Knee Surg Sports Traumatol Arthrosc
DOI 10.1007/s00167-017-4423-z

HIP

Non-surgical treatment of pubic overload and groin pain in amateur football players: a prospective double-blinded randomised controlled study

M. Schöberl[1] · L. Prantl[2] · O. Loose[3] · J. Zellner[1] · P. Angele[1] · F. Zeman[4] · M. Spreitzer[5] · M. Nerlich[1] · W. Krutsch[1]

Received: 31 July 2016 / Accepted: 3 January 2017

Abstract
Purpose The incidence of groin pain in athletes is steadily increasing. Symptomatic pubic overload with groin pain and aseptic osteitis pubis represent well-known and frequently misdiagnosed overuse injuries in athletes. This study investigated the benefits of standardised non-surgical treatment for swift return-to-football.
Methods In a prospective double-blinded controlled study, 143 amateur football players with groin pain as well as radiological signs and clinical symptoms of pubic overload were analysed for 1 year. Two randomised study groups participated in an intensive physical rehabilitation programme, either with or without shock wave therapy. The control group did not participate in any standardised rehabilitation programme but only stopped participating in sports activity. Follow-up examinations took place 1, 3 months and 1 year after the beginning of therapy. Endpoints were visual analogue scale (VAS), functional tests, the time of return-to-football, recurrent complaints and changes in the MR image.
Results Forty-four football players with groin pain and aseptic osteitis pubis were randomised into two study groups; 26 received shock wave therapy, 18 did not. Clinical examination showed pubic overload as a multi-located disease. Players receiving shock wave therapy showed earlier pain relief in the VAS ($p<0.001$) and returned to football significantly earlier ($p=0.048$) than players without this therapy. Forty-two of 44 players of both study groups returned to football within 4 months after the beginning of therapy and had no recurrent groin pain within 1 year after trauma. Fifty-one players of the control group returned to football after 240 days ($p<0.001$), of whom 26 (51%) experienced recurrent groin pain. Follow-up MRI scans did not show any effect of shock wave therapy.
Conclusion Non-surgical therapy is successful in treating pubic overload and osteitis pubis in athletes. Shock wave therapy as a local treatment significantly reduced pain, thus enabling return-to-football within 3 months after trauma. Early and correct diagnosis is essential for successful intensive physiotherapy.
Level of evidence I.

Keywords Football · Soccer · Pubic overload · Groin pain · Shock wave therapy · Osteitis pubis

✉ W. Krutsch
werner.krutsch@ukr.de

[1] Clinic of Trauma Surgery, University Medical Centre Regensburg, Franz-Josef-Strauss-Allee 11, 93053 Regensburg, Germany

[2] Centre for Hand, Plastic and Reconstructive Surgery, University Medical Centre Regensburg, Regensburg, Germany

[3] Clinic of Paediatric Surgery, Clinic St. Hedwig, Regensburg, Germany

[4] Centre for Clinical Studies, University Medical Centre Regensburg, Regensburg, Germany

[5] Physiodrom Regensburg, Regensburg, Germany

Introduction

Groin pain is a frequent condition in both amateur and professional athletes worldwide, particularly in stop-and-go sports such as football with typical sport-specific movements [13, 44, 46]. Groin pain is still not fully understood. Several reviews and consensus statements with controversial results about the definition, diagnosis and treatment of this disease have been published recently [8, 38, 45].

Because of the high recurrence rate and the low number of specific treatment options for osteitis pubis, hardly any standardised diagnostic or therapeutic guidelines for treating groin pain are established in daily practice [1]. Because players with groin pain frequently have to stay away from sports for more than 6 months, this affliction represents a severe chronic overuse injury for athletes [2, 6, 34, 46]. Osteitis pubis is a self-limiting disease for which no systematic consecutive treatment is yet available [28]. However, long absence from sports is not acceptable for competing athletes.

Groin pain is a symptom with several aetiologies and differential diagnoses, thus representing a multi-factorial and multi-located complex of complaints [7, 16, 17, 19, 46]. MRI scans not only provide radiological evidence of aseptic osteitis pubis [48] but have also improved the understanding of the aetiology of pubic overload. The aetiology of osteitis pubis is not yet clear. One explanation for intraosseous oedema of the os pubis is musculotendinous pubic overload [6, 24] caused by stop-and-go sports such as football that put continuous stress on the symphysis pubis [12, 14].

Because diagnosing is rather difficult and often results in incorrect diagnoses or in diagnoses of exclusion, the treatment of osteitis pubis is based on clinical symptoms. Non-surgical treatment is still preferable [42]. Surgical intervention becomes only necessary in the case of differential diagnoses or long-term complaints [22]. Hardly any standard regimens are available for treating groin pain in athletes [8], and the quality of available studies on managing groin injuries is insufficient [38]. The still increasing number of athletes developing groin pain in sports such as football necessitates improving treatments and complaint management. The purpose of this study was to show the positive effect of a standardised treatment programme for symptomatic pubic overload in athletes with groin pain and osteitis pubis in a prospective randomised controlled study. This study investigated how an intensive conservative treatment programme may influence the main outcome parameters 'pain reduction', 'time of return-to-football' and 'recurrent complaints' in athletes with symptomatic pubic overload and assessed the effects of shock wave therapy.

Materials and methods

This prospective double-blinded randomised controlled study was conducted at the University Medical Centre Regensburg (FIFA Medical Centre of Excellence) between October 2011 and March 2013. All follow-up examinations had been finished by June 2013. Patients were mainly examined during consultations in the outpatient and emergency department or referred to the department of sports traumatology by other sports clinics or sports physicians.

Patient selection

Inclusion criteria for the study group were male amateur athletes aged between 18 and 40 years with specific groin pain symptoms. Considering the multi-factorial aetiology of groin pain in different stop-and-go sports, only football players were included into this study. The diagnosis of groin pain and pubic overload was verified by anamnesis and physical examination, the diagnosis of osteitis pubis by MRI images [6, 41] (Figs. 1, 2).

Exclusion criteria were all other differential pathologies resulting in groin pain. Athletes with any contraindication for diagnostic and treatment procedures such as shock wave therapy or MRI were also excluded as well as professional football players and athletes from other sports. The players were randomised into two study groups. All players of both study groups underwent an intensive rehabilitation programme. Study group 1 additionally received shock wave therapy, study group 2 did not. The football players of the control group did neither take part in any standardised intensive physical programme nor did they receive shock wave therapy. Players of the control group were not randomised because of ethical considerations and only infrequently received physiotherapy. Follow-up examinations in the control group were only focused on return-to-football and the possible

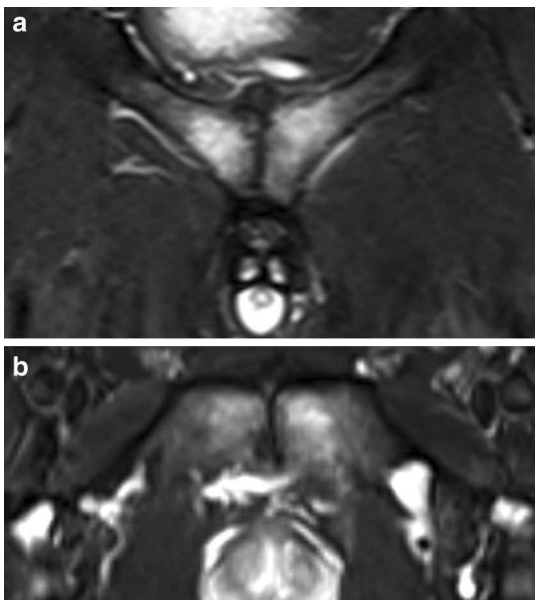

Fig. 1 **a, b** Osteitis pubis in an amateur football player (MRI, T2 stir, coronal and axial plane): bilateral bone bruise around the symphysis joint

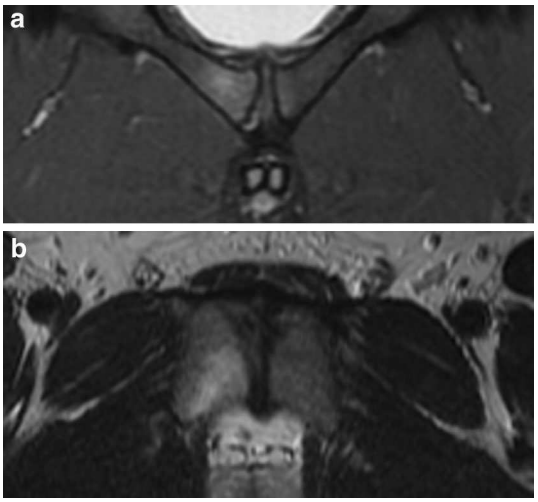

Fig. 2 a, b Osteitis pubis in an amateur football player (MRI, T2 + contrast agent, coronal and axial plane): unilateral bone bruise on the right os pubis

occurrence of recurrent complaints after 1 year. Football players of the control group decided against participating in the standardised intensive rehabilitation programme for different reasons; however, such participation was essential for inclusion into the study groups.

Standardised non-surgical treatment

All amateur football players included into the two study groups participated in an intensive 3-phase rehabilitation programme, which was developed to serve as a guideline for treating clinical symptoms of pubic overload in football players and as a schedule for the return-to-play process (Fig. 3). This schedule was partially based on previous studies [23, 27, 37] and adapted to develop an individualised multi-modal treatment approach for this multi-located disease. In the first phase (28 days) of the standardised schedule, no sports activity was permitted, and players received physiotherapy for 90 min at least three times a week [21]. In the second phase (day 29–56), light sports activities were allowed, such as cycling, skating and mild stretching. Running exercises started at week 8 (from day 56 onwards) [21], but rapid stop-and-go movements still had to be avoided. After the eighth week (day 56–84), players started proprioceptive exercises and football-specific training. Intensive physiotherapy was continued beyond the time of return-to-football and football competition until 1 year after the beginning of therapy. The return-to-play decision was made by the players, the team coach and the physician. Abdominal muscle training was not permitted during the entire rehabilitation period (Fig. 3).

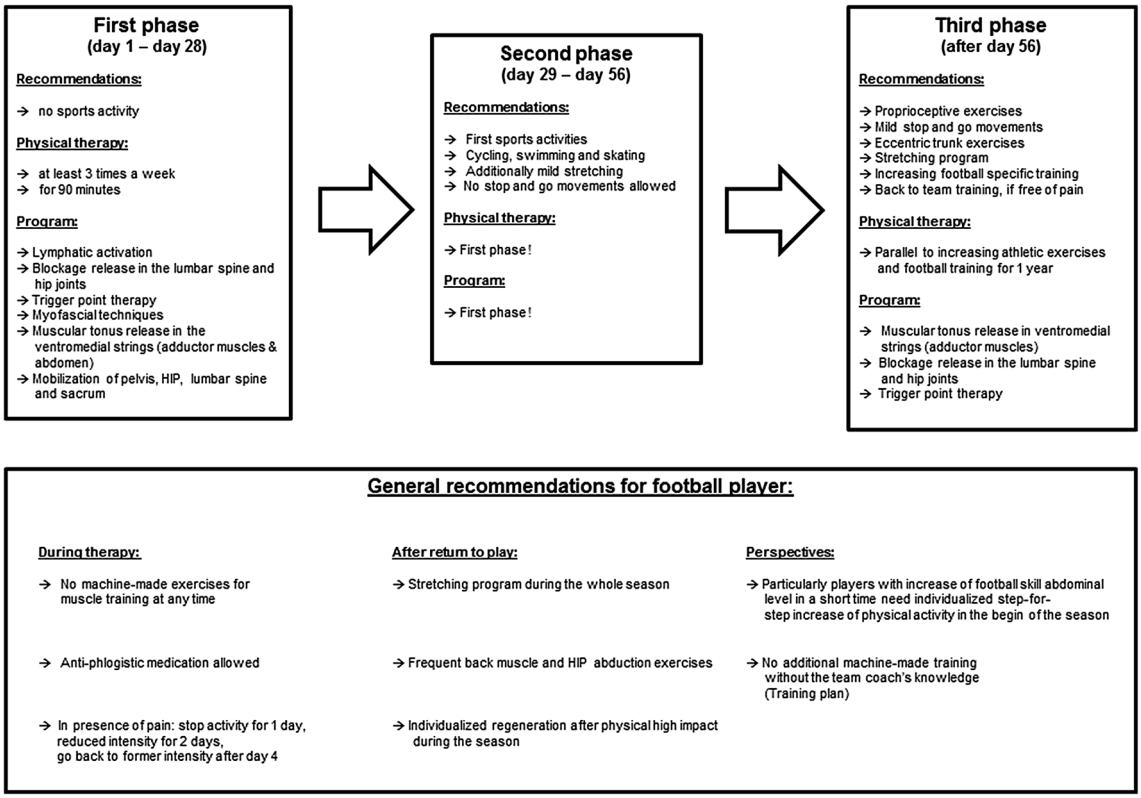

Fig. 3 Standardised intensive rehabilitation protocol

Shock wave therapy

In study group 1, aseptic osteitis pubis was treated with extracorporeal shock wave therapy directly on the os pubis on day 1 and two more times at an interval of 1 week. Both study groups were blinded during the treatment. Study group 2 was treated with sham shock wave therapy consisting of a device that reabsorbed the shock waves. Study participants, physicians, physiotherapists and the examiner of the results were blinded for the application of shock wave therapy. A Storz Medical Duolith device was used for applying 1500 impulses of extracorporeal focused shock waves on the symphysis with a frequency of 15–21 Hz per session.

Data assessment

Clinical follow-up examinations and MRI scans were carried out 1 and 3 months after shock wave application. All football players were monitored by means of a questionnaire at the time of return-to-football and 1 year after the beginning of therapy. Depending on the multi-located complaints regarding pubic overload with groin pain and osteitis pubis, each football player received individual physiotherapy based on the standardised schedule. The primary outcome parameter for assessing the benefit of the standardised intensive conservative treatment programme in this study was pain reduction measured by the visual analogue scale (VAS) and the consecutive time of return-to-football after the beginning of treatment defined as the time of the first competitive match. Secondary outcome parameters were the presence of recurrent complaints within 1 year, findings at clinical examinations, clinical scores and MRI results. An anamnestic interview helped analysing a patient's medical history and detecting potential influencing factors for pubic overload. Clinical examination focused on the multi-located aetiology of pubic overload. Specific os pubic tests were carried out, such as the adductor squeeze test, the pubic stress test and pressure pain over the os pubic, the inguinal canal and the adductor tendon [41]. For assessing diagnostic data on pain and other complaints, a system of four grades from 0 to 3 (0 = absent, 1 = mild, 2 = moderate, 3 = considerable) was used as established in previous studies [39]. The selection of clinical scores was also adapted to the multi-located disease. Valid clinical scores specific for pubic overload or osteitis pubis are still lacking. Therefore, the focus was on different scores mainly used for chronic pain, lower back pain or chronic pelvic diseases, i.e. body localisations frequently involved in pubic overload complaints in athletes. Local pain in the symphysis bone and general complaints of athletes were evaluated with the VAS. Lower back pain (LBP) was assessed with the Oawestry low back pain disability questionnaire. Pelvic complaints and functional assessment of pelvic mobility were analysed with the Hip disability and Osteoarthritis Outcome Score (HOOS). The Pain Catastrophizing Scale was used for evaluating mental strain due to pubic overload and groin pain in general. MRI examinations were conducted by two blinded examiners experienced in overuse injuries in athletes. The severity of osteitis pubis was classified by means of MRI scans according to a 4-grade system [26, 33, 39, 43]. Changes in bone marrow oedema found on the MRI were graded depending on the affected bone marrow extension as 0 (normal), 1 (minimal; <2 cm area), 2 (moderate; >2 cm area) and 3 (severe; both rami of the os pubis). The study design was approved by the Ethics Committee of the University of Regensburg (Number: 11-101-0166).

Statistical analysis

Sample size was calculated according to the primary endpoint VAS 3 months after therapy. The VAS as primary outcome parameter was analysed by a ruler with one decimal; therefore, one decimal was reported in the results. Alpha was set at 0.05, beta at 0.2 (power 80%) and the lost-to-follow up rate to 5%. Thus, to detect the expected mean difference of 1 (SD 1) between the two study groups, 18 patients per group were needed to be enrolled. Because of the randomization algorithm, 26 patients were randomised to study group 1 before the last patient was randomised to study group 2. Categorical data are presented as absolute numbers and percentages. Continuous data are presented as mean ± standard deviation (SD), (min–max) and compared with the independent t test for between group comparisons and with repeated measures ANOVA for analyses between follow-up visits. The significance level was set at $p < 0.05$. All analyses were done with SPSS 23.0.

Results

Sixty of the 143 athletes diagnosed with pubic overload and groin pain met the inclusion criteria. Forty-four of the 60 patients with clinical groin pain showed osteitis pubis in the MRI scan. The other 16 patients were excluded from the study because of also having participated in other sports, which may have been another cause of groin pain. Twenty-six of the 44 included patients were randomised into the study group receiving shock wave therapy and 18 into the study group undergoing sham shock wave therapy. Of the 83 patients with pubic overload who had neither received any intensive rehabilitation nor shock wave therapy, 51 patients agreed to be included into the control group, the other 32 patients were excluded. The mean age of the study population was 24 years. Seventy-eight percent of all

football players with osteitis pubis had additionally carried out unsystematic fitness training and machine-based exercises of the trunk muscles before the start of the complaints. Hardly any player had done any stretching exercises for the abdominal muscles (Table 1). Adapted to the multi-located disease of pubic overload, all athletes showed positive clinical findings in the lumbar spine, sacroiliac joints and thigh muscles as well as weak findings in the hip joints (Table 2). At the follow-up examinations, players of both study groups reported continuously decreasing complaints from the beginning of treatment onwards. The VAS, Oawestry low back pain and HOOS showed fewer complaints already 1 month after the beginning of therapy ($p < 0.001$ for both groups). Complaints started to abate earlier in study group 1 undergoing shock wave therapy than in the group receiving sham shock therapy, which was proved by significant differences in the VAS and HOOS after 1 month as well as in the Pain Catastrophizing Scale after 3 months (Table 3). In contrast to the MRI examination after 1 month showing hardly any reduction in osteitis pubis, the MRI examination after 3 months showed considerably reduced osteitis pubis (a mean reduction from 2.5 at week 4 to 1.5 after 3 months). After 3 months, oedema regression had not been any faster in the study group receiving shock wave therapy (1.5) than in the study group without shock wave therapy (1.5; n.s.). 42/44 football players of both study groups returned to football within 4 months, but return-to-football was significantly earlier after shock wave therapy (mean time 73.2 days) than after sham shock treatment (mean time 102.6 days; $p = 0.048$). No player of the two study groups had to stop playing football because of groin pain within 1 year after the beginning of treatment. The period of return-to-football of the control group was much longer and lasted over 8 months (mean time 240 days; $p < 0.001$). Players of the control group frequently experienced recurrent groin pain during the first year after the beginning of therapy (26/51; 51%).

Discussion

The major finding of this study was the successful and fast recovery of athletes after non-surgical treatment of osteitis pubis due to reduced pain. Adapted to the mechanisms and

Table 1 Anthropometric and football-specific data

Anthropometric and specific data	Study group 1 with shock wave	Study group 2 without shock wave	Control group, absence from sports only
Number of patients	26	18	51
Age (years)	24.4 ± 4.4 (18–33)	24.3 ± 3.7 (20–31)	25.2 ± 4.6 (19–33)
Height (cm)	181.9 ± 6.8 (170–193)	183.2 ± 4.8 (176–192)	179.1 ± 4.9 (172–185)
Weight (kg)	80.2 ± 8.1 (70–91)	76.9 ± 5.2 (70–86)	82.7 ± 6.7 (72–90)
BMI (kg ± m²)	24.2 ± 1.7 (21.8–26.6)	22.9 ± 1.6 (20.8–25.1)	26.0 ± 5.6 (21.3–27.4)
Football increases pain (%)	92.3 ± 0.3 (0–1)	88.9 ± 0.3 (0–1)	82.9 ± 0.6 (0–1)
Abdominal fitness training in the gym (%)	77.0 ± 0.4 (0–1)	78.0 ± 0.4 (0–1)	78.3 ± 0.7 (0–1)
Stretching abdominal muscles (*n*)	0/26	0/18	2/51

Table 2 Clinical findings in all players with pubic overload

Clinical findings	Study group 1, mean ± SD (range)	Study group 2, mean ± SD (range)	Control group, mean ± SD (range)
Pain in lumbar vertebral column	1.0 ± 1.0 (0–3)	1.2 ± 1.2 (0–3)	1.5 ± 1.2 (0–3)
Pain in sacroiliac joint	1.2 ± 1.1 (0–3)	1.1 ± 0.9 (0–2)	1.4 ± 0.9 (0–3)
Pain in hip joint	0.2 ± 0.4 (0–1)	0.1 ± 0.3 (0–1)	0.3 ± 0.5 (0–1)
Pressure pain—os pubis	2.5 ± 0.7 (1–3)	2.8 ± 0.4 (2–3)	2.8 ± 0.7 (2–3)
Muscle tightness—adductor muscle group	1.7 ± 0.4 (1–2)	2.2 ± 0.5 (2–3)	2.1 ± 0.8 (1–3)
Pressure pain—adductor tendon	2.1 ± 0.8 (1–3)	2.0 ± 1.0 (0–3)	2.0 ± 0.7 (1–3)
Pressure pain—inguinal canal	0.4 ± 0.7 (0–2)	0.4 ± 0.8 (0–2)	0.5 ± 0.5 (0–2)
Adduction squeeze test	2.2 ± 0.7 (1–3)	2.1 ± 1.2 (0–3)	2.4 ± 0.8 (1–3)
Pubic stress test	0.4 ± 0.5 (0–1)	0.4 ± 0.5 (0–1)	0.5 ± 0.3 (0–1)
Pain while doing sit ups	0.3 ± 0.5 (0–1)	0.9 ± 0.8 (0–2)	0.7 ± 0.5 (0–1)

Table 3 Clinical scores in pubic overload of the two study groups

Clinical scores (scale range)	Study group 1, mean ± SD (range)	Study group 2, mean ± SD (range)	Significance level between the two study groups
General pain, visual analogue scale (0–10)			
Before treatment	8.1 ± 0.8 (7-9.5)	7.8 ± 1.1 (6-9.5)	NS
1 month after treatment	3.0 ± 1.4 (1–5)	4.6 ± 1.0 (3-5.5)	<0.001**
3 month after treatment	0.7 ± 0.6 (0-1.5)	1.7 ± 0.8 (0-2.5)	<0.001**
1 year after treatment	0.5 ± 0.5 (0–1)	0.7 ± 0.6 (0-1.5)	NS
Lumbar region, Oawestry low back pain (0–100)			
Before treatment	24.6 ± 6.4 (18–38)	23.3 ± 8.7 (12–42)	NS
1 month after treatment	11.0 ± 3.7 (6–18)	12.4 ± 0.9 (12–14)	NS
3 month after treatment	5.2 ± 2.4 (2–10)	6.2 ± 1.6 (4–8)	NS
1 year after treatment	4.0 ± 1.5 (2–6)	5.1 ± 2.3 (2–8)	0.045*
Hip region, HOOS (0-100)			
Before treatment	59.2 ± 7.0 (50-72.5)	58.8 ± 10.0 (42.5–70)	NS
1 month after treatment	78.7 ± 5.2 (71.9–90.6)	68.8 ± 5.5 (60.6–76.9)	<0.001**
3 month after treatment	89.8 ± 4.8 (80.6–97.5)	79.2 ± 4.5 (73.8–86.9)	<0.001**
1 year after treatment	91.9 ± 4.5 (80.6–97.5)	87.4 ± 4.3 (80.6–92.4)	0.001**
Mental load, pain catastrophizing scale (0–52)			
Before treatment	20.9 ± 10.2 (5–42)	23.3 ± 10.0 (9–41)	NS
1 month after treatment	15.6 ± 8.4 (3–34)	18.3 ± 12.9 (0–40)	NS
3 month after treatment	12.4 ± 8.4 (0–28)	18.2 ± 11.2 (0–33)	0.048*
1 year after treatment	9.4 ± 5.0 (2–16)	11.0 ± 6.7 (0–18)	NS

NS not significant

*$p < 0.05$ = significant; **$p < 0.01$ = highly significant

the aetiology of the complaints of pubic overload, intensive conservative therapy was shown to be a superior treatment option to absolute break from sports only. Osteitis pubis in combination with groin pain, which mainly results from musculotendinous pubic overload in stop-and-go sports, is a frequent condition in amateur football players [6]. The aetiology of pubic overload is multi-factorial; hence this disease is controversially discussed, difficult to prevent, frequently misdiagnosed and involves long absence from sports [40, 47]. Specific therapies have been established for treating groin pain due to aetiologies other than muscular-tendinous causes [5, 11, 30, 31], whereas no specific treatment is known for osteitis pubis as a result of muscular-tendinous pubic overload. This level 1 study showed the benefits of intensive non-surgical treatment and a standardised return-to-play process in amateur athletes with symptomatic osteitis pubis caused by pubic overload. Early and accurate diagnosis of this commonly misdiagnosed disease is important to avoid long absence from sports due to chronic complaints and surgery [22]. Early MRI examination in the case of groin pain lasting more than 6 weeks is essential to detect clinical indications for osteitis pubis in the intraosseous oedema and to enable diagnosis of overuse injury [24]. The main reason for misdiagnosis is the high number of differential diagnoses and the unspecific clinical findings typical for a multi-located disease [19]. The adduction squeeze test as well as pressure pain around the os pubis and the attached adductor muscles [35, 41] may indicate pubic overload, as presented in this study. Differential diagnoses of groin pain such as nerve-compression syndrome or abdominal hernia [4, 31] are focal problems, requiring specific focal therapies, for instance surgery. In such patients, exclusive localised therapy of pubic overload or osteitis pubis would not be successful. Injections with antiphlogistic and analgesic medication into the symphysis joint [32], surgical neurolysis of the os pubis [3], open surgical resection [40], arthroscopic curettage [22] or symphysis joint arthrodesis [10] have been described as partially successful treatment options. However, invasive therapy may be second-line treatment or should generally be avoided. No successful causal treatment option for pubic overload to hasten return-to-football has yet been published in the literature.

Generally, the effectiveness of physiotherapy in treating chronic adductor-related groin pain is well known [21, 27, 47] and can be transferred to muscular-tendinous pubic overload. During the first treatment period, physiotherapists may reset musculoskeletal imbalance by different

techniques. Treating multi-located complaints in athletes is the main step to reduce pain, not only in the first treatment period but also after the beginning of football competition. After a step-by-step increase in the physical load and the frequency of sport activities according to a standardised schedule, athletes in this study were able to return to football early and avoid absence from sports for more than 6 months [7]. High compliance on the part of the athletes is essential for the success of conservative treatment programmes. Further factors for successful treatment are close communication with patients and between members of the medical professions and intensity of the treatment schedule. These facts cannot always be taken for granted in non-competitive amateur athletes. For competitive salaried professional athletes, the intensive time schedule of this study may be necessary and represents a successful way of decreasing pain and returning to football quickly.

Another important finding of this study was the successful use of extracorporeal shock wave therapy for treating osteitis pubis. Besides the multifunctional rehabilitation programme for general muscular imbalance, shock wave therapy represents a focal non-invasive treatment option to reduce inflammation and pain in the symphysis [29]. The multiple biological and beneficial effects of shock wave therapy are well known, for instance increase in cell metabolism, blood flow and anti-inflammatory reactions, release of nitrous oxide and a number of growth factors that further the healing process of musculoskeletal tissues [9, 18]. These effects of increased tissue regeneration, relief of nerve pain [25] on the os pubis and chronic tendinitis of the attached tendons and muscles were used for this study population. To the knowledge of the authors of this study, this is the first investigation to describe shock wave therapy in patients with osteitis pubis and pubic overload.

The question if MRI examinations are necessary for primary diagnostics or follow-up examinations may also be answered with this study. MRI scans are essential for early diagnosis of pubic overload due to intraosseous oedema in the symphysis pubis. MRI scans in follow-up examinations in the case of reduced pubic oedema, as presented in this study design, are not necessary in daily practice.

Repetitive micro trauma or shearing forces on the pubic joint by attached muscles of the ventromedial muscular-tendinous string with the abdominal and adductor muscles may cause overuse complaints in this body region [24]. The reason why only some football players develop pain and subsequently muscular imbalance due to football-specific stress is not yet clear. This study showed that the majority of amateur football players affected by groin pain had additionally carried out unsystematic training exercises on fitness machines and no stretching exercises for the abdominal muscles, and both factors may potentially influence the pathology of osteitis pubis. The heavy pulling forces in sports such as football may cause an imbalance of the muscles of the os pubis [33]. Thus, flexibility and active muscular trunk stability are known to be essential for successful football competition [36]. Prevention of pubic overload in football should consequently start with reducing permanent stress and imbalance on the muscles around the os pubis. Because of the lack of other successful strategies for avoiding groin pain in football players [15, 20], the avoidance of unsystematic trunk exercises additionally to football training may help prevent chronic overuse around the os pubis.

The strength of this study is the prospective double-blinded randomised controlled study design. However, some limitations have to be considered when interpreting our data. The physiotherapeutic programme was adapted to the respective clinical finding and, therefore, not identical in all participants due to the heterogenic presentation of clinical symptoms. Because osteitis pubis represents a multi-located disease, clinical scores were used for LBP or HIP pathologies. The effect of this non-surgical treatment programme compared to other treatment options may be a future step to implement both intensive physiotherapy and shock wave therapy when treating osteitis pubis. Particularly the influence of HIP pathologies and lower back pathologies on osteitis pubis were not focus of this study and represent an important research field for the future. Highly experienced physiotherapists for individual athlete requirements are necessary for carrying out this specialised treatment, but such physiotherapists are not generally available in amateur football. Athletes affected by osteitis pubis also have to be willing to undergo intensive physiotherapy over a long period of time. This treatment also requires the necessary funding by health insurances. Continuous communication between patients, physicians and physiotherapists—as in this study—does not reflect daily clinical routine. The selection of the control group was not randomised for ethical reasons, which represents a further limitation of the study. Therefore, only athletes who did not want to participate in the treatment programme of the study for private reasons were included into the control group.

Conclusion

Non-surgical therapy is successful in treating pubic overload and osteitis pubis in athletes. For daily routine, early and correct diagnosis are essential for successful intensive physiotherapy. Shock wave therapy as a local treatment to reduce pain enabled return-to-football within 3 months. For the daily routine of athletes with osteitis pubis and groin pain, this study presents an option for successful treatment with non-surgical strategies and a way of how to find the best treatment strategy by exact early clinical as well as radiological diagnostics.

Acknowledgements We would like to thank the co-initiator and responsible physiotherapist Shyrin Spreitzer (Physiodrom Regensburg, former physiotherapist of the German National Women's Football Team) for participating in this study and for preparing the physiotherapeutic programme. The close interaction between Shyrin Spreitzer, the study participants and the study physician was fundamental for the successful realisation of this study. After the completion of the data sample for this study, Mrs. Spreitzer passed away unexpectedly on 13th December 2013 at the age of 46. Many thanks also to Dr. Andreas Harlass-Neuking, Dr. Bernd Meyer and Dr. Susanne Zimmermann for their support in recruiting study participants and to Mr. Pavel Novak/Storz Medical for his support in the novel application of shock wave therapy.

Compliance with ethical standards

Conflict of interest None of the authors has any personal or financial relationship with other people or organisations involved in or targeted by this RCT. None of the authors has any competing interests.

References

1. Aroori S, Spence RA (2007) Chronic pain after hernia surgery-an informed consent issue. Ulster Med J 76:136–140
2. Bizzini M (2011) The groin area: the Bermuda triangle of sports medicine? Br J Sports Med 45:1
3. Bradshaw C, McCrory P, Bell S, Brukner P (1997) Obturator nerve entrapment. A cause of groin pain in athletes. Am J Sports Med 25:402–408
4. Callesen T, Bech K, Kehlet H (1999) Prospective study of chronic pain after groin hernia repair. Br J Surg 86:1528–1531
5. Carbajo MA, del Olmo JC, Blanco JI, de la Cuesta C, Martín F, Toledano M, Perna C, Vaquero C (2000) Laparoscopic treatment of ventral abdominal wall hernias: perliminary results in 100 patients. JSLS 4:141–145
6. Caudill P, Nyland J, Smith C et al (2008) Sports hernias: a systematic literature review. Br J Sports Med 42:954–964
7. Choi H, McCartney M, Best TM (2011) Treatment of osteitis pubis and osteomyelitis of the pubic symphysis in athletes: asystematic review. Br J Sports Med 45:57–64
8. Delahunt E, Thorborg K, Khan KM, Robinson P, Hölmich P, Weir A (2015) Minimum reporting standards for clinical research on groin pain in athletes. Br J Sports Med 49:775–781
9. Diehl P, Gollwitzer H, Schauwecker J, Tischer T, Gerdesmeyer L (2014) Conservative treatment of chronic tendinopathies. Orthopade 43:183–193
10. Dreyfuss P, Dreyer SJ, Cole A, Mayo K (2004) Sacroiliac joint pain. J Am Acad Orthop Surg 12:255–265
11. Ekberg O, Persson NH, Abrahamsson PA, Westlin NE, Lilja B (1988) Longstanding groin pain in athletes. A multidisciplinary approach. Sports Med 6:56–61
12. Ekstrand J, Gillquist J (1983) Soccer injuries and their mechanisms: a prospective study. Med Sci Sports Exerc 15:267–270
13. Ekstrand J, Ringborg S (2001) Surgery versus conservative treatment in soccer with chronic groin pain: a prospective randomised study in soccer players. Eur J Sports Traumatol 23:141–145
14. Emery CA, Meeuwisse WH (2001) Risk factors for groin injuries in hockey. Med Sci Sports Exerc 33:1423–1433
15. Engebretsen AH, Myklebust G, Holme I, Engebretsen L, Bahr R (2008) Prevention of injuries among male soccer players: a prospective, randomized intervention study targeting players with previous injuries or reduced function. Am J Sports Med 36:1052–1060
16. Falvey EC, Franklyn-Miller A, McCrory PR (2009) The groin triangle: a patho-anatomical approach to the diagnosis of chronic groin pain in athletes. Br J Sports Med 43:213–220
17. Gabbe BJ, Bailey M, Cook JL, Makdissi M, Scase E, Ames N, Wood T, McNeil JJ, Orchard JW (2010) The association between hip and groin injuries in the elite junior football years and injuries sustained during elite senior competition. Br J Sports Med 44:799–802
18. Haupt G (1997) Use of extracorporeal shock waves in the treatment of pseudarthrosis, tendinopathy andother orthopedic diseases. J Urol 158:4–11
19. Hölmich P (2007) Long-standing groin pain in sportspeople falls into three primary patterns, a "clinical entity" approach: a prospective study of 207 patients. Br J Sports Med 41:247–252
20. Hölmich P, Larsen K, Krogsgaard K, Gluud C (2010) Exercise program for prevention of groin pain in football players: a cluster-randomized trial. Scand J Med Sci Sports 20:814–821
21. Hölmich P, Uhrskou P, Ulnits L, Kanstrup IL, Nielsen MB, Bjerg AM, Krogsgaard K (1999) Effectiveness of active physical training as treatment for long-standing adductor-related groin pain in athletes: randomised trial. Lancet 353:439–443
22. Hopp SJ, Culemann U, Kelm J, Pohlemann T, Pizanis A (2013) Osteitis pubis and adductor tendinopathy in athletes: a novel arthroscopic pubic symphysis curettage and adductor reattachment. Arch Orthop Trauma Surg 133:1003–1009
23. Jarosz BS (2011) Individualized multi-modal management of osteitis pubis in an Australian Rules footballer. J Chiropr Med 10:105–110
24. Koulouris G (2008) Imaging review of groin pain in elite athletes: an anatomic approach to imaging findings. AJR Am J Roentgenol 191:962–972
25. Kuo YR, Wang CT, Wang FS, Chiang YC, Wang CJ (2009) Extracorporeal shock-wave therapy enhanced wound healing via increasing topical blood perfusion and tissue regeneration in a rat model of STZ-induced diabetes. Wound Repair Regen 17:522–530
26. Lovell G, Galloway H, Hopkins W, Harvey A (2006) Osteitis pubis and assessment of bone marrow edema at the pubic symphysis with MRI in an elite junior male soccer squad. Clin J Sport Med 16:117–122
27. Machotka Z, Kumar S, Perraton LG (2009) A systematic review of the literature on the effectiveness of exercise therapy for groin pain in athletes. Sports Med Arthrosc Rehabil Ther Technol 1:5
28. Macintyre J, Johson C, Schroeder EL (2006) Groin pain in athletes. Curr Sports Med Rep 5:293–299
29. Mariotto S, de Prati AC, Cavalieri E, Amelio E, Marlinghaus E, Suzuki H (2009) Extracorporeal shock wave therapy in inflammatory diseases: molecular mechanism that triggers anti-inflammatory action. Curr Med Chem 16:2366–2372
30. McCarthy JC (1995) Hip arthroscopy: applications and technique. J Am Acad Orthop Surg 3:115–122
31. Muschaweck U, Berger LM (2010) Sportsmen's groin-diagnostic approach and treatment with the minimal repair technique: a single-center uncontrolled clinical review. Sports Health (London) 2:216–221
32. O'Connell MJ, Powell T, McCaffrey NM, O'Connell D, Eustace SJ (2002) Symphyseal cleft injection in the diagnosis and treatment of osteitis pubis in athletes. AJR Am J Roentgenol 179:955–959
33. Paajanen H, Hermunen H, Karonen J (2011) Effect of heavy training in contact sports on MRI findings in the pubic region of asymptomatic competitive athletes compared with non-athlete controls. Skeletal Radiol 40:89–94
34. Renström P, Peterson L (1980) Groin injuries in athletes. Br J Sports Med 14:30–36

35. Robb A, Pajaczkowski J (2011) Immediate effect on pain thresholds using active release technique on adductor strains: pilot study. J Bodyw Mov Ther 15:57–62
36. Rösch D, Hodgson R, Peterson TL, Graf-Baumann T, Junge A, Chomiak J, Dvorak J (2000) Assessment and evaluation of football performance. Am J Sports Med 28:29–39
37. Serner A, Jakobsen MD, Anderesen LL, Hölmich P, Sundstrup E, Thorborg K (2013) EMG evaluation of hip adduction exercises for soccer players: implications for exercise selection in prevention and treatment of groin injuries. Br J Sports Med 48:1108–1114
38. Serner A, van Eijck CH, Beumer BR, Hölmich P, Weir A, de Vos RJ (2015) Study quality on groin injury management remains low: a systematic review on treatment of groin pain in athletes. Br J Sports Med 49:813
39. Slavotinek JP, Verrall GM, Fon GT, Sage MR (2005) Groin pain in footballers: the association between preseason clinical and pubic bone magnetic resonance imaging findings and athlete outcome. Am J Sports Med 33:894–899
40. Tibor LM, Sekiya JK (2008) Differential diagnosis of pain around the hip joint. Arthroscopy 24:1407–1421
41. Verrall GM, Slavotinek JP, Barnes PG, Fon GT (2005) Description of pain provocation tests used for the diagnosis of sports-related chronic groin pain: relationship of tests to defined clinical (pain and tenderness) and MRI (pubic bone marrow oedema) criteria. Scand J Med Sci Sports 15:36–42
42. Verrall GM, Slavotinek JP, Fon GT, Barnes PG (2007) Outcome of conservative management of athletic chronic groin injury diagnosed as pubic bone stress injury. Am J Sports Med 35:467–474
43. Verrall GM, Slavotinek JP, Fon GT (2001) Incidence of pubic marrow oedema in Australian Rules football players: relation to groin pain. Br J Sports Med 35:28–33
44. Waldén M, Hägglund M, Ekstrand J (2007) Football injuries during European Championships 2004–2005. Knee Surg Sports Traumatol Arthrosc 15:1155–1162
45. Weir A, Brukner P, Delahunt E, Ekstrand J, Griffin D, Khan KM, Lovell G, Meyers WC, Muschaweck U, Orchard J, Paajanen H, Philippon M, Reboul G, Robinson P, Schache AG, Schilders E, Serner A, Silvers H, Thorborg K, Tyler T, Verrall G, de Vos RJ, Vuckovic Z, Hölmich P (2015) Doha agreement meeting on terminology and definitions in groin pain in athletes. Br J Sports Med 49:768–774
46. Werner J, Hägglund M, Waldén M et al (2009) UEFA injury study: a prospective study of hip and groin pain injuries in professional football over seven consecutive seasons. Br J Sports Med 43:1036–1040
47. Williams PR, Thomas DP, Downes EM (2000) Osteitis pubis and instability of the pubic symphysis. When nonoperative measures fail. Am J Sports Med 28:350–355
48. Zoga AC, Mullens FE, Meyers WC (2010) The spectrum of MR imaging in athletic pubalgia. Radiol Clin North Am 48:1179–1197