Groin pain in athletes and non-interventional rehabilitative treatment: a systematic review

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Athletic groin pain and non-interventional rehabilitative treatment: a systematic review.

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ABSTRACT

INTRODUCTION. Groin pain is a common complaint in high-performance athletes and in the recreational athletes it has been less frequently described. This syndrome occurs more often in men and in sports requiring kicking and sudden changes in direction or speed. The diagnosis is generally based on accurate patient's anamnesis and physical examination. The instrumental evaluations are often considered to exclude other pathologies. The treatment can be conservative or surgical. The purpose of this study was to investigate the effectiveness of different non-interventional rehabilitative treatment for the athletes and provide guidelines of intervention.

EVIDENCE ACQUISITION. The following electronic databases were searched: PubMed, Physiotherapy Evidence Database (PEDro), Scopus, Web of Science, Google and Google Scholar. Databases were investigated from January 1997 until March 2017.

EVIDENCE SYNTHESIS. The articles included in this review were heterogeneous in term of study design, treatment strategies and number of subjects. The results reported in the randomized clinical trial studies highlight that the active treatments as strengthening, neuromuscular coordination and stabilization exercises showed superior results compared with passive treatment. Comparing the active strategies with respect to multi-modal treatments no significant differences was reported both in terms of return to sport activities and pain improvement. With respect to case-series and case-report all studies benefited active treatment strategies. The results reported highlight a return to sport activities equal or greater of 50%.

CONCLUSION. On the basis of literature available data, we were unable to assess Practice Guidelines. Further studies are necessary to set the best rehabilitative treatment of pubalgia in athletes.

Key words: Groin pain, Athletes, Rehabilitative treatments, Neuromuscular coordination, Muscular strengthening

INTRODUCTION

Groin pain is a pathological condition described from many Authors[1-6] and it is reported in very physically active person, well-described in high-performance athletes and sometimes in amateur[7, 8].

This discomfort is localized in the anterior pelvic region and involve the inguinal region, which is a complex anatomy area located on the lower part of the abdominal wall. The anterior wall of this region is composed by the internal oblique muscle and the aponeurosis of the external oblique muscle. The posterior wall include the fascia transversalis and the conjoint tendon on the common insertion of the internal oblique and transverse abdominus (TA) muscles[9, 10].

No univocal interpretation is present in literature regarding groin pain definition, diagnosis and treatment. Groin pain, sports hernia, adductor-related groin pain, Gilmore's groin, athletic pubalgia, footballer's groin injury complex, osteitis pubis, athletic pubalgia syndrome are different terms used to identify this pathological condition[11-14]. Taylor and colleagues introduced the term athletic pubalgia which refers to athletes chronic inguinal or pubic-area pain that is only exertional and not explainable by a palpable hernia or other medical diagnosis[15]. Hegedus and colleagues define athletic pubalgia as groin pain presents in athletes and referred to damage of tendons, fascia, sheaths or bone[16].

Athletic pubalgia is more common in men than in women[17, 18], probably for differences in pelvic anatomy, lower extremity alignment, and muscle activation[19-22]. Repetitive hyperextension of the trunk with hyperabduction of the thigh pivoting on the anterior pelvis and pubic symphysis (i.e. kicking, twisting and fast direction changes) are associated with groin pain onset. This mechanism occurs in sports like football, rugby, basketball, hokey, handball, swim, run[14, 23-25].

There are intrinsic and extrinsic risk factors to develop groin pain. The intrinsic risk factors are muscle weakness, inadequate muscle conditioning, poor groin flexibility, poor pelvic and core stability, ethnicity/race, increasing age. The extrinsic risk factors are associated with post-injury, inadequate rehabilitation, inadequate warm up, fatigue, decreased fitness, muscle tightness, poor

posture, neural tightness and recurrent injury[26]. Others predisposing factors are functional imbalance between abdominal and adductor muscles, significant difference in leg length, decreased hip movements, reduced flexibility of the posterior muscle chain and/or of the iliopsoas, lumbar hyperlordosis, dysfunction of the temporo-mandibular articulation and malocclusion, foot alterations, inadequate footwear and uneven playing fields[27-30].

Diagnosis

The pubalgia diagnosis is very difficult and complex because different pathologies, often coexisting, can cause anterior pelvic region pain[3, 7, 8, 31-37] (Figure 1).

To performed a correct diagnosis of athletic groin pain, the conference of the British Hernia Society's in Manchester (Unite Kingdom 2012) has coined a term to accurately describe the pain in the inguinal region close to pubic tubercle: inguinal disruption.

The diagnosis can be made if at least three out of the five clinical signs are present[9, 38] (Table I).

In Doha Agreement Meeting (2014) was defined three major categories to classify athletes groin pain and carry out a correct diagnosis[39]:

1. inguinal-related , pubic-related, iliopsoas-related, adductor-related groin pain;
2. hip-related groin pain;
3. other causes.

Pain history, clinical and instrumental examinations are needed for a correct pubalgia diagnosis. The inguinal pain is often described as deep and intense, can be unilateral or bilateral[23, 40]. The symptoms are insidious in the onset but occasionally subject reports a specific event that leads to injury. Moreover, pain can be aggravating by acceleration, twisting, turning, kicking, repeated sit-ups, coughing/sneezing[19, 41].

The clinical diagnosis is done through a physical examination that includes: pelvic and hip regions

palpation, hip and lumbar active and passive tests to measure Range of Motion (ROM), strength tests, pain provocation tests and neurological assessment[42, 43]. Mens and colleagues (2006) reported that the Active Straight Leg Raise (ASLR) test must be performed with and without a pelvic belt. The latter may be helpful in categorizing patients with pain in groin area[44]. The instrumental diagnosis of pubalgia is important to rule out other pathologies. Magnetic Resonance Imaging (MRI) is used to identify different lesions in athletes with clinical conditions referred to pubalgia[45]. Other instrumental diagnosis techniques are ultrasound (US) and radiography[42]. Dynamic US can be used in asymptomatic élite athletes to assess a posterior wall defect and to monitor them during sportive season[14]. Moreover, surface electromyography (sEMG) can be used to measure specific muscles activation and to select appropriate exercises to prevention and treatment of groin injuries[46]. Isokinetic dynamometers can be also employed to investigate the hip muscles imbalance in athletes with osteitis pubis[47].

Treatment

The management of injuries in élite athletes are more difficult than in active people, because the goal of the former is a fast return to pre-injury performances. Different rehabilitative treatments are used to obtained pain resolution and the return to sport activity. Athletic pubalgia is treated with nonsurgical modalities, including heat or ice, anti-inflammatory medications, deep massage, stretching and rest followed by a gradual return to sport activities. In the last few years it has been given importance to core stability and resolution of hip muscles imbalance. Surgical exploration and surgical repair should be considered when 6 to 8 weeks of conservative treatments fail[48]. The aim of surgical approach is the tensioning or detensioning of the soft tissues of inguinal region using open repair with or without mesh reinforcement, laparoscopic repairs and mini open repairs[19, 43, 49].

The purpose of this study was to define the best rehabilitative treatment and provide guidelines for the management of pubalgia in athletes.

EVIDENCE ACQUISITION

The review was conducted and reported in accordance with the PRISMA statement.

Databases and search strategy

The following electronic databases were searched: PubMed, Physiotherapy Evidence Database (PEDro), Scopus and Web of Science.

The list of terms used for database strategy search was reported in Appendix A.

A manual search of reference lists of selected papers and reviews on the topics was performed to identify additional relevant articles. To identify gray literature, a search was conducted in Google and Google Scholar using the same terms of Appendix A.

The electronic databases were investigated from January 1997 until March 2017.

Selection criteria for treatment strategies

In order to find the most current non-interventional rehabilitative strategies for athletic pubalgia we included articles that met the following inclusion criteria based on PICO (Patient, Intervention, Comparison, Outcome) principles:

- ✓ treatment strategies included: manual therapy, stretching and postural gym, neuromuscular coordination;
- ✓ athletes of both sexes;
- ✓ case-report/case-series studies and Randomized Clinical Trial (RCT);
- ✓ all types of individual or team sports;
- ✓ articles written in English.

Exclusion criteria were as follow:

- ✓ surgical treatment;
- ✓ infiltration therapy;
- ✓ physical and instrumental therapy;
- ✓ pharmacological therapy;
- ✓ use of orthoses;
- ✓ mesotherapy.

Three authors (IR, BB and VB) independently screened the articles by title and abstract against the selection criteria. Articles that were unclear from their title or abstract were reviewed against the selection criteria through the full text. Any discrepancies between authors were resolved through

discussion with the fourth author (CC). The second step was to screen all full-text articles that passed the first step. Conference and symposium abstract were assessed but deemed unsuitable due to the limited body of data related to the study design and the intervention program.

Data extraction and analysis

Data were extracted from the 11 studies that met the inclusion criteria. In agreement with PICO principles, the data included the following: number of participants, type of sport, protocol of intervention, duration and frequency of intervention, outcomes, participant retention and dropouts, and adverse effects associated with intervention strategies.

Assessment of risk bias

The level of evidence of the articles included were stratified according to Oxford Centre for Evidence-Based Medicine (OCEBM)[50].

The methodological quality of RCT study included was also assessed using the PEDro scale check list (Table II).

EVIDENCE SYNTHESIS

Overview of the inclusion process and methodological quality assessment

The reviewing process is presented in Figure 2. Duplicate articles, review articles, unavailable full text and articles out of topic were excluded from the initial records retrieved from different databases.

From a total of 383 selected articles, 372 did not meet the inclusion criteria as previously reported in methods section. A total of 11 articles were included in this review. Three articles are RCT[51-53], one article is a longitudinal single-cohort study[54], four articles are case-series[55-58] and the other three articles are case-report[59-61].

The level of evidence according to Oxford Centre for Evidence-Based Medicine (OCEBM)[50] is Level 4 for case-reports[59-61], case-series[55-58] and the longitudinal single-cohort study[54]. For the others three articles included the OCEBM level of evidence is comprised between Level 1[52] and Level 2[51, 53].

For the three RCTs[51-53] were also reported the PEDro scale score (Table II). Eligibility criteria were not used to calculate the PEDro scale score because they influenced external validity but not the internal or statistical validity of the trial.

Details of the included articles

The details of the reviewed articles are reported in Table III. Most of the studies concern soccer and football players[51-58]. Others sports like rugby[51-54], hockey[51-53, 56], speed skaters[53, 54, 57], basketball[51, 53], long distance running[51-54, 56, 57], tennis[51, 53, 56, 57], badminton[51, 52], handball[51-53], horseriding[51], squash[53], cricket[60], cycle[59], javelin throw[61], track and field[53] and fitness[54] are reported.

In the RCTs the number of subject is 68 in the study reported by Holmich and colleagues[51] and 54 in the study reported by Weir and colleagues[53]. In the case-series the number of subject per study ranged from 4[58] to 44[56]. Studies included subjects of different age, the youngest is the 10-years old male cricket fast bowler[60].

Most studies included only male athletes[51, 52, 55, 58-61] while in the studies of Weir et al., 2009[57] and Weir at al., 2010[56] were included 3 and 7 female athletes, respectively. In two studies there was only one female among all athletes included[53, 54].

All studies presented subjects with long-lasting groin pain. In most of the included studies athletes had already done many previous therapies without pain resolution[51, 53, 55, 57]. In the study of Weir et al., 2011, 7 athletes among 54 had not been subjected to any treatment[53]. In two case report the athlete had been subjected to previous treatment like US therapy[61] and conventional physical therapy[59].

Self-reported questionnaires, physical performance scales and tests were used for athletes clinical examination[51-61]. In order to diagnose pubalgia four studies utilized also instrumental approach, i.e. pelvis radiography and bone scintigraphy[51], US imaging[54] and Magnetic Resonance Imaging (MRI)[55, 58].

Outcomes of treatment strategies

The treatment strategies of included studies are reported in Table VI. The common outcome of all studies was the return to pre-injury activity levels of athletes. The secondary outcome was the pain resolution after the specific treatment.

Three out of the eleven studies included have compared two different strategies as groin pain treatment[51-53]. In the studies reported by Holmich and colleagues[51, 52] the effects of active treatment (AT) was compared with a physiotherapy treatment without active training (PT). The subjects in AT group performed the treatment 3 times a week. The program included mainly balance exercises and adductor and abdominal muscles strength exercises. No adductor muscles stretching exercises were allowed. Athletes in PT group carried out treatment twice a week. The protocol included laser treatment, massage, transcutaneous electrical nerve stimulation and adductor, hamstring and hip flexor muscles stretching exercises. No athletic activity was permitted neither for AT group athletes nor for PT group athletes. At the end of the study 23 athletes belonging to AT group returned to sport activity at their previous level whereas only 4 athletes belonging to PT group returned to sport

activity at their previous level. Data showed a significant difference in favour of AT strategy. Moreover, the follow-up study highlighted the long-lasting effect of AT program[52].

In the study reported by Weir and colleagues the effects of Exercise Therapy (ET) strategy was compared with the Multi-Modal Treatment (MMT) program[53]. The ET treatment included the exercises reported for AT in the study of Holmich and colleagues[51]. Moreover, athletes performed a return to running program. The MMT program enclosed the Van Den Akker manual therapy method, adductors muscle stretching exercises and the same return to running program reported for ET strategy. Athletes were able to return-to-activity after an average of 12.8 ± 6.0 and 17.3 ± 4.4 weeks, for MMT and ET groups, respectively. However, the percentage of athletes who returned to sport activity, pain perceived during palpation and VAS score were not different between the two groups (50-55%). The effects of MMT strategy were also assessed in a retrospective case series study conducted by the same Authors[57]. Twenty-five out of the thirty athletes enrolled were treated once and five had undergone a second treatment. Results highlighted a significant statistically decrease of pain score during both ADL and sport activity. Moreover, 15 athletes returned to sport activity at pre-injury level, 12 returned under pre-injury level and 3 no returned to sports. The Authors have ascribed the difference in athletes who were successfully treated in their two studies due to study design, and the age and level of sport activity of athletes enrolled[53].

Jansen and colleagues[54] investigated if changes in abdominal muscle resting thickness and changes in relative thickness during lower extremity tasks after treatment was related to changes in clinical status. The intervention tasks included transversus abdominus (TA) recruitment exercises, passive mobilization/manipulation of adductor muscles strength exercises and sport-specific exercises. At the end of 14 weeks intervention 16 athletes reported improvement on sports restriction, 3 reported to have an increase in sports restriction, 2 maintained the same level of sports restriction. Data shown no significant association between abdominal muscle thickness and change in athletes sports restriction.

In the study reported by Verrall and colleagues[55] athletes were followed for two football seasons. The treatment strategy was organized in three phases. For the first 12 weeks the athletes rested from all weight-bearing activities; only swim, cycle and light upper body weights were allowed. The stepping activity was introduced from the 6th week whereas the return to run activity occurred from the 3rd month. Following treatment program 89% of athletes returned to competition in the first football season and all athletes by the second playing season. In term of symptoms resolution only 41% of athletes were without symptoms at the beginning of the first football season (20-24 weeks after diagnosis) whereas 81% of athletes were without symptoms by the end of the second season (24 months after diagnosis). However, Authors highlighted that 26% of athletes were playing at a lower competition level in the second season.

Weir and colleagues[56] demonstrated the beneficial effects of a treatment that enclosed both active and passive physical therapy. Specifically, the treatment consisted in specific motor control training for TA muscle function, manual therapy for hip joint and sacroiliac joints, agility drills and sport-specific exercises. Results shown that after treatment 38 out of 44 athletes returned to their same sport level (34 without any symptoms); the median time was 142 days. At mid-term follow-up (median 22 months) 23 out of 44 athletes were active at their previous level of sports and 5 were active at a higher level. However, 10/38 athletes had experienced a groin pain recurrence.

In the case series reported by Wollin & Lovell[58] the rehabilitation program was organized in four different phases. In the first, pelvic floor and TA retraining using real time US and isometric hip adduction were performed. In the other three phases the treatment was based on core stability, gluteal and adductor muscles conditioning and two running programs. At the end of rehabilitation protocol all players returned to sport activity between 10 and 16 weeks. Moreover, no athletes reported recurrence groin pain at 12 months follow-up.

In the case report study of Navot and colleagues[59] the cyclist performed two treatment sessions of pelvic floor fascial mobilization associated with hip stabilizing exercises. At the end of treatment strategy athlete has become pain-free and returned to his usual sport and work activity. Moreover, at one month follow-up athlete was still pain free.

Sudarshan and colleagues[60] proposed a treatment strategy based on hip mobilization and sacroiliac joint manipulation, TA recruitment, core stability exercises, stretching, and finally on field-training exercises, agility exercises and swim. The 10-year old cricket fast bowler returned to sport activity without pain. Moreover, at six month follow-up athlete was still pain free.

Reiman & Manske[61] also proposed a multimodal approach for groin pain treatment. Manual therapy, hip mobilization exercises, gluteal and trunk stabilization exercises, strength and aerobic training and sports-specific drills were integrated with athlete's on-going functional assessment. After the rehabilitation program the javelin thrower athlete returned to a progressive sport training program. Moreover, the follow-up study highlighted the long-lasting effect of treatment.

DISCUSSION

Summary of the results

Our purpose was to investigate the effectiveness of different non-interventional rehabilitative treatment for the athletes and provide guidelines of intervention.

Related to RCTs selected, Holmich and colleagues highlighted that the AT strategy was better than passive treatment[51, 52]. Moreover, the Authors evidenced the long-lasting beneficial effect of the AT strategy[52]. Weir and colleagues[53] compared the ET and MMT protocols. Athletes enrolled in MMT

group returned to sport activity quicker than ET group, but no significant differences were reported between groups both in term of pain resolution and the athletes percentage that returned to sport. With respect to case-series the different program proposed to athletes results in a return to sport activities equal or greater than 50%. Clinical signs improvements associated with groin pain were also reported in all the case report included. Noteworthy, no selected studies reported adverse effects associated with treatment strategy proposed. Moreover, no injury recurrence events or a very low rate were highlighted.

Limitation of the study and further research

The limitation of this review is related to the few available studies concerning the non-interventional rehabilitative treatment for athletic pubalgia. The selected studies reported different approaches with respect to intervention frequency and duration, and proposed treatment and very heterogeneous athletes in term of age, gender, sport level and sport activity.

CONCLUSIONS

Pubalgia is a very complex physical condition that affect athletes. In particular it is a serious problem because can restrain athletes from sport for a long period, determining the loss of fitness and performances. The crucial aims of athletic pubalgia management are the reduction of pain and a fast return to pre-injury performances.

We can shed light on common key aspects able to improve the typical signs of pubalgia. In details, in the rehabilitative programs must be included: (i) TA muscle recruitment exercises, (ii) core stability exercises; (iii) stretching exercises and manual therapy to increase ROM and reducing muscle stiffness. Furthermore, workload must be increased only if the athlete does not feel pain and program must include specific-sport exercises and the return to running program before the full return to sport.

On the basis of data included it is quite difficult to suggest a meta-analysis and a practice guidelines. Specific studies are necessary to define the best treatment algorithm for pubalgia in athletes.

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FIGURE AND TABLES LEGEND

Figure 1. Most frequent pathologies which cause anterior pelvic/groin pain (modified from Pogliacomi et al., 2014[7]).

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Table I. Inguinal disruption clinical signs (modified from Dimitrakopoulou & Schilders, 2016[9]).

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

Table II. Study design quality assessment based on PEDro scale score.

Study	1	2	3	4	5	6	7	8	9	10	11	Total score
Holmich et al., 1999[51]	X	X	X	X			X	X	X	X	X	**8**
Holmich et al., 2011[52]		X		X			X			X	X	**5**
Weir et al., 2011[53]	X	X	X	X			X	X		X	X	**7**

PEDro criteria: 1-Eligibility criteria (not used to calculate the PEDro score); 2-Random allocation; 3-Concealed allocation; 4-Baseline comparability; 5-Blind subjects; 6-Blind therapists; 7-Blind assessors; 8-Adequate follow-up; 9-Intention-to-treat analysis; 10-Between-group comparisons; 11-Point estimates and variability provided.

Table III. Population and clinical examination of athletes.

Study	Sport	Study population	Clinical examination
Holmich et al., 1999[51] (RCT)	Soccer Running Tennis Handball Badminton Ice hockey Basketball Horseriding Rugby	68 male athletes (18-50 y) AT group: 34 (5 wd) PT group: 34 (4 wd) Groin pain for at least 2 months	Clinical examination protocol Questionnaire Plain pelvis radiograph Bone scintigraphy
Holmich et al., 2011[52] (RCT)	Soccer Running Handball Badminton Ice hockey Rugby	59 male athletes AT group: 29 (5 wd) PT group: 30 (7 wd) During the time period of 8 to 12 years most of the participants in both groups had reduced their athletic activity	Clinical examination protocol Questionnaire
Weir et al., 2011[53] (RCT)	Soccer Rugby Running Field hockey Speed skating Squash Other sports	54 athletes (18-50 y) ET group: 25 (3 wd) MMT group: 29 (3 wd) Groin pain for at least 2 months	Clinical examination protocol ROM measurement VAS
Jansen et al., 2009[54] (single-cohort study)	Fitness Running Soccer Speed skating Rugby	21 athletes (18-45 y) Groin pain for at least 4 weeks	Questionnaire 11-point Likert scale ASLR test (supine position) and squeeze tests with and without a pelvic belt US imaging
Verrall et al., 2007[55] (case series)	Football	27 male athletes (18-29 y) Groin pain for at least 6 weeks	Questionnaire Point tenderness examination Squeeze test Bilateral adductor test Hip provocation test MRI

Weir et al., 2009[57] (case series)	Soccer Tennis Speed skating Running	30 male and female athletes (median age 20.5 y) Groin pain for at least 2 months	Pain on palpation Resisted adduction test
Weir et al., 2010[56] (case series)	Soccer Running Field hockey Tennis Other sports	44 male and female athletes (27 ± 10.8 y) Groin pain for at least 4 weeks	Pain on palpation Resisted adduction test
Wollin & Lovell, 2006[58] (case series)	Football	(i) male, 17 y, onset groin pain within 2 weeks on return to activity (ii) male, 16 y, onset groin pain following an increase in training intensity (iii) male, 16 y, onset groin pain following many highly competitive games (iv) male, 17 y, onset groin pain during a second peak in training	Squeeze test Pubic symphysis palpation PSST MRI
Navot & Kalichman, 2016[59] (case report)	Cycle	32 y male athlete Groin pain started after a severe hip contusion and tear of fascia lata and gluteus medius muscle	ROM measurement Pelvic floor muscle active contractions Palpation
Sudarshan et al., 2013[60] (case report)	Cricket	10 y male athlete Groin pain for two and half months	LEFS VAS Valsalva maneuver Postural analysis Gait analysis Palpation Neurological screening ROM measurement Gillet test Sitting flexion test Standing flexion test Long set test Prone knee bend test Thomas test Neuromuscular tests Sacro-iliac pain test cluster FADIR impingement test

Reiman & Manske, 2012[61] (case report)	Javelin throw	26 y male athlete Groin pain for at least 2 weeks	Bilateral and single leg squat PPMs SRMs FADIR impingement test Sacroiliac joint thrust test

RCT: Randomized Control Trial; AT: Active Training; PT: Physiotherapy Treatment without active training; y: years; ASLR: Active Straight-Leg Raise; US: Ultrasound; MRI: Magnetic Resonance Imaging; ET: Exercise Therapy; MMT: Multi-Modal Treatment Program; ROM: Range of Motion; VAS: Visual Analogue Scale; LEFS: Lower Extremity Functional Scale; PSST: Pubic Symphysis Stress Test; FADIR: Flexion-Adduction-Internal Rotation; PPMs: Physical Performance Measurements; SRMs: Self-Reported measurements; wd: withdrawn number.

Table IV. Details of treatment strategies for pubalgia in athletes.

Study	Treatment strategy	Outcomes
Holmich et al., 1999[51] (RCT)	AT group*: 3 times a week (about 90 min), 8-12 weeks treatment period. 1. First 2 weeks: static adduction against soccer ball; abdominal sit-ups; combined abdominal sit-up and hip flexion; balance training on wobble board; one-foot exercises on sliding board. 2. From third week: leg adduction and abduction exercises lying on side; low-back extension exercises; one-leg weight-pulling abduction and adduction standing; abdominal sit-ups; one-leg coordination exercise; training on a "Fitter", balance training on wobble board; skating movements on sliding board. No adductor muscles stretching but other lower extremities, abdominal and back muscles could be stretched. PT group: twice a week (about 90 min), 8-12 weeks treatment period. Laser treatment; transverse friction massage on painful area; stretching of adductor, hamstring and hip flexor muscles by contract-relax techniques; transcutaneous electrical nerve stimulation at painful area. No sport activity during treatment period in both groups.	AT treatment group: 23 (79%) return to sports activity at their previous level or higher (median time: 18,5 weeks) without groin pain. PT group: only 4 (14%) patients return to sports activity without groin pain. The adduction strength improved significantly in the AT group with respect to the PT group whereas no differences in ROM hip abduction was highlighted between the groups. Data showed a significant difference in favour of the AT strategy.
Holmich et al., 2011[52] (RCT)	Treatment protocols as reported in Holmich et al., 1999[51].	The 8- to 12-year follow-up study highlighted that the beneficial effect of the AT reported in the primary RCT[51] was lasting.
Weir et al., 2011[53] (RCT)	ET group: 3 times a week at home. Treatment protocols as reported in Holmich et al., 1999[51] for AT group. At six weeks athletes performed the "return to running" program: 1st phase: slow jogging; progress to phase 2 when 30 min of jogging provokes no pain. 2nd phase: straight sprints; progress to phase 3 when 15 straight sprints provoke no pain.	Athletes in MMT group returned to sports quicker than athletes in ET group (12.8 ± 6.0 and 17.3 ± 4.4 weeks, respectively). The percentage of athletes who returned to sport activity was not different between the groups (50-55%). There was no significant difference in objective outcome or

	3th phase: sprints with changing directions; progress to sports when 15 cutting sprints can be performed without provoking pain. MMT group: muscle heat, Van Den Akker manual therapy and stretching of adductors of both legs; progress to the same return to running program of ET group after 14 days of stretching if no pain or discomfort were felt. MMT treatment has been repeated maximum twice.	VAS between the groups.
Jansen et al., 2009[54] (single-cohort study)	14 weeks of treatment (from 4 to 6 weeks twice a week; from 8 to 10 one/twice a week). 1st phase: exercises for TA recruitment using palpatory feedback medial to the anterior superior iliac spines; passive joint mobilization or manipulation techniques; exercises to integrate TA activation and abdominal muscles respiratory activity. 2nd phase: extending/bending a lower extremity and/or an upper extremity. 3th phase: prone bridge, lateral bridge, and back bridge. The intensity of exercises was increased enhancing repetitions number or using Swiss ball or wobble board. More functional exercises (such as squat and lunge) were also integrated. 4th phase: sport-specific exercises and hip adductor muscle strengthen exercises (Holmich 1999)[51]. In addition to supervised treatment, athletes were instructed to perform home exercises at least twice a week.	Sports participation restriction and pain during the squeeze test were significantly decreased following intervention. TA resting thickness, measured by US imaging, was significantly increased after intervention. Data shown no significant association between abdominal muscle thickness and change in athletes sports restriction.
Verrall et al., 2007[55] (case series)	Athletes were followed for 2 playing seasons. 1st phase: 12 weeks rest from all weight-bearing activities; permitted activities (with no pain): swim with a flotation device between the legs and light upper body weights; from	89% athletes returned to competition in the first football season, and 100% returned to competition by the second season after diagnosis. 41% of athletes were without symptoms at the beginning of

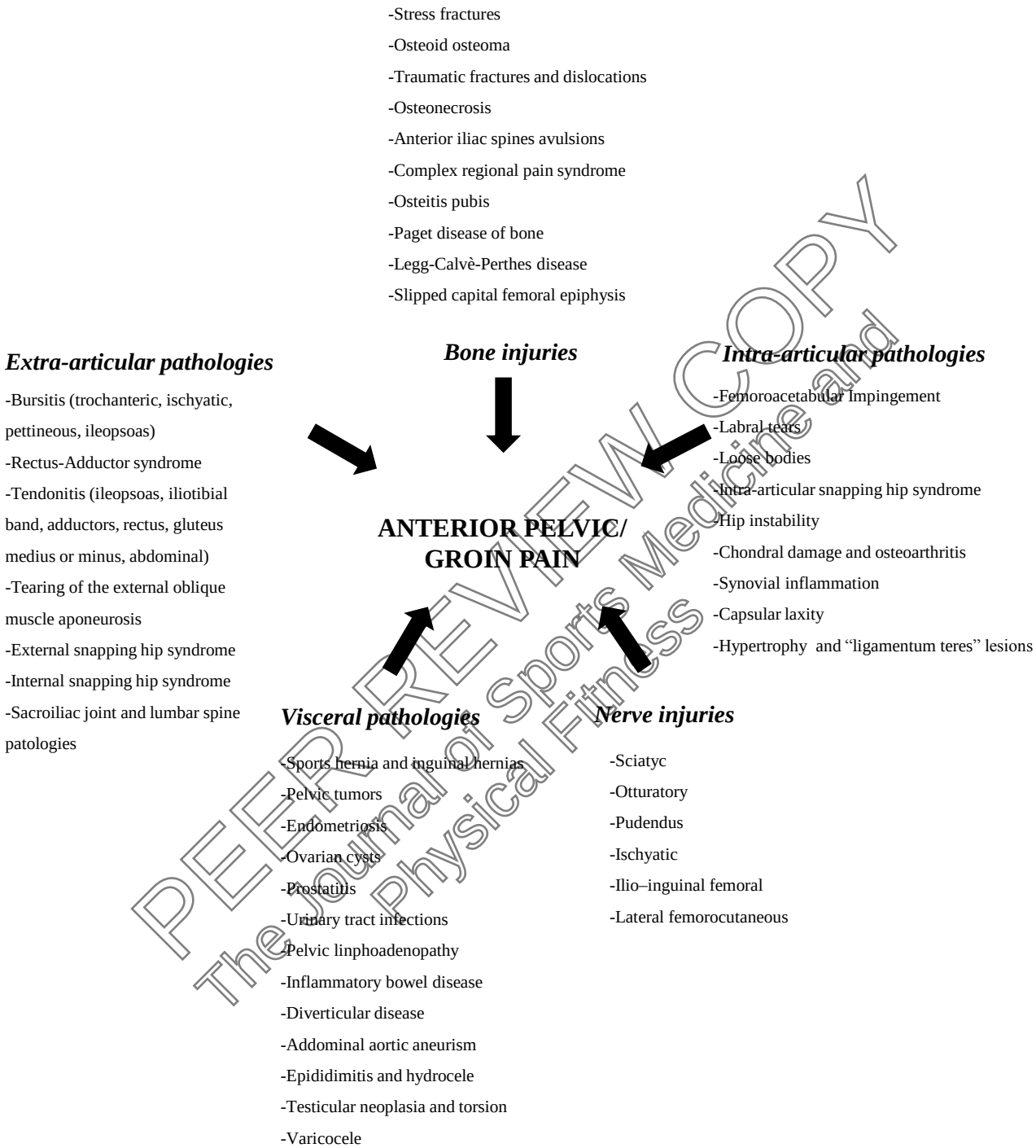
	the 4th week stationary cycling. 2nd phase (at 6 weeks): activity on stepping device 5 min/days, increasing 1 min/day if the athletes were pain free. 3rd phase (at 3 months): 5 min running session, increasing 1 min/session until 30 min of running (interval running 500 m). If 30 min pain-free interval running is tolerate athletes will return to football training. Pelvic/core stability exercises program from 3-6 weeks after start of the resting program.	the first football season (20-24 weeks after diagnosis); 81% of athletes were without symptoms by the end of the second season (24 months after diagnosis). 26% of athletes were playing at a lower competition level in the second season after diagnosis.
Weir et al., 2009[57] (case series)	Van Den Akker manual therapy treatment; 5 min warm-up each day using slow jogging or cycling, stretching of adductors of both legs, 10 min warm bath. After 14 days athletes start training activities and then progress to competitive sports. Protocol treatment was repeated maximum twice.	25/30 athletes were treated once and 5/30 athletes had undergone a second treatment. 15 athletes return at pre-injury level, 12 return under pre-injury level, 3 no return to sports. The pain score during ADL and sport activity statistically decrease after treatment.
Weir et al., 2010[56] (case series)	Stop competitive sport for a minimum of 3 weeks. 1st phase: mobilization for hip, sacroiliac joints and lumbar spine; basic TA recruitment. 2nd phase: TA recruitment combined with core stability exercises; low load hip adduction machine exercises. 3rd phase: whole body stabilizing exercises; increase in hip adduction strength exercise intensity; start running. 4th phase: agility drills and sport-specific exercises. 5th phase: return to sports. Phase 1-4: physiotherapy session once a week, exercises	After treatment 38 athletes returned to their same sport level (34 without any symptoms). Median of return to sport activity was 142 days. At mid-term follow up (median 22 months) 23/44 athletes were active at their previous level of sports and 5 were active at a higher level; 10/38 athletes had experienced a groin pain recurrence.

	twice a week without supervision (90 min/session).	
Wollin & Lovell, 2006[58] (case series)	Module 1: pain reduction, pelvic floor and TA retraining using real time US, and isometric hip adduction. Module 2-4: progressive core stability, gluteal and adductor muscle conditioning and two running programmes. All players were prescribed neoprene groin shorts for the running programmes. Athletes returned into football training on completion of 9 Km of various intensities running programme.	All players returned to football 10-16 weeks after treatment. No injury recurrence event has been reported. Athletes returned to their pre-injury fitness level.
Navot & Kalichman, 2016[59] (case report)	Two treatment session of 25 min, 7 days apart. Each session includes: (i) internal pelvic floor fascial mobilization over three restricted points and four external fascial restricted points; (ii) hip stabilizing exercises (one-legged squats, step-up/step-down, lunges as conventional recommended exercise for hip).	A significant improvement in both hip joint ROM and in pelvic floor muscle function were observed after the first treatment. The pain in sitting and cycling statistically decrease after treatment. Athlete became pain-free after the second session and he returned to his usual sports and work activity. At one month phone call follow-up, patient was still pain free.
Sudarshan et al., 2012[60] (case report)	Once session/week for 9 weeks. 1st phase (1 - 3 weeks): hip mobilization with belt, sacroiliac joint manipulation, isolated isometric contraction of TA, isometric gluteal contractions, TA recruitment and hip extension, pelvic bridging exercises, stretching exercises, core exercises. At home athlete performed stretching exercises of hip flexors. 2nd phase (4-6 weeks): Progressive core exercises with Swiss Ball, TA contraction during alternate movements of the upper and lower extremities, wall sliding exercises, exercise in quadruped position, pelvic drop exercise, walking every day for 20 min. From sixth on-field cricket activities and 15 min of mild jogging. 3rd phase (7-9 weeks): on-field cricket activities; agility	VAS score reduced from 7.2 (at initial evaluation) to 0.8 (at the beginning of seventh session). LEFS score increased from 21 (at initial evaluation) to 73 (at the beginning of seventh session). At 6 month follow-up patient was completely pain free.

	exercises and swim.	
Reiman & Manske, 2012[61] (case report)	Six visits over a 4-week period. Intervention includes: orthopaedic manual therapy (thrust and posterior capsule mobilization to the right hip); gluteal and trunk stabilization training exercises, self-mobilization of posterior hip in quadruped, anaerobic capacity training, and conditioning (aquatic training and upper body ergometer). Progression to weight training, running, jumping drills and sports-specific training was integrated throughout the rehabilitation process.	After six treatment session athlete was able to return to a progressive, periodized sport training program. At 6 month follow-up patient performed normal training and job duties.

RCT: Randomized Clinical Trial; AT: Active Training; PT: Physiotherapy Treatment without active training; TA: Transversus Abdominis muscle; US: Ultrasound; ET: Exercise Therapy; MMT: Multi-Modal Treatment; VAS: Visual Analogue Scale; ADL: Activities of Daily Living; ROM: Range Of Motion; LEFS: Lower Extremity Functional Scale.

Figure 1. Most frequent pathologies which cause anterior pelvic/groin pain (modified from Pogliacomi et al., 2014[7]).



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