvic belt of non-elastic material		Not reported	G1 showed improvement in force value and decreasing in pain value during squeeze test performed with pelvic belt.	None
Moreno et al. 2017 ³⁴	RCT (level of evidence II)	SG 10 non-professional players and 12 non-professional football players. CG 12 non-professional (age 26.0 ± 4.7 year; height 178.7 ± 8.0 cm; body mass 73.9 ± 6.9 kg)	Longstanding adductor-related GPS	SG: intratissue percutaneous electrolysis 2 times a week and physiotherapeutic exercise. CG : physiotherapeutic exercise.	6 months after the end of treatment	Non specified	SG and CG showed a significant improvement in NRS, NRScontr and PSFS. SG a greater and faster reduction of pain in NRS and NRScontr in comparison to CG	None
O'Connell et al. 2002 ⁴⁶	Case series (level of evidence IV)	16 athletes (14 men and 2 women average age equal to 28.4 years range 20–41 years). Sport activity was not specified.	Longstanding adductor-related GPS	Single corticosteroid injection (20 mg of methylprednisolone acetate and 1 ml of 0.5% bupivacaine hydrochloride)	2 weeks, 3 months and 6 months after injection	Not specified	At 6 months follow up symptoms persisted in 31.25% (5 patients), and 12.5% (2 patients) at symptoms of provocation test.	None
Otten et al. 2019 ³³	Double blinded RCT	34 males amateur football players (age 25 ± 5 years, range: 18–37)	Adductor-related GPS from > 4 weeks	High compression shorts (ZHCshorts), non-zoned low compression shorts (NZLC-short)	2 weeks	Not reported	Pain reduction measured with Numeric Pain Rating Scale and HAGOS questionnaire with the use of ZHCshorts	None
Sawle et al. 2019 ³²	Plot blinded RCT	16 athletes (13 men and 3 women, 8 recreational and 8 professionals). Study group (SG): 9 subjects, age :26 +/- 5.3 years (range:23–36). Control group (CG), 8 subjects, age: 30.7 +/- 9.3 years (range. 22–48).	Sub-acute (1–3 months duration) and chronic (> 3 months) adductor-related GPS clinically assessed.	Customized compression shorts delivering targeted compression to the pelvic girdle	1-2-4-6-weeks	Not reported	The SG subjects showed moderate to large estimated effect sizes (d = 0.6–1.1) on clinical test while wearing customized compression shorts. On the contrary, they showed a small effect sizes (d = 0.2) on performance tests	None

TABLE 3. Continue.

Reference	Study design and level of evidence	Participants and study setting	Diagnosis	Type of rehabilitation	Follow-up	Time loss injury	Outcome	Complications
Schilders <i>et al.</i> , 2007 ⁴⁷	Case series (level of evidence IV)	24 competitive male athletes: 18 (75%) professional soccer players, 2 (8.3%) professional rugby players, 2 (8.3%) Olympic track and field athletes, 1 (4.2%) semi-professional soccer player and 1 (4.2%) squash player, whose mean age was 27.7 years, range 19–41 years). G1: 7 subjects without MRI signs for adductor longus tendinopathy and/or enthesopathy. G2: 17 subjects with MRI signs for adductor longus tendinopathy and/or enthesopathy	Longstanding adductor-related GPS	Triamcinolone acetate -80 mg in 2 ml mixed with marcaine-bupivacaine -3 ml of 0.5% solution	1 year	Not reported	Performed by questionnaire. None of the G1 subjects had recurrence. 16 (94.1%) of the G2 subjects had recurrence of the symptoms ($p < 0.001$) at a mean of 5 weeks (range, 1–16 weeks) after the injection	None
Schilders <i>et al.</i> , 2009 ⁴⁶	Case series (level of evidence IV)	G1 composed by 15 patients (22 years, range 18–40) not showing MRI signs of adductor longus tendinopathy. G2 composed by 13 patients showing MRI signs of adductor longus tendinopathy. Sport activity not specified.	Longstanding adductor-related GPS	Triamcinolone acetate -80 mg in 2 ml mixed with marcaine-bupivacaine -3 ml of 0.5% solution	6 weeks and 1 year	Not reported	At 1 year follow up, 33.3% (5 subjects) belonging to G1 had recurrence of the symptoms, and 30.7% (4 subjects) of G2 showed a symptoms recurrence.	None
Topol <i>et al.</i> , 2005 ²⁸	Case series (level of evidence IV)	24 athletes (22 rugby and 2 male soccer players, average age equal to 25 years)	Longstanding adductor-related GPS	Prolotherapy based on a monthly injection of 12.5% dextrose and 0.5% lidocaine into the adductor longus origins (mean 2.8 treatments)	6 and 32 months after therapy	Between 6 weeks and 3 months	The VAS score improved 6.3+/-1.4 to 1.0+/-2.4 ($p < .001$). NPPS score improved from 5.3+/-0.7 to 0.8+/-1.9 ($p < .001$). Twenty-two (91.6%) subjects returned to play with any restrictions.	None
Topol and Reeves, 2008 ²⁷	Case series (level of evidence IV)	72 athletes 39 subject (54.1%) were rugby players, 29 (40.3%) football players, and 4 (5.5%) practiced other sports. Age and sex not specified	Longstanding adductor-related GPS	Prolotherapy based on a monthly injection of 12.5% dextrose and 0.5% lidocaine into the adductor longus origins (mean 2.8 treatments)	26 months (range 6–73)	3 months (1–5 months)	VAS improvement was 82% ($p < 0.001$) and Nirschl Pain Phase Scale improvement was 78% ($p < 0.001$). Sixty-six (91.7%) subjects returned to play with any restrictions.	None

TABLE 3. Continue.

Reference	Study design and level of evidence	Participants and study setting	Diagnosis	Type of rehabilitation	Follow-up	Time loss injury	Outcome	Complications
Weir et al., 2009 ⁴⁹	Retrospective case series (level of evidence IV)	30 athletes (27 men and 3 women) athletes average age 20.5 years) 23 (77%) soccer players, 4 (30%) tennis players, 2 (7%) speed skaters, 1 (3%) distance runner	Longstanding adductor-related groin pain	Manual therapy	6–12 months after treatment	Not specified	The level of satisfaction: 4 athletes (47%) excellent, for 11 (37%) good, for 3 (10%) fair, and for 2 (6%) poor. 15 athletes (50%) returned at sport activity at pre injury level, 12 (40%) returned under preinjury level specified) and 3 (10%) did not return to sport	None
Weir et al., 2010 ⁵⁰	Retrospective case series (level of evidence IV)	44 subjects. men 37, women 7 Age 27 (+/-10.8) Soccer 31 (70.4%), running 3 (6.8%), Field hockey 3 (6.8%), tennis 2 (4.5%), other sports 5 (11.3%)	Longstanding adductor-related GPS	Mobilization, core exercises, general whole body stabilizing exercises, agility drills and sport specific exercises.	6.5–51 months	Not specified	At the end of the treatments 38 athletes (86%) returned to the same level of sport, and 34 athletes (77%) were asymptomatic. At 6.5–51 months follow up 10 over the previous mentioned 38 athletes (26%), and 22 athletes (50%) were able to participate in their sport activity in the same level without any restriction	The risk for recurrence was high.
Weir et al., 2011 ²³	Single blinded, RCT (level of evidence II)	54 subjects. G1 group 25 subjects (age 27.4 +7.3 years). G2 group: 29 subjects (age 28.7+8.2 years). Sport activity not specified.	Longstanding adductor-related GPS.	Exercise therapy (G1) versus multi modal treatment (G2)	0, 6, 16, and 24 weeks	G1: 17.3 ± 4.4 weeks. G2: 12.8 ± 6.0 weeks.	In G1 50% (13/26) returned to full sport participation versus 55% (12/22) in G2. The difference was not significant. G2 subjects returned to sports quicker than G1 subjects (12.8 ± 6.0 weeks versus 17.3 ± 4.4 weeks, p < 0.05).	None
Yousefzadeh et al. 2018 ²⁴	Case series (level of evidence IV)	15 men athletes (mean age 26.13 ± 4.48 years, range 18–35 years). Sport activity non specified.	Longstanding adductor-related GPS	10-weeks modified Hölmich therapeutic exercise protocol	10 weeks	10.9 ± 8.3 weeks range 3–24 weeks)	Significant improvement in comparison to the baseline of IHAB, EHAB, EHAD and EHAD/EHAB ratio. Significant improvement in VAS scores. T-test, THT and ESST. The ROM increased significantly. 13 athletes (86.6%) returned to full sports activity in 12.06 ± 3.41 weeks	None
Yousefzadeh et al. 2018b ²⁵	Case series (level of evidence IV)	17 male athletes (mean age 25.07 ± 4.96 years). Sport activity non specified.	Longstanding adductor-related GPS	10-weeks Hölmich therapeutic exercise protocol	12.06 ± 3.41 weeks	10.9 ± 8.3 weeks range 3–24 weeks)	Statistical improvement in comparison to the baseline data of IHAB, EHAB, EHAD and EHAD/EHAB ratio. A significant improvement in VAS pain scores. T-test, THT and ESST. The ROM increased significantly. 11 athletes (78.57%) returned to their sports activities in 14.2 weeks (range, 10–20 weeks	None

Standard of exercise intervention

In studies involving the use of physical exercises, the standard of exercise intervention was evaluated by the use of “Consensus on exercise reporting template (CERT): explanation and elaboration statement” [40]. CERT is a template devised for evaluating studies based on exercise programmes. The CERT checklist is formed by 16 items with a maximum score of 19 points.

If the studies satisfied $\geq 75\%$ of the CERT criteria, the study was considered to be of a high standard; if the CERT criteria were satisfied by a percentage of 60–74%, the study was considered as having a moderate standard; if the CERT criteria were satisfied for $< 60\%$ the study was considered as having a low standard [38–39].

The exercise intervention of the studies taken into account was considered as “reproducible” if it met all of the following three criteria [39]:

1. Detailed description of the exercise was specified;
2. Detailed description of the sets, repetitions and frequency of the training session was specified;
3. Detailed description concerning the intensity, the methodology of external load application and the method of progression were specified.

The standard of exercise intervention and their reproducibility are showed in Table 4.

Level of strength of evidence

The level of strength of evidence of the conservative programmes proposed in the studies was evaluated using the van Tulder [41] and the Reurink [42] methods. In accordance with these methods, the level of evidence was defined as strong if “consistently identified in two or more studies, and greater than or equal to 75% of all contributing findings”; moderate if “consistently identified in two or more

studies” and greater than 50% of all contributing findings”; conflicting if “inconsistency was found in two or more studies”. The level of strength of evidence is shown in Table 5.

Evidence level

The hierarchy of the evidence level for the conservative programme proposed in the studies was performed using The Oxford Centre of Evidence-based Medicine (OCEBM) – The Levels of Evidence [43]: the highest level of evidence (level I) is based on systematic reviews with specific criteria, whilst the lowest level of evidence (level V) relates to ‘mechanism- based reasoning’. The evidence level of the selected studies is shown in Table 2.

Grade of recommendation

The grade of recommendation was established using the GRADE framework [44]. The grade of recommendation is showed in Table 5.

Data extraction, synthesis and analysis.

Three authors (ANB, ALB and KC) extracted the following data in a standardized form from studies that proved relevant:

- i. Study design.
- ii. Level of evidence (using GRADE framework classification) [44].
- iii. Participants.
- iv. Study setting (sport type, level, gender, age).
- v. Diagnosis.
- vi. Type of conservative treatment
- vii. Time loss injury
- viii. Follow-up
- ix. Outcome
- x. Complications

TABLE 4. CERT criteria score, standard of exercise intervention and reproducibility of the studies reviewed.

Study	CERT score (%)	Standard	Reproducibility
Yousefzadeh et al., 2018a ²⁴	74	Moderate	Yes
Yousefzadeh et al., 2018b ²⁵	74	Moderate	Yes
Hölmich et al., 1999 ²²	63	Moderate	Yes
Weir et al., 2011 ²³	63	Moderate	No
Weir et al., 2009 ⁴⁹	16	Low	No
Weir et al., 2010 ⁵⁰	16	Low	No

TABLE 5. Level of strength of evidence and grade of recommendation of the studies reviewed.

Type of intervention	Level of strength of evidence	Grade of recommendation
Compression clothing therapy	Moderate	C
Manual therapy and strengthening exercise	Moderate	C
Prolotherapy	Moderate	C
Corticoid injection therapy	Conflicting	D
PRPt	Conflicting	D
EPI	Conflicting	D
PDR	Conflicting	D

Search strategy items Details

Searched databases PubMed/MEDLINE, Scopus, ISI, Cochrane Database of Systematic Reviews, and PEDro.

Searched string (longstanding adductor-related groin pain syndrome OR chronic adductor-related groin pain syndrome OR adductor-related groin pain syndrome) AND (adductor tendinopathy OR adductor tendinitis OR adductor tendinosis) AND (conservative treatment OR physiotherapy).

Inclusion criteria: P: randomized controlled trials and/or case series studies investigating longstanding adductor-related GPS conservative treatment in sport population. I: longstanding adductor-related GPS conservative treatment. C: comparison between different types of conservative treatments. O: outcome in terms of time loss, levels of outcome, levels of return to play, complication and sequelae.

Exclusion criteria: P: randomized controlled trials and/or case series investigating athletes suffering longstanding adductor-related GPS associated with other pathologies causing GPS. I: adductor tendinopathy surgical treatment. C: comparison between conservative and surgical treatments. O: not specified outcome in term of level of outcome, level of return to play, complication and sequelae.

Time filter: none set.

Language filter: none set.

Statistical Analysis

For all data, descriptive standard statistical indices (average \pm standard deviation) were calculated. Data were analyzed and, when possible, the data were treated statistically for a quantitative analysis. Frequency and percentage were used to describe the categorical outcomes such as return to sports activity, time loss, level of patient satisfaction, and level of return to play.

Results of systematic review

After screening 234 articles, 19 studies were included and summarized in this current systematic review (Table 3). All studies were checked to identify any potential conflicts of interest.

Study design

Among the studies selected, 2 were RCTs (level of evidence II) [22–34], 1 was a double blind RCT (level of evidence II) [33], 2 were a single blind prospective RCT (level of evidence II) [23, 32], 11 were case series (level of evidence IV) [24–29, 35, 45–48], 2 were retrospective case series (level of evidence IV) [49, 50] and 1 was a cross sectional study [31].

Participants and study setting

For the RCTs, a total of 151 and 84 subjects were considered, with an average age of 27.9 ± 2.3 years respectively for the study groups and the control groups. With reference to sports activities 122 (52.0%) subjects played football, 14 (6.0%) subjects practiced others sport activities, whereas the sports activities practiced by the remaining 99 (42.0%) subjects were not specified.

For the case series studies, a total of 440 subjects were considered whose average age was 27.8 ± 6.3 years. With reference to sport activities 167 (38%) were football players, 63 (14.3%) rugby players, 11 (2.5%) long distance runners, 6 (1.4%) high jumpers, 7 (1.6%) hockey players, 5 (1.1%) swimmers, 6 (1.4%) tennis players, 2 (0.5%) speed skaters, 2 (0.5%) track and field athletes, 1 (0.2%) squash player and 23 (5.2%) subjects practiced others sports activities. For the remaining 147 (33.4%) subjects the practiced sports activities were not specified.

Compression clothing therapy

Compression clothing therapy involves the use of compressive garments to reduce pain during sports activity; in the specific case of longstanding adductor-related GPS, compressive shorts are employed. In literature, one double blind RCT [33] (level of evidence II), one blind pilot RCT [32], one cross sectional study [31] and one case series [29] can be found dealing with compression clothing therapy.

McKim et al. [29] (case series, level of evidence IV, MINORS score: 8 over 16, risk of bias: high) considered the effectiveness of compression shorts in the treatment of athletes suffering from longstanding adductor-related GPS. This study considered 10 subjects: 8 males and 2 females. Neither inclusion/exclusion criteria, nor time loss injury were specified. The outcome of this type of treatment was assessed by a questionnaire using a pain rating scale gauging the pain levels before and after exercise. The results showed that wearing compression shorts significantly reduced adductor pain after exercise and furthermore, a slight decrement in performance was observed (fifty meters sprint, figure of eight running, twenty meters cutting drill, single leg hop, and stork squat). The questionnaire carried out in follow-up, although subjective, indicated an increase in pelvic stability when the subject was wearing the compression shorts. Based on such results, the authors concluded that the compression shorts, considered in the study, significantly reduced symptoms of longstanding adductor-related GPS and allowed a prompter return to sports activity.

Mens et al. [31] (cross sectional study, level of evidence IV, MINORS score 13 over 16, risk of bias: low, included a study group (G1) of 44 athletes (32 men and 12 women) affected by adductor-related GPS for at least 1 month, and with pain reproduced during isometric adduction tests (squeeze test) [51]. All patients stopped their sports activity for more than 1 week, and 31 subjects did not practice sports at the moment of the clinical examination due to adductor-related GPS. The average duration of the adductor-related GPS symptoms was 16.3 months (range 1.5–84.2 months). The control group (G2) was composed of 44 healthy sports people (32 men and 12 women). The subjects belonging to G1 were asked to perform a squeeze test using a handheld dynamometer for three attempts. The dynamometric score of the highest attempt was recorded for the analysis. The test was then repeated using a pelvic belt of a non-elastic material: the subjects were asked if the pain felt during the squeeze test was inferior, the same or more than that

perceived during the squeeze test performed without the pelvic belt. The same test protocol was applied to the control group G2 and the adduction force measured with and without the use of the pelvic belt was found to be respectively equal to 291 N (95% CI, 262–320) and 329 N (95% CI 304–354). The median increase was 9.8% (IQR +1.3 to +24.6%) ($p < 0.002$). During the squeeze test performed with the pelvic belt, the pain was unchanged in 12 (27.3%) patients, decreased in 30 (68.2%) patients and increased in two (4.5%). Furthermore, the force measured during the squeeze test performed without the pelvic belt was less than the force recorded in the same test performed by the subjects belonging to G2 ($p < 0.002$), whereas no difference in the force value was recorded between G1 and G2 subjects when the squeeze test was performed with the pelvic belt ($p < 0.002$). In G2, the force recorded during the squeeze test, performed with and without the pelvic belt, was respectively 350 N (95% CI 329–371) and 356 N (95% CI 334–379); the median increase was 1.8% (-2.0 to +5.4) and the difference was not statistically different. Based on these results, the authors concluded that adductor-related GPS showing a positive pelvic belt squeeze test may be treated using a pelvic belt or other means of stabilizing the pelvis.

Sawle *et al.* [32], in a blind pilot RCT (level of evidence II, MINORS score 20 over 24, risk of bias: low) investigated the effect of customized compression shorts delivering targeted compression to the pelvic girdle in 16 athletes (13 men and 3 women). The athletes' competition levels ranged from recreational (8) to professional (8). All the recruited athletes suffered from sub-acute (1–3 months duration) and longstanding (> 3 months) adductor-related GPS clinically assessed. The athletes were randomly subdivided into 2 groups: study group (SG) and control group (CG) composed respectively of 9 and 7 subjects. The age of the athletes in the SG and CC was respectively 26 +/- 5.3 years (range: 23–36) and 30.7 +/- 9.3 years (range: 22–48). The outcome measures were: the active straight leg raise (ASLR) test, squeeze test (ST), broad jump (BJ), and the multiple single-leg hop-stabilization test (MSLHS). Outcome measures were recorded at week one (baseline), 2 weeks, 4 weeks and 6 weeks. The authors estimated effect size of the customized compression shorts on clinical tests (ASLR and ST) and performance tests (BJ, MSLHS). Effect sizes were interpreted as being small = $\geq 0.2 < 0.5$; medium = ≥ 0.5 ; or large = ≥ 0.8 . The athletes from SG showed moderate to large estimated effect sizes on the ST and ASLR ($d = 0.6$ – 1.1) whilst wearing customized compression shorts. On the contrary, they showed small effect sizes ($d = 0.2$) on BJ and MSLHS. The aim of this study was to verify the study design for a future definitively powered RCT, and to provide an estimate of effect size of the customized compression shorts on selected clinical and performance tests. Based on these results, the authors concluded that the protocol was feasible and the recorded effect size suggests that the intervention holds promise for a future definitively powered RCT.

In a double blind RCT (level of evidence II, MINORS score: 20 over 24; risk of bias: low), Otten *et al.* [33] investigated the effects of

compression shorts on pain and performance in 34 males amateur football players (age 25 ± 5 years, range: 18–37) affected by adductor-related GPS for more than 4 weeks. The study tested the effect of wearing zoned high compression shorts (ZHC-shorts), non-zoned low compression shorts (NZLC-shorts) and normal sports clothes, on pain and performance. The pain was measured with the Numeric Pain Rating Scale (NPRS) while performance was measured using the Copenhagen five-second squeeze test (CS), the Illinois Agility test (IAT), and the maximum shooting test (ST). The results showed that wearing ZHC-shorts reduced pain during the IAT (1.4, ES = 0.58, $p = < 0.01$) and ST (1.2, ES = 0.47, $p = < 0.01$) compared to wearing normal sports clothes, and did not negatively affect the performance. In the second part of the study 27 of the 34 athletes (79.4%) participating in the first part of the study wore ZHC-shorts and NZLC-shorts during their football activity (training and competition) and the effects of wearing ZHC versus NZLC shorts on pain symptomatology were measured using the hip and groin outcome score (HAGOS). The follow-up was at 2 weeks. The HAGOS score showed an improvement in symptoms (9.7, ES = 0.63, $p = < 0.01$) and sport/recreation (13.2, ES = 0.68, $p = 0.01$) subscales were found when wearing the ZHC-shorts during football activities. Based on these results, the authors concluded that the use of ZHC-shorts could be useful in reducing the pain symptoms accompanying longstanding adductor related GPS in football players during their football activities.

Manual therapy and strengthening exercises

The conservative programmes focused on manual therapy and strengthening exercises are mainly based on therapeutic exercise, focusing on hip and abdominal muscle strengthening and manipulation consisting of transversal friction massage, assisted passive movements such as hip adduction, abduction and stretching of abductor muscles [22–25, 49, 50].

Six studies regarding the effectiveness of manual therapy and strengthening exercises were found in literature: 1 RCT [22], 1 single blinded prospective RCT [23], 4 case series [24, 25, 49, 50].

Hölmich *et al.* [22] compared the effectiveness of physical training rehabilitation versus manual therapy programme in 2 separate groups in an RCT (level of evidence II, MINORS score 13 over 24, risk of bias high, CERT standard: moderate, reproducibility: yes). The active training group (AT) was composed of 34 subjects (average age 30 years, range 20–50 years), of which 26 (76%) performed soccer and 8 (24%) performed other sports activities, and all of which suffered from longstanding adductor-related GPS for ~38 weeks (range 14–200 weeks). The subjects belonging to this group performed a standardized active training programme 3 times a week, based on isometric adductor exercise, abdominal strengthening, balance training and skate movement. The physiotherapy group (PT) was also composed of 34 subjects (average age 30 years, range 21–50 years), of which 28 (82%) performed soccer and 6 (18%) performed other sports activities, and all of which suffered from

longstanding adductor-related GPS for ~41 weeks (range 16–572 weeks). The PT group performed an intervention treatment based on transversal friction massage and stretching of adductor muscle, complemented by laser therapy and transcutaneous electrical electrostimulation. The treatment period ranged from 8 to 12 weeks. Standardized blind examination was performed 4 months post-treatment. The primary outcome considered was full return to sport at the same level without adductor pain. The results showed that in the AT group 23 (67.6%) subjects had an excellent outcome, 2 (5.9%) subjects good outcome, 6 (17.6%) subjects poor outcome and 3 (8.8%) subjects exhibited failed intervention. In the PT group 4 subjects had excellent, 6 subjects good, 18 subjects poor outcome, and 6 subjects exhibited failed intervention. In the AT group 23 subjects (67.6%) returned to their prior level of sports activity, without complaining of adductor-related GPS symptoms, after in average 18.5 weeks. In the PT group only 5 subjects (14.7%) returned to their prior level of sport without pain (time loss injury was not specified in this case). Based on these results, the authors concluded that a programme based on active training is more effective than a programme based on manual therapy and physiotherapy.

Weir et al. [23] considered 2 different groups of subjects (in total 54 subjects, 53 males and 1 female) in a single blind prospective RCT (level of evidence II, MINORS score: 19 out of 24, risk of bias: low, CERT standard: moderate, reproducibility: no). The first group (G1) was composed of 25 subjects (age 27.4 ± 7.3 years) suffering from longstanding adductor-related GPS for 32 weeks (IQR 17.5–81.0) who performed different sports activity. The subjects belonging to the G1 performed a home based exercise rehabilitation and a structured plan focused on returning to running. The subjects of G1 group received instructions from sport physical therapists only 3 times during the entire rehabilitation period. The second group (G2), composed of 29 subjects (age 28.7 ± 8.2 years) suffering from longstanding adductor-related GPS for 32 weeks (IQR 16.0–72.0), performed a rehabilitation programme conducted by a physiotherapist and based on a specific multi-modal treatment devised by the authors (multi modal programme). The G2 rehabilitation programme consisted in heat therapy, manual therapy, stretching, and a specific return to running programme. Of note is that the manual therapy programme employed in this study was very similar to the programme used in a previous study by the same authors [49]. The primary outcome considered in both groups was the time required to return to full sports participation. The secondary outcome was the pain perceived during sports activities measured by the same pain rating score. Follow-up was performed at 0, 6, 16 and 24 weeks post-intervention. The results showed that G2 athletes returned to sports quicker than the athletes belonging to G1 group (12.8 ± 6.0 versus 17.3 ± 4.4 weeks, $p = 0.043$). At the end of follow-up (range 6.5–51 months) in the G2 group 50% of the subjects (13/26) returned to full sport participation versus 55% of the subjects (12/22) in the G1 group. The difference was not significant. The authors concluded that the multi modal programme performed by the G2 group allowed

for a quicker return to sport than the exercise therapy performed by G1 group. In both cases, the authors admitted that neither of the two treatments were very effective.

Weir et al. [49] in a retrospective case series (level of evidence IV, MINORS score 12 over 24, risk of bias high, CERT standard: low, reproducibility: no) considered 30 subjects (27 men and 3 women) whose average age was 20.5 years, (IQR 17.75–29.75, min-max not provided). Twenty-three subjects (76.6%) were soccer players, 4 (13.3%) tennis players, 2 (6.6%) speed skaters, and 1 (3.3%) was a distance runner. All the athletes suffered from longstanding adductor-related GPS and the duration of the syndrome was ~9 months (IQR 3–24 months). All subjects performed a manual therapy programme. The manual therapy consisted in mobilization of the hip in adduction, abduction and in external rotation, stretching of adductor muscles, and heat application. The outcome was measured using different levels of satisfaction (poor, fair, good and excellent) and a numeric pain score ranging from 1 to 10. The follow-up was performed 6–12 months after treatment. The level of satisfaction at 12 months follow-up was considered excellent for 4 athletes (47%), good for 11 (37%), fair for 3 (10%), and poor for 2 (6%). Fifteen athletes (50%) returned to their sports activity at pre-injury levels, 12 (40%) returned to sub pre-injury levels (the time loss injury was not specified) and 3 (10%) did not return to sport. Based on these results the authors concluded that this manual therapy treatment programme may be a promising useful tool for longstanding adductor-related GPS.

Still Weir et al. [50], in another retrospective case series (level of evidence IV, MINORS score: 12 over 24, risk of bias moderate, CERT standard: low, reproducibility: no), considered 44 athletes (37 males and 7 females, age 27.0 ± 10.8 years) suffering from longstanding adductor-related GPS. Concerning the sport practiced, 31 subjects (70.4%) were football (soccer) players, 3 (6.8%) runners, 3 (6.8%) field hockey players, 2 (4.5%) tennis players, and 5 (11.3%) performed other sports. The duration of the symptoms ranged from 4 and 10 weeks for 11 (25%) subjects, from 10 and 26 weeks for 11 (25%) subjects, from 26 to 52 weeks for 9 (20.4%) subjects and was over 52 weeks for 13 (29.5%) subjects. The programme was based on the physical training protocol presented by Hölmich et al. [22]. In addition to this protocol, a motor control exercise for the *transversus abdominis* muscle was added to improve the strength of the pelvic stability and consequently the strength of the pelvic ring [52]. The average duration of the treatment was 20 weeks. The main outcome measurements were: return to the same level of sport, restriction in sports activity and recurrences. At the end of the treatments, 38 (86%) athletes returned to the same level of sport, and 34 (77%) athletes were asymptomatic (time loss injury was not specified). In the follow-up tests at 6.5 and 51 months, respectively only 10 (26%) and 22 (64.7%) of the original 34 athletes chosen were able to participate in their sports activity at the same level without any restriction. Furthermore, the data showed that the risk for developing a recurrence in groin injury within the period of

6.5 to 51 months was 26% (10 subjects over 38). The authors concluded that this type of programme shows good short term results, whereas the mid-term results were moderately positive since the risk of re-injury was too high.

Yousefzadeh *et al.* [24] in a prospective case series study (level of evidence IV, MINORS score 9 over 16, risk of bias: high, CERT standard moderate, reproducibility: yes) considered 15 male athletes (average age 26.13 ± 4.48 years, range 18–35 years) suffering from longstanding adductor-related GPS for at least two months (22.5 ± 21.08 months). All the subjects followed a 10-week modified Hölmich therapeutic exercise protocol²². The programme adopted by the authors, although based essentially on the same exercises proposed by Hölmich *et al.* [22], was much more intense. Indeed, the entire programme was reduced in 10 weeks, compared to the 18 weeks proposed by Hölmich *et al.* [22]. The outcome was measured by a dynamometric adductor/abductor assessment thus composed:

- (i). Maximal isometric hip abduction (IHAB);
- (ii). Maximal isometric hip adduction (IHAD);
- (iii). Maximal eccentric hip abduction (EHAB);
- (iv). Maximal eccentric hip adduction (EHAD);
- (v). Maximal IHAD/IHAB and EHAD/EHAB ratio.

Pain was assessed by VAS while the functional abilities were assessed by:

- i. T-test;
- ii. Triple Hop Test for Distance (THT);
- ii. Edgren Side Step Test (ESST).

Finally, the passive Range of Motion (ROM) of the hip joint was also measured.

The follow-up at 10 weeks showed:

A statistical improvement in comparison to the baseline data of IHAB, EHAB, EHAD and EHAD/EHAB ratio.

A significant improvement in VAS pain scores ($p < 0.0001$).

T-test, THT and ESST improved significantly ($p < 0.0001$).

The ROM increased significantly ($p < 0.0001$).

No adverse effects due to treatment were reported and 13 athletes (86.6%) returned to full sports activity without adductor-related GPS in an average time of 12.1 ± 3.4 weeks.

Based on these results, the authors concluded that the proposed, modified Hölmich protocol is safe and more effective than the classic Hölmich protocol [22] permitting the athletes, affected by longstanding adductor-related GPS, to return more promptly to their sports activity.

Yousefzadeh *et al.* [25] in a successive prospective case series study (level of evidence IV, MINORS score 9 over 16, risk of bias: high, CERT standard moderate, reproducibility: yes) considered 17 male athletes (mean age 25.07 ± 4.96 years) affected by longstanding adductor-related GPS who completed a 10 week treatment period following the Hölmich protocol [22]. The outcome was measured with the same parameters used in the above-mentioned study

conducted by the same authors [24]. At 10 week follow-up, all these parameters were significantly improved. Eleven athletes (78.6%) returned to their sports activities in 14.2 weeks (range, 10–20 weeks). The authors concluded that the Hölmich protocol [22] is an effective treatment for athletes suffering from longstanding adductor-related GPS. However, the authors underlined that it would be necessary to give more emphasis to the adductor muscles eccentric strength.

Injection therapy

Six case series studies were found in literature regarding the role of injection therapy in longstanding adductor-related GPS: four studies focused on the use of corticosteroid injection [26, 45–47], whilst 2 studies considered prolotherapy [27, 28].

Corticosteroid injection

Corticosteroids injections are commonly used to manage a wide number of tendinopathies, such as mid-portion Achilles tendinopathies [53], rotator cuff tendinopathies [54], gluteal tendinopathies [55], epicondylitis [56] and epitrocleitis [57]. Despite their wide use, their effectiveness in treating tendinopathies is much debated [57, 58].

Holt *et al.* [45] (level of evidence IV, MINORS score: 9 over 16, risk of bias: high) considered in their study 12 intercollegiate athletes, 10 males and 2 females (age range 20–35 years). Sports activities were not specified. All the athletes showed clinical and radiological signs of longstanding adductor-related GPS. All the athletes received a corticosteroid injection (1 ml 1% lidocaine, 1 ml 0.25% bupivacaine, and 4 mg dexamethasone) in the pubic symphysis area. Three (27.2%) athletes did not show a resolution of symptoms, 3 (27.2%) athletes showed a resolution of the symptoms after 1 injection, 3 (27.2%) athletes became pain free after 2 injections and needed between 11 and 16 weeks for full recovery, and 1 (9%) athlete received 3 injections and became symptom free after 24 weeks. Time loss injury was equal to 10.9 ± 8.3 weeks (range 3–24 weeks). The remaining 1 (9%) athlete was symptomatic for 2 years during which period he received 2 injections and after which he underwent an inguinal herniorrhaphy. Based on these results, the authors concluded that the use of corticosteroid injections might allow a rapid return to sports activity in longstanding adductor-related GPS. However, the study presents several problems. The first is the absence of a valid description of including/excluding criteria concerning both the clinical and imaging examination. Another very important point of bias is the lack of a clear description of the follow-up and the criteria adopted for evaluating the outcome.

O'Connell *et al.* [46] (level of evidence IV, MINORS score: 9 over 16, risk of bias: high) considered 16 professional athletes (14 men and 2 women, average age 28.4 years, range 20–41 years, sport activities were not specified) with scintigraphy- and MRI- imaging positive for longstanding adductor-related GPS. The patients underwent a single corticosteroid injection (20 mg of methylprednisolone acetate and 1 ml of 0.5% bupivacaine hydrochloride). The follow-up

was performed at 2 weeks, 3 months and 6 months post-injection. During each follow-up, clinical symptom provocation was assessed. At 2 week follow-up, 10 (62.5%) subjects reported lasting significant pain relief, 2 (12.5%) subjects had no symptoms but showed pain upon execution of the provocation test, 1 (6.25%) subject presented complete resolution of symptoms. At 6 month follow up, 1 (6.25%) subject had continuous symptoms, and the remaining 2 (12.5%) subjects experienced symptom resolution but only at rest. In total, at 6 month follow-up, symptoms persisted in 5 (31.25%) subjects and 2 (12.5%) subjects recalled symptoms upon the provocation test. In any case, for all patients, symptoms were less severe compared to those at the beginning of the therapy. Based on these results, the authors concluded the role of corticosteroid injections for longstanding adductor-related GPS to be controversial. This study shows several weak points. The first weak point is the description of the clinical framework. Indeed, the authors did not describe the imaging signs accurately for each of the subjects nor did they for the follow-up.

Schilders et al. [47] (level of evidence IV, MINORS score: 10 over 16, risk of bias: high) considered 24 competitive male athletes (18 professional soccer players, 2 professional rugby players, 2 Olympic track and field athletes, 1 semi-professional soccer player and 1 squash player) whose mean age was 27.7 (range 19–41 years) affected by longstanding adductor-related GPS. All the subjects performed an MRI to assess the proximal origin of the adductor longus and to verify the presence of tendinopathy and/or enthesopathy. Based on the MRI results, the subjects were subdivided into two groups. The first group (G1) was composed of 7 subjects who showed no signs of tendinopathy and/or enthesopathy on MRI. The second group (G2 – 17 subjects) showed signs of tendinopathy and/or enthesopathy on MRI assessment. Under the guidance of image intensification or ultrasound, each subject from both groups underwent a single injection of local anesthetic and corticoid (80 mg in 2 ml of triamcinolone acetonide and 3 ml of a 0.3% solution of bupivacaine) into the adductor enthesis. The follow-up was performed one year after treatment. The outcome was measured by a questionnaire evaluating their response to treatment. The results showed that none of the subjects from G1 experienced a recurrence, while 16 (94.1%) of the subjects from G2 experienced a recurrence of the symptoms ($p < 0.001$) at an average 5 weeks (range 1–16 weeks) after injection. Based on these results, the authors concluded that a single corticoid injection can be expected to grant a pain-free period of at least one year in those subjects affected by longstanding adductor-related GPS yet without showing any signs of adductor longus tendinopathy and/or enthesopathy during MRI assessment. On the contrary, the same therapeutic intervention granted only a short period of pain relief in subjects showing evidence of adductor longus tendinopathy and/or enthesopathy on MRI examination.

Schilders et al. [26], (level of evidence IV, MINORS score: 10 over 16, risk of bias: high) considered the role of corticoid injections (triamcinolone acetonide – 80 mg in 2 ml mixed with marcaine-bupivacaine -3 ml of 0.5% solution) in longstanding adductor-related

GPS. The study included recreational athletes with various complaints ranging from adductor related GPS through to adductor longus tendinopathy. For these athletes, a period of conservative treatment was attempted but failed. The subjects were subdivided into 2 groups. Upon MRI examination, the first group G1 (15 patients, age: 22, range 18–40 years) did not show signs of adductor longus tendinopathy, whereas the second group G2 (13 patients, age: 35 years, range 25–50 years) did show signs of adductor longus tendinopathy. The follow-up was performed at 6 weeks and then 1 year. At 6 weeks 1 (6.6%) subject of G1 and 2 (15.4%) subjects in G2 complained about symptom recurrence; 5 (33%) patients from G1 showed recurrence at a mean 14 weeks post-injection (range 7–20 weeks). At the 1-year follow-up, 5 (33.3%) subjects from G1 and 4 (30.7%) subjects from G2 showed symptom recurrence, with no significant difference in the rate of symptom recurrence in the 2 groups. Based on these results, the authors concluded that corticoid injections in longstanding adductor related GPS could have a positive effect on pain relief. Furthermore, they underlined that the positive outcome is independent of the findings in imaging magnetic resonance (MRI). It is important to note that the authors, using the same therapeutic protocol of their previous study⁴⁷, obtained different results and drew contrasting conclusions. This discrepancy exemplifies the need to involve more patients (higher statistical power) in such studies.

Prolotherapy

Prolotherapy is based on the injection of a hypertonic dextrose solution to provoke osmotic cellular rupture [59]. By increasing the level of glucose in the extracellular matrix, prolotherapy causes a local irritation of the tissues and triggers an acute inflammatory response that stimulates fibroblast proliferation and collagen synthesis leading to tissue healing [60]. However, the exact biological mechanism upon which prolotherapy is based is not yet completely clear [60]. Prolotherapy is described in 2 studies where it is used to treat adductor-related GPS [27, 28].

Topol et al. [28] (level of evidence IV, MINORS score: 14 over 16, risk of bias: low) considered 24 elite athletes (22 rugby and 2 male soccer players, average age: 25 years -standard deviation not specified) affected by longstanding adductor-related GPS and non-responsive to conservative therapy. The subjects had experienced longstanding adductor-related GPS symptoms for an average of 15.5 months (range 6–60 months). All subjects underwent prolotherapy based on a monthly injection of 12.5% dextrose and 0.5% lidocaine into the adductor longus origin. On average, 2.8 treatments (standard deviation not specified) were given to each subject. The outcome was assessed by the Visual Analog Scale (VAS) for pain during sports activity and the Nirschl Pain Phase Scale (NPPS) which measures functional impairment caused by pain. The follow-up was performed at 6 and 32 months after therapy. The VAS score improved from 6.3+/-1.4 to 1.0+/-2.4 ($p < .001$) and NPPS score improved from 5.3+/-0.7 to 0.8+/-1.9 ($p < .001$). Twenty-two (91.6%) subjects returned to play without restrictions after a period between 6 weeks and 3 months

post treatment. Based on these results the authors concluded that dextrose prolotherapy showed a marked efficacy for longstanding adductor-related GPS in this group of elite athletes.

Topol and Reeves [27 (level of evidence IV, MINORS score: 14 over 16, risk of bias. low) considered 72 athletes of which 39 (54.2%) were rugby players, 29 (40.3%) football players, and 4 (5.5%) practiced other sports. Age and the sex were not specified. The protocol of prolotherapy was identical to that of the previous study [28] and the outcome was measured as in this first study [28]. After a follow-up of 26 months (range 6–73 months, standard deviation not specified), VAS improvement was 82% ($p < 0.001$) and the Nirschl Pain Phase Scale improvement was 78% ($p < 0.001$). Of the 72 athletes considered, 6 (8.33%) athletes showed no improvement following prolotherapy, whilst the remaining 66 (91.7%) athletes returned to unrestricted sports activity within an average after 3 months (range 1–5 months). The authors concluded that prolotherapy was a useful therapy for permitting a quick return to sport in the case of longstanding adductor-related GPS.

Platelet-rich plasma therapy

Platelet-rich plasma therapy (PRPt) is based on the injection of blood plasma rich in a high concentration of autologous platelets containing growth factors. PRPt is widely used for treatment of different medical conditions. However, the clinical use of PRPt in the treatment of tendinopathies is still controversial [17, 61, 62]. Only one study is present in literature focused on PRPt in the treatment of longstanding adductor-related GPS [48].

In one case series, Dallaudière *et al.* [48] (level of evidence IV, MINORS score: 4 over 16, risk of bias: high) considered 408 subjects (age 44.4 ± 12.4 years, sex and sport activity were not specified), affected by medial and lateral epicondylar tendinopathy, patellar tendinopathy, Achilles tendinopathy, hamstring tendinopathy, peroneal tendinopathy and adductor longus tendinopathy (41 subjects). All the subjects underwent a platelet-rich plasma therapy (PRPt) consisting of a single intra-tendinous ultra-sound (US)-guided PRP injection. The authors used a fixed platelet concentration PRP (X3) without adjuvant. Furthermore, the PRP preparation was “leucocyte-reduced” to minimize the acute inflammatory response. The outcome was measured by the *QuickDASH* score, Western Ontario and MacMaster Universities Osteoarthritis Index (WOMAC). The follow-up was carried out within 32 months after the PRPt procedure (mean 20.2 months). Furthermore, US assessment was performed before treatment and 6 months after. At the end of the follow-up, the *QuickDASH* score and WOMAC were significantly improved ($p < 0.01$), whereas at the 6 week- follow-up the US residual tendinopathy signs were lower than the baseline signs observed before the PRPt. Based on these results, the authors concluded that intra-tendinous US-guided PRPt is a well-tolerated therapy allowing for rapid tendon healing. To the best of our knowledge, this is the only study present in literature that takes into account the use of PRPt in adductor tendinopathy. However, the study is subject to numerous biases,

which affect its study design and purpose, such as inclusion and exclusion criteria, and the unbiased assessment of the study endpoint. For these reasons, the study scored relatively little (4 out of 16) on the Methodological Index for Non-Randomized Studies [37] and a high risk of bias [38]. Therefore, the results of this study should be interpreted with caution.

Intra-tissue percutaneous electrolysis

Intra-tissue percutaneous electrolysis (EPI) is an US-guided medical therapy producing a non-thermal electrochemical ablation of the tendon tissues by means of a cathode inserted into the tendinopathy zone. EPI therapy causes local inflammation, which leads to regeneration of the tendon affected by the degeneration process [63]. Only one study is present in literature, which focuses on EPI therapy in longstanding adductor-related GPS [34].

Moreno *et al.* [34] in a RCT (level of evidence II, MINORS score: 16 over 24, risk of bias: moderate) evaluated the EPI therapeutic efficacy, in combination with physiotherapeutic exercise (EPI-PE), in the treatment of longstanding adductor-related GPS. The study group (SG) and the control group (CG) were respectively composed of 10 and 12 non-professional soccer players (age 26.0 ± 4.7 year; height 178.7 ± 8.0 cm; body mass 73.9 ± 6.9 kg) suffering from longstanding adductor-related GPS diagnosed by clinical and ultrasound imaging assessment. The SG followed the EPI-PE programme, while the CG followed the physiotherapeutic exercise programme (PE) only. The PE programme was essentially based on adductor longus isometric (during phase I), concentric- (during phase II) and eccentric-contractions (during phase III). The average duration of each phase depended on the functional and symptomatic improvement shown by each subject but was not specified by the authors. The subjects belonging to SG underwent EPI only twice a week during phase I of the protocol, previously reported by Abat *et al.* [63–65] for treatment of patellar tendinopathy. The average number of EPI sessions was not specified. After the end of the treatment all subjects were allowed to perform up to 3 soccer-specific training sessions with a maximum duration of 60 minutes and one official game every week. The follow-up was at 6 months post-treatment. The follow-up took into account the pain experienced upon palpation of the adductor longus insertion into the pubic tubercle by the Numeric Rating Scale, (NRS), the pain during the test of bilateral adductor isometric contraction against resistance (Numeric Rating Scale, NRScontr), and the subjective, perceived level of performance during the sports activity (Patient Specific Functional Scale, PSFS). Both SG and CG showed a significant improvement in NRS, NRScontr and PSFS but the SG showed a greater and quicker reduction in pain according to the NRS and NRScontr in comparison to the CG. In addition, the subjects from SG showed a tendency for better PSFS values both after treatment and during the follow-up period ($7.8 \pm 3.8\%$; $p = 0.093$). The authors, based on these data, concluded that the EPI-PE programme prompted a greater and quicker reduction in pain and, at the same time, promoted a greater functional recovery of the sports activity compared to PE.

Pulse-Dose Radiofrequency

Pulse-Dose Radiofrequency (PDR) delivers pulses, named “doses”, with well-defined and precise current and voltage values. In PDR pulses are first defined and then maintained constant over time (45 volts for 20 ms duration) with temperatures not exceeding 42°C [66]. Recently, PDR has been introduced to clinical practice by virtue of its analgesic effect. However, PDR is not a “definitive” procedure as its analgesic effects have a limited lifespan [67]. The major nerve that is implicated in longstanding adductor-related GPS is the obturator nerve which runs along the medial margin of the iliopsoas muscle and through the obturator foramen. The obturator nerve subdivides into two branches: anterior and posterior [67, 68]. The anterior branch provides motor innervation to the adductor muscles and its sensory ramifications innervate the hip joint and the medial skin of the thigh. The posterior branch consists of sensitive fibers that primarily innervate the knee joint and, as a secondary role, the adductor muscles [69]. In sports activities with a high functional demand of the lower limbs, entrapment of the obturator nerve between the long and short adductor muscles may cause the onset of pain. Adductor-related GPS in athletes could also involve other nerves such as the genital branches of the genito-femoral nerve, ilio-inguinal and ilio-hypogastric nerves [67, 68]. To date, only one study focusing on PDR therapy in longstanding adductor-related GPS is present in literature [35].

Masala et al. [35] in a case series (level of evidence IV, MINORS score: 10 over 16, risk of bias high) administered Pulse-Dose Radiofrequency therapy (PDRt) to 32 patients with a longstanding adductor-related GPS refractory to conservative therapies during the previous 3 months (average duration of symptoms 7.0 ± 3.2 months). The nerves treated were the obturator nerve; and the genital ramifications of the genito-femoral nerve, ilio-inguinal and ilio-hypogastric nerves. The PDRt consisted of the insertion of a 10 cm, 20-gauge cannula through a percutaneous access on the upper and lower edge of the ilio-pubic branch. In the second step, the spindle is removed and a 10 mm radiofrequency needle inserted. The administered pulse-dose (a single administration) was equal to 1200 pulses at 45 V with a 20 millisecond- duration, followed by a 480 millisecond- silent phase. The follow-up consisted of a clinical examination performed at 1, 3, 6 and 9 months after therapy. During the clinical examination, the patients were asked to rate their pain on the VAS Scale (0–10). The average VAS score before treatment was $8,4 \pm 0,6$. Twenty-four (75.8%) patients performed only one PDRt and reported a 50% reduction of pain in VAS scores. Seven (28.2%), patients performed two sessions of PDRt and reported a reduction of pain more than 50% in VAS scores. One (3.1%) patient had no pain relief with two treatments. The final data at 9 months follow-up showed a decrease in pain value in 31 (96.9%) patients out of 32. No complications were reported. Based on these results the authors concluded that PDRt is an effective and safe technique in the management of adductor-related GPS in athletes.

DISCUSSION

Adductor-related GPS is a frequent problem in athletes practicing a wide range of sports such as football/soccer, hockey or athletics [71, 72]. For example, in football, adductor-related GPS accounts for 16–18% of all football injuries with an incidence of time loss injury equal to 1.0–1.1 injury/1000 hours of exposure [3, 73]. The first-choice in therapeutic treatment is conservative therapy [20], and surgical treatment should be considered only if conservative treatment fails [74, 75]. Despite the significant incidence of adductor-related GPS in sports, there are relatively few studies validating the various types of conservative treatment in literature. For instance, there are no studies regarding the use of extra-corporal shock wave therapy, which is widely used in tendinopathies [76]. Furthermore, only one study [48] investigated the effects of PRPt in adductor-related GPS. Meta-analysis of the studies, focusing on the conservative programmes for longstanding adductor-related GPS, was not possible due to the small number of studies present in today's literature, the difference in the athletic population taken into account, the overall risk of bias and the low exercise reporting standard (CERT). A point that is important to underline is that only 7 studies [22–25, 27, 28, 45] out of 19 report the time loss injury. This could confirm the “tip of the iceberg” theory introduced by Harøy et al. in 2017 [10]. Indeed, it is possible that in the studies not reporting time loss injury, the players trained despite experiencing pain [11, 12].

From the studies found in literature and presented in this paper, the following conclusions can be drawn.

Compression clothing therapy

One double blind RCT [33] (level of evidence II), one blind pilot RCT [32], one cross sectional study [31] and one case series [29] dealing with compression clothing therapy are present in literature. The results of these studies are in line with other studies showing that compression shorts reduce the activation of the adductor longus muscle and consequently reduce the load on the adductor longus entheses in correspondence to the symphysis [30, 77], contributing to the improvement of pelvic stability [78] and reducing muscle oscillation [79]. This may lead to a reduction in pain [80]. Another explanation for the reduction in pain that emerged could be the placebo effect linked to the expectation or belief of the subjects [81]. In summary, the use of compression clothing therapy in longstanding adductor-related GPS, shows a “moderate” level of strength of evidence and a grade of recommendation C.

Manual therapy and strengthening exercise

The efficacy of manual therapy is rather controversial. Indeed, from an objective examination of the data reported in various studies, it is possible to conclude that multimodal programmes which also include active training, have a superior outcome in comparison to programmes based solely on manual therapy and physiotherapy [22, 24, 25, 49]. Nevertheless, the outcome shows good results only on a short-term basis, whilst the mid-term results were moderately positive because

of a high risk of re-injury [23, 50]. Furthermore, we must consider another bias, common to all the studies reviewed: the athletes' level of strength before the conservative treatment was not specified. Indeed, the athletes that showed a low base level of resistance training showed a greater response to the programmes based on strength exercises [82]. This could have led to an overestimation of the results.

In any case, overall results show a “moderate” level of strength of evidence and a grade of recommendation C for the manual therapy in the conservative treatment of longstanding adductor-related GPS. This evidence is based on a small number of RCTs [22, 23] and a relatively large number of case studies [23–25, 49]. However, we hope that the next study involving the use of muscle strengthening exercises, will provide more technical details so as to increase the reproducibility of the rehabilitation plans.

Injection therapy

The studies concerning injection therapies may be subdivided in

- i. Studies on corticoid injection therapy.
- ii. Studies on prolotherapy.
- iii. Studies on platelet rich plasma therapy.

Corticoid injection therapy

The studies using corticosteroid injection in longstanding adductor-related GPS are of low quality. Indeed, the scores obtained concerning MINORS criteria [37] are only 9 for Holt *et al.* [45], 9 for O'Connell *et al.* [46], and 10 for Schilders *et al.* [26]. The risk of bias [38] was high for all four studies. Furthermore, the conclusions drawn by Schilders *et al.* [26, i.e. that the positive outcome of corticoid injection therapy is dependent of the MRI findings, are in contrast with a previous study [47] performed by the same authors, in which the authors obtained better results using the same therapeutic protocol and consequently formulated opposite conclusions. Thus, in the light of the conflicting results, the use of corticoid injection therapy for longstanding adductor-related GPS requires further studies and greater level of evidence. In summary, the use of corticoid injection therapy in longstanding adductor-related GPS shows a “conflicting” level of strength of evidence and a level of recommendation D.

Prolotherapy

Based on the studies present in literature [27, 28], prolotherapy seems to show a marked efficacy for longstanding adductor-related GPS allowing a prompt return to sports activity, with no adverse effects reported. In summary, the use of prolotherapy in longstanding adductor-related GPS shows a “moderate” level of strength of evidence and a level of recommendation C.

Platelet-rich plasma therapy

Only one study on the use of PRPt in longstanding adductor-related GPS [48] (level of evidence IV, MINORS score: 4 over 16, risk of bias: high) is currently present in literature. Unfortunately, this study is of a low level and has a high risk of bias: therefore, the authors'

conclusion should be interpreted with caution. Further studies with more evidence are needed to justify the utilization of PRPt in longstanding adductor related GPS.

In summary, the use of PRPt in longstanding adductor-related GPS, currently backed by only a single study, shows a conflicting level of strength of evidence and a grade of recommendation D.

Intra-tissue percutaneous electrolysis

To date, only one RCT (MINORS score 16 over 24; risk of bias: moderate) regarding the use of EPI in longstanding adductor-related GPS is present in literature [34]. Based on the results of this study, EPI seems to be a promising therapy for longstanding adductor-related GPS. Clearly, we should wait for further studies providing solid evidence to further support the effectiveness of this technique.

To summarize, with only one study to date, the use of EPI in longstanding adductor-related GPS shows a conflicting level of strength of evidence and a grade of recommendation D.

Pulse-Dose Radiofrequency

Based on the results of this study, PDR seems a promising therapy for subjects suffering from longstanding adductor-related GPS. However, the only study (RCT) present in literature [34] (MINORS score: 16 over 24; risk of bias: moderate) presents an important bias: the authors had performed PDR contemporarily on not only the obturator nerve, but also the genito-femoral nerve, ilio-inguinal and ilio-hypogastric nerves. This fact does not allow us to judge the results obtained impartially and objectively: therefore, although PDR seems to be a promising therapy for longstanding adductor-related GPS, other studies focusing on the treatment of the obturator nerve and with clear diagnostic inclusion criteria are needed to confirm its effectiveness in longstanding adductor-related GPS.

In brief, with only a single study to its name, the use of PDR in longstanding adductor-related GPS, shows a conflicting level of strength of evidence and a grade of recommendation D.

CONCLUSION

This systematic review provides a detailed and critical summary of the studies currently available in the literature concerning conservative treatment for longstanding adductor-related GPS. A limitation of this study was the impossibility of performing a meta-analysis of the results due to a myriad of various aspects regarding the studies. In summary, the interventions showing the greater level of strength of evidence (moderate) and the greater grade of recommendation (C) are compression clothing therapy, manual therapy and strengthening exercises, and prolotherapy. All the other types of therapeutic intervention considered have, to date, only shown a conflicting level of strength of evidence and a grade of recommendation D. Last, but not least, it is important to remember that in this period of training restart after the COVID-19 pandemic lockdown, it is reasonable to expect an increase in overuse tendinopathies, including adductor tendinopathies [83]. Therefore, it would be important to consider proposing future

investigations based on a correct and appropriate injury surveillance recording methodology [84] able to shed light on this issue.

Conflicts of interest

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The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in, or financial conflict with, the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

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