

# Effectiveness of active physical training as treatment for long-standing adductor-related groin pain in athletes: randomised trial

Per Hölmich, Pernille Uhrskou, Lisbeth Ulnits, Inge-Lis Kanstrup, Michael Bachmann Nielsen, Anders Munch Bjerg, Kim Krogsgaard

## Summary

**Background** Groin pain is common among athletes. A major cause of long-standing problems is adductor-related groin pain. The purpose of this randomised clinical trial was to compare an active training programme (AT) with a physiotherapy treatment without active training (PT) in the treatment of adductor-related groin pain in athletes.

**Methods** 68 athletes with long-standing (median 40 weeks) adductor-related groin pain—after examination according to a standardised protocol—were randomly assigned to AT or PT. The treatment period was 8–12 weeks. 4 months after the end of treatment a standardised examination was done. The examining physician was unaware of the treatment allocation. The ultimate outcome measure was full return to sports at the same level without groin pain. Analyses were by intention to treat.

**Findings** 23 patients in the AT group and four in the PT group returned to sports without groin pain (odds ratio, multiple-logistic-regression analysis, 12.7 [95% CI 3.4–47.2]). The subjective global assessments of the effect of the treatments showed a significant ( $p=0.006$ ) linear trend towards a better effect in the AT group. A per-protocol analysis did not show appreciably different results.

**Interpretation** AT with a programme aimed at improving strength and coordination of the muscles acting on the pelvis, in particular the adductor muscles, is very effective in the treatment of athletes with long-standing adductor-related groin pain. The potential preventive value of a short programme based upon the principles of AT should be assessed in future, randomised, clinical trials.

Lancet 1999; **353**: 439–43

## Introduction

Groin pain is a problem for athletes in several sports. Among male soccer players the incidence of groin pain is 10–18% per year.<sup>1–3</sup> Groin pain can be ascribed to various disorders, few of which are well defined. There is no consensus on definitions or diagnostic criteria. However, adductor-muscle pain is a frequent cause of groin pain<sup>4,5</sup> and is known to cause long-standing problems.<sup>4</sup>

The non-operative treatments of groin pain in athletes are not based on randomised clinical trials.<sup>6–11</sup> Most of the studies on operative treatment of groin injuries were retrospective,<sup>12–17</sup> and the few prospective studies were not randomised.<sup>18</sup>

In sports medicine various training programmes to treat overuse injuries in particular have been designed primarily on an empirical basis. However, the efficacy of training programmes for a few diagnostic entities such as functional instability of the ankle<sup>19</sup> and low-back pain,<sup>20</sup> has been documented in randomised clinical trials.

Muscular imbalance of the combined action of the muscles stabilising the hip joint could, from an anatomical point of view, be a causative factor of adductor-related groin pain.<sup>21</sup> Muscular fatigue and overload might lead to impaired function of the muscle and increase the risk of injury. The adductor muscles act as important stabilisers of the hip joint.<sup>22</sup> They are, therefore, exposed to overloading and risk of injury if the stabilisation of the hip joints is disturbed. Laboratory studies have shown that strengthening exercises could protect muscles from injury.<sup>23</sup>

The purpose of this randomised clinical trial was to compare an active training programme with a conventional physiotherapy programme in the treatment of severe and incapacitating adductor-related groin pain in athletes.

The treatment mortalities were: a physiotherapy treatment without active training (PT) with elements of both passive and active therapy put together according to the contemporary practice among physicians and physiotherapists working in the field of sports injuries, and an active training programme (AT) aimed at improving the coordination and strength of the muscles stabilising the pelvis and hip joints, in particular the adductor muscles.

## Methods

### Study population

Potential participants were referred from physicians and physiotherapists. The study was also announced in journals and magazines for athletes and coaches, and on posters in sports-medicine clinics and sports facilities in Copenhagen. The ethics committee of Copenhagen County and the Danish Data Protection Agency approved the study.

Between January, 1991, and November, 1995, 177 patients were referred for interview and examination. 68 (38%) patients fulfilled the entry criteria and gave informed consent.

Clinic of Sports Medicine, Department of Orthopaedic Surgery, Amager University Hospital (P Hölmich MD); Departments of Rheumatology (P Uhrskou PT, L Ulnits PT) and Clinical Physiology (I-L Kanstrup DMedSci), Herlev University Hospital; Departments of Radiology, Glostrup University Hospital (M Bachmann Nielsen PDMedSci); and Copenhagen Trial Unit, Centre of Clinical Intervention Research, Institute of Preventive Medicine, University of Copenhagen, Denmark (A Munch Bjerg MSc, K Krogsgaard DMedSci)

**Correspondence to:** Dr Per Hölmich, Clinic of Sports Medicine, Department of Orthopaedic Surgery, Amager University Hospital, DK-2300 Copenhagen S, Denmark

## Panel 1: Elements of AT

## Module 1 (first 2 weeks)

- 1 Static adduction against soccer ball placed between feet when lying supine; each adduction 30 s, ten repetitions.
- 2 Static adduction against soccer ball placed between knees when lying supine; each adduction 30s, ten repetitions.
- 3 Abdominal sit-ups both in straightforward direction and in oblique direction; five series of ten repetitions.
- 4 Combined abdominal sit-up and hip flexion, starting from supine position and with soccer ball placed between knees (folding knife exercise); five series of ten repetitions.
- 5 Balance training on wobble board for 5 min.
- 6 One-foot exercises on sliding board, with parallel feet as well as with 90° angle between feet; five sets of 1 min continuous work with each leg, and in both positions.

## Module II (from third week; module II was done twice at each training session)

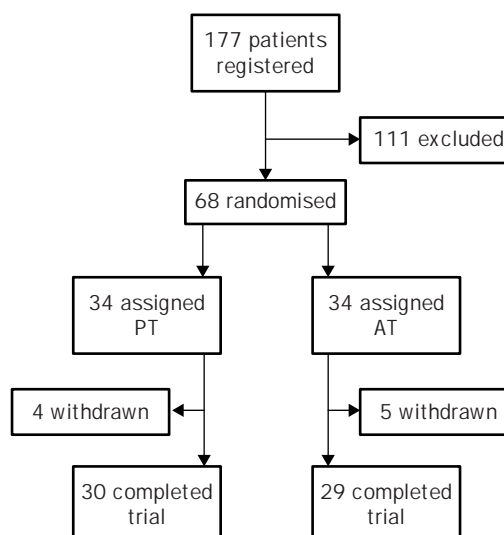
- 1 Leg abduction and adduction exercises lying on side; five series of ten repetitions of each exercise.
- 2 Low-back extension exercises prone over end of couch; five series of ten repetitions.
- 3 One-leg weight-pulling abduction/adduction standing; five series of ten repetitions for each leg.
- 4 Abdominal sit-ups both in straightforward direction and in oblique direction; five series of ten repetitions.
- 5 One-leg coordination exercise flexing and extending knee and swinging arms in same rhythm (cross country skiing on one leg); five series of ten repetitions for each leg.
- 6 Training in sideways motion on a "Fitter" (rocking base curved on top and bottom; user stands on platform that rolls laterally on tracks on top of rocking base) for 5 min.
- 7 Balance training on wobble board for 5 min.
- 8 Skating movements on sliding board; five times 1 min continuous work.

To be included in the study athletes had to be male, aged 18–50 years, and to have had groin pain due to sport for at least 2 months. Study participants had to have in addition, a desire to continue sports at the same level of competition as before the injury, pain at palpation of the adductor tendons or the insertion on the pubic bone, or both, and groin pain during active adduction against resistance. Moreover, a minimum of two of the following four criteria had to be met: a characteristic history of, for instance, groin pain and stiffness in the morning, groin pain at night, groin pain with coughing or sneezing; pain at palpation of the symphysis joint; increased scintigraphic activity in the pubic bone; radiographical signs of osteitis pubis around the symphysis joint.

The exclusion criteria were: clinical findings indicating inguinal or femoral hernia; evidence of prostatitis or chronic urinary-tract disease; pain of the vertebrae from the tenth thoracic segment to the fifth lumbar segment, including the facet

## Panel 2: Elements of PT

- 1 Laser treatment with a gallium aluminium arsen laser (Endolaser 465B; Enraf Nonius, Hvidovre, Denmark). All painful points of the adductor-tendon insertion at the pubic bone received treatment for 1 min, receiving 0.9 mJ per treated point. The probe was in contact with the skin at 90° angle. The laser was fitted with an 830 nm ( $\pm 0.5$  nm) 30 mW, diode. Beam divergence was 4° and area of probe head was 2.5 mm<sup>2</sup>.
- 2 Transverse friction massage for 10 min on painful area of adductor-tendon insertion into pubic bone.
- 3 Stretching of adductor muscles, hamstring muscles, and hip flexors. The contract-relax technique was used. The stretching was repeated three times and the duration of each stretch was 30 s.
- 4 Transcutaneous electrical nerve stimulation was given for 30 min at painful area. The apparatus used was a Biometer, Elpha 500, frequency 100 Hz and a pulse width of one and a maximum of 15 mA (100% effect).



## Trial profile

joint; presence of malignant disease; coexisting fracture of the pelvis or the lower extremities; other lesions of the lower extremities preventing the patient from fulfilling the treatment programme; clinical findings showing nerve entrapment of the ilioinguinal, genitofemoral, or lateral femoral cutaneous nerves; radiographic evidence of hip-joint osteoarthritis or any other hip-joint disease; and bursitis of the hip or groin region.

For the per-protocol analysis, exclusion criteria after randomisation were: disease preventing the patient from completing the treatment programme; absence from more than 25% of the treatment sessions.

## Design

The study was designed as a randomised clinical trial of two interventions with an observer unaware of treatment allocation. All patients were examined by the same physician, who used a standardised protocol.<sup>24</sup> The clinical examination techniques used to examine the adductor muscles, the iliopsoas muscles, the rectus abdominis muscles, and the symphysis joint were previously validated in an intraobserver and interobserver reliability study.<sup>25</sup>

A questionnaire based upon a personal interview was completed with information about demographic data, onset of groin pain, possible cause of injury, previous treatment, former and present state of athletic activity, and the situations in which the groin pain was provoked.

A plain anterior-posterior radiograph of the pelvis in the standing position was taken for all participants, as well as planar-bone scintigraphy. The bone scintigraphy was done 2 h after an intravenous injection of 700 MBq 99m technetium-DPD, with a gamma camera (ZLC, Siemens, Germany) with a low-energy ultra-high resolution collimator. An anterior and posterior view of  $5 \times 10^5$  counts was taken over the pelvis. An observer unaware of the history of the patients assessed the radiographs and the activity distributions of the bone scintigraphs. After registration of all data, patients to be included in the study were randomly allocated by sealed, opaque, and serially numbered envelope to AT or PT by means of block randomisation (block size four). The secretary at the physiotherapy office, upon request, opened the next envelope, once a new patient was ready for randomisation. She told the physiotherapist, who in turn told the patient by telephone. The patient was told which treatment he was allocated to and the first treatment session was arranged. The treatment programme was started within 3 weeks for all randomised patients. The examining physician was not involved in the randomisation procedure and remained unaware of the treatment allocation.

Treatment in the AT group was given three times a week. It was done as group treatment with two to four patients exercising

	Group AT (n=34)	Group PT (n=34)
<b>Median (range) age (years)</b>	30 (20–50)	30 (21–50)
<b>Sports</b>		
Soccer	26 (76%)	28 (82%)
Other sports*	8 (24%)	6 (18%)
<b>Level of athletic activity</b>		
Elite (>5 times per week)	4 (12%)	4 (12%)
Competitive (3 or 4 times per week)	21 (62%)	23 (68%)
Exercise (1 or 2 times per week)	9 (26%)	7 (20%)
<b>Onset of injury†</b>		
Acute	15 (44%)	14 (41%)
Gradual	19 (56%)	20 (59%)
<b>Pain</b>		
Moderate	12 (35%)	8 (24%)
Severe	22 (65%)	26 (76%)
Bilateral	5 (15%)	15 (44%)
<b>Median (range) time affected (weeks)</b>		
Duration of injury	38 (14–200)	41 (16–572)
Absence from sport	16 (0–159)	15 (0–130)
<b>Sports activity at baseline</b>		
Ceased	24 (71%)	25 (76%)
Reduced	6 (18%)	4 (12%)
Unchanged	4 (12%)	4 (12%)
<b>Clinical data</b>		
Median VO <sub>2</sub> max (range)	48 (32–65)	43 (31–73)
Positive bone scan	30 (88%)	28 (82%)
Radiographic signs of osteitis pubis	24 (71%)	21 (62%)

\*Running (3), tennis (2), European handball (2), badminton (1), ice hockey (1), basketball (1), horseriding (1), and rugby (1). †Patient's report.

Table 1: Baseline characteristics of the patients in AT and PT groups

according to the instructions of a physiotherapist. Two physiotherapists were responsible for the treatment of the AT group. The duration of each individual training session was about 90 min. The patients were told to do the exercises from module I (panel 1) on the days in between the treatment days. No stretching of the adductor muscles was allowed at the AT group, but the other muscles of the lower extremities, the abdominal muscles, and the back muscles could be stretched when needed and desired after the training sessions.

Treatment in the PT group (panel 2) was given twice a week as individual treatment by one physiotherapist. Two physiotherapists were responsible for the treatment in this group. The duration of treatment was again about 90 min. The patients in the PT group were told to do the stretching exercises included in the treatment programme for the adductor, hamstring, and hip-flexor muscles on the days in between the treatment days.

Patients in both treatment groups were not allowed to receive any other treatments for the groin pain before the final follow-up. No athletic activity was allowed during the treatment period in either group. Patients were allowed to ride a bicycle if it did not cause any pain. After the first 6 weeks of treatment patients were allowed to jog in running shoes on a flat surface so long as it did not provoke groin pain.

The minimum treatment period was 8 weeks. Treatment was stopped when neither the treatment nor the jogging caused any pain. The patient and the physiotherapist decided when to stop the treatment; no patient was given more than 12 weeks of treatment. After the treatment the patients in both groups were given identical written instruction about sport-related rehabilitation.

At 4 weeks and at 4 months after the end of treatment a standardised clinical examination was done and patients were interviewed; a fresh questionnaire was filled in that focused on groin symptoms and the present state of athletic activity. The patients were examined and interviewed by the physician who recorded the initial data. The physician was unaware of the treatment allocation. The patients were instructed by the person who arranged the examination and on arrival at the physician's office not to reveal information to the examining physician about the treatment.

The maximum oxygen consumption (VO<sub>2</sub> max) was measured before and after the treatment period by open-circuit spirometry

(CPX-max, Medgraphics, Minnesota) on a bicycle ergometer; workload started at 75 W for 2 min and increased by 25 W per min until the patient was exhausted.

### Outcome measures and statistical methods

The outcome measures of successful treatment of the trial were: no pain at palpation of the adductor tendons and the adductor insertions at the pubic bone, and no pain during active adduction against resistance; no groin pain in connection with or after athletic activity in the same sport and at the same level of competition as before the onset of the groin pain; return to the same sport and at the same level without groin pain.

If all three measures were reached, the result was labelled excellent, if two measures were reached, the result was good, if one measure was reached, the result was fair and if no measures were reached, the result was poor.

The patients' subjective global assessment of their groin problems regarding both function and pain as compared with their situation before they started the treatment programme was registered. The possibilities were much better, better, not better, worse, and much worse.

Double-data entry was done and both the data manager and the statistician were unaware of treatment allocation. Logistic-regression models were used to investigate the odds ratio for groups AT and PT. The odds ratio is the odds in group AT divided by the odds in group PT.

The levels of the outcome variable were excellent versus good, fair, and poor. The explanatory variables were: the type of treatment received; presence of bilateral symptoms; pain level at entry to the study; age; duration of the injury.

Univariate and multiple logistic regressions were done. Significant ( $p < 0.05$ ) variables in the multiple regression were found by the backward elimination method. Tests for interaction between significant variables were done in multiple-regression analysis.

Results are given as odds ratios and 95% CIs.  $p$  values were two tailed. Mantel-Haenszel  $\chi^2$  was used to test for linear trend for the outcome measure and the subjective global assessment. The type-1 error was fixed at 5%.

The sample size of the study gave 80% power to detect a difference in effect between the treatments of 35% at a significance level of 5%.

## Results

68 male athletes were included (figure). 59 patients completed the study. Nine patients withdrew before the study was completed, five from the AT group and four from the PT group. Baseline data for these patients did not differ from those for the 59 patients who completed the study. The reasons for withdrawal were: knee injury (one patient); immigration to Australia (one); loss to follow-up at 4 months (two); did not want the treatment they were assigned (two patients assigned AT); could not get sufficient time off from work to complete the study (three).

The only significant difference in baseline characteristics between treatment groups was that more patients in the PT group had bilateral groin pain ( $p = 0.008$ , table 1).

The analysis of effect of treatment was done according to intention to treat. The distribution of outcomes (table 2) showed a significant difference in favour of AT ( $p$  for trend = 0.001). Table 3 shows the results from the

Treatment outcome	AT	PT
Excellent	23	4
Good	2	6
Fair	3	6
Poor	6	18

$p = 0.001$ .

Table 2: Distribution of patients in AT and PT groups

	Odds ratio (95% CI)	
	Univariate analysis	Multiple logistic-regression analysis
<b>Treatment</b>		
AT	15.7 (4.4–55.7)	12.7 (3.4–47.2)
PT*	1	1
<b>Groin pain</b>		
Unilateral	9.8 (2.0–46.9)	6.6 (1.2–37.2)
Bilateral*	1	1
<b>Level of pain at entry</b>		
Moderate	3.3 (1.1–9.7)	..
Severe*	1	..

\*Reference category.

Table 3: Univariate and multiple logistic-regression analysis of the three significant variables influencing outcome measures

univariate and the multiple-logistic-regression analysis. Treatment, unilateral or bilateral, and severity of pain were predictors of outcome in the univariate analysis. In the multiple-logistic-regression analysis, only treatment or bilateral symptoms were independent predictors. After adjustment for unilateral groin pain, the odds ratio for the AT treatment was 12.7 (95% CI 3.4–47.2). There were no significant interactions between the explanatory variables. A per-protocol analysis including the 59 patients who completed the study did not show appreciably different results.

The subjective global assessment of the effect of treatment in the two groups based solely on results from patients completing the study (per-protocol analysis) are shown in table 4. No patient assessed his result as worse or much worse. There was a significant ( $p=0.006$ ) linear trend towards better effect of the AT treatment. The relation between the subjective global assessment and the outcome measures is shown in table 4. Almost all patients (26 of 27) rates as excellent assessed their condition to be much better. The linear trend was significant ( $p=0.001$ ).

In the AT treatment group, 23 (79%) of the athletes completing the study returned to sports activity at their previous level without any symptoms of groin pain. The median time from entering the study until complete symptom-free return to sport was 18.5 weeks (range 13–26). The range of motion of the hip-joint abduction increased significantly in both treatment groups ( $p=0.0004$ ), but no difference was found between the groups. The adduction strength improved significantly in the AT group compared with the PT group ( $p=0.001$ ) but the  $VO_2$ -max values (table 1) of the two treatment groups did not change during the treatment period.

## Discussion

We found that treatment of long-standing adductor-related groin pain with an active programme of specific exercises aimed at improving strength and coordination of the muscles acting on the pelvis was significantly better than a conventional physiotherapy programme. Moreover, 79% of the patients in the AT group had no

Subjective global assessment	Treatment		Treatment outcome	
	AT*	PT*	Not-excellent†	Excellent†
Much better	22	13	9	26
Better	7	14	20	1
Not better	0	3	3	0

$p=0.006$ . † $p=0.001$ .

Table 4: Subjective global assessment of AT and PT and the relationship between subjective global assessment and outcome measures of the treatments

residual groin pain at clinical examination and had returned to sport at the same level or an even higher level of activity without groin pain, compared with only 14% in the PT group. The patients' subjective assessments of the treatments accorded with the objective outcome measures. AT resulted in significantly better subjective assessment than PT.

AT was a group treatment, and PT was an individual treatment. This difference was taken into account when the amount of physiotherapy attendance given to each patient was planned. The number of treatments with regard to physiotherapy attendance received in the AT group was a median of 15 treatments and in the PT group 14 treatments.

The patients included in our study were very active before the injury; most trained three to four times a week (table 1) but at study entry they were athletically disabled. They had been injured for 9 months (median), and 75% had ceased to participate in sports because of groin pain. Because most of the patients had abstained from sport for 4 months without improvement of symptoms and were judged to need therapy, a control group consisting of those who received no therapy, and who did not participate in any sport, would have been unethical.

The PT group used methods derived from physiotherapy: manual techniques (transverse friction massage), electrotherapy (laser and transcutaneous electrical nerve stimulation), and exercise therapy (stretching). The PT programme was constructed from a range of techniques including, for example, ultrasonography, muscle massage, and heat or cold application.

The AT group used exercises aimed at muscular strengthening with special emphasis on the adductor muscles, as well as training muscular coordination to improve the postural stability of the pelvis.

Passive treatments such as ultrasonography (59%), soft laser (48%) and massage (47%) had been used by patients frequently in the past, but active treatment such as stretching (56%) was also common. None of the participants had had a systematic intensive course of physiotherapy before. Active training exercise similar to those used in the AT group had been tried by about 20% of patients.

Stretching is known to increase range of joint motion in the leg.<sup>26–28</sup> The patients in the PT group used stretching exercises for the adductor muscle both during treatment with the physiotherapist and as home exercise on the days between treatment days. The patients in the AT group were not allowed to do stretching exercises for the adductor muscle at all; nonetheless they had the same increase of hip-joint range of motion as the PT group. In the AT group, pain was initially a limiting factor to the range of motion in some of the exercises, but, as the muscle coordination and strength increased and the groin pain decreased, the load and the range of motion increased. Tolerance towards an increased range of motion might thereby be achieved. Two examples of this type of exercise are the one-leg exercise on the sliding board (module I, exercise 6) and the weight-pulling exercise (module II, exercise 4). Ekstrand has suggested that decreased range of motion in the abduction of the hip joint could predispose to adductor-related injuries.<sup>29</sup> Stretching exercises are therefore commonly recommended in the treatment of long-standing adductor-related groin pain. The results of our study do

not support this recommendation. Another possibility is that stretching of the adductor muscle and thereby pulling on the insertions at the pubic bone might worsen the injury. But this possibility and an effect of stretching and strengthening training of the adductors in the prevention of groin injuries, are merely theoretical. Randomised clinical trials are needed to assess such ideas.

The exercises in the AT group involved limited muscle groups and were not aimed at improving endurance. The AT programme as such was insufficient to affect the maximum oxygen uptake. The main elements of the AT programme are restoration of muscle strength in combination with balance and coordination training. The hypothesis that similar treatment principles would be effective in the case of other injuries related to tendons and tendon insertions should be investigated in randomised clinical trials, as should the potential benefit of a shorter programme of AT.

#### Contributors

Per Hölmich was responsible for the study design, running of the study, analysis, and writing. Pernille Uhrskov and Lisbeth Ulnits ran the physiotherapy programme. Michael Bachmann Nielsen did the radiological investigations. Inge-Lis Kanstrup did the clinical physiological investigations. Anders Munch-Bjerg did the statistical analysis. Kim Krogsgaard did analysis and writing. All the authors read and revised the manuscript.

#### Acknowledgments

This study was supported by grants from the Danish Research Council of Sport, the Danish Sports Federation, and the Scientific Commission of TEAM Denmark.

#### References

- Ekstrand J, Gillquist J. Soccer injuries and their mechanisms: a prospective study. *Med Sci Sports Exerc* 1983; **15**: 267–70.
- Nielsen AB, Yde J. Epidemiology and traumatology of injuries in soccer. *Am J Sports Med* 1989; **17**: 803–07.
- Engström B, Forssblad M, Johansson C, Törnkvist H. Does a major knee injury definitely sideline an elite soccer player? *Am J Sports Med* 1990; **18**: 101–05.
- Renström P, Peterson L. Groin injuries in athletes. *Br J Sports Med* 1980; **14**: 30–36.
- Lovell G. The diagnosis of chronic groin pain in athletes: a review of 189 cases. *Aust J Sci Med Sport* 1995; **27**: 76–79.
- Karlsson J, Swärd L, Kålebo P, Thomée R. Chronic groin injuries in athletes. *Sports Med* 1994; **17**: 141–48.
- Renström PAFH. Groin and hip injuries. In: Renstrom PAFH, ed. *Clinical practice of sports injury prevention and care*, 5th edn. Oxford: Blackwell Scientific Publications, 1994: 97–114.
- Balduini FC. Abdominal and groin injuries in tennis. *Clin Sports Med* 1988; **7**: 349–57.
- Swain R, Snodgrass S. Managing groin pain. *Physician Sportsmed* 1995; **23**: 55–66.
- Hasselman CT, Best TM, Garrett WE. When groin pain signals an adductor strain. *Physician Sportsmed* 1995; **23**: 53–60.
- Holt MA, Keene JS, Graf BK, Helwig DC. Treatment of osteitis pubis in athletes, results of corticosteroid injections. *Am J Sports Med* 1995; **23**: 601–06.
- Taylor DC, Meyers WC, Moylan JA, Bassett FH, Garrett WE. Abdominal musculature abnormalities as a cause of groin pain in athletes. *Am J Sports Med* 1991; **19**: 239–42.
- Hackney RG. The sports hernia: a cause of chronic groin pain. *Br J Sports Med* 1993; **27**: 58–62.
- Martens MA, Hansen L, Mulier JC. Adductor tendinitis and muscular rectus abdominis tendopathy. *Am J Sports Med* 1987; **15**: 353–56.
- Åkermark C, Johansson C. Tenotomy of the adductor longus tendon in the treatment of chronic groin pain in athletes. *Am J Sports Med* 1992; **20**: 640–43.
- Kålebo P, Karlsson J, Swärd L, Peterson L. Ultrasonography of chronic tendon injuries in the groin. *Am J Sports Med* 1992; **20**: 634–38.
- Bradshaw C, McCrory P, Bell S, Brukner P. Obturator nerve entrapment, a cause of groin pain in athletes. *Am J Sports Med* 1997; **25**: 402–08.
- Malycha P, Lovell G. Inguinal surgery in athletes with chronic groin pain: the “sportsman’s” hernia. *Aust N Z J Surg* 1992; **62**: 123–25.
- Tropp H. Functional instability of the ankle joint (thesis) University of Sweden: Linköping, 1985.
- Manniche C, Hesselsoe G, Bentzen L, Christensen I, Lundberg E. Clinical trial of intensive muscle training for chronic low back pain. *Lancet* 1988; **31**: 1473–76.
- Hölmich P. Adductor related groin pain in athletes. *Sports Med Arth Rev* 1998; **5**: 285–91.
- Morrenhof JW. Stabilisation of the human hip-joint (thesis). Netherlands: Rijksuniversiteit to Leiden, 1989.
- Garrett WE, Safran MR, Seaber AV, Glisson RR, Ribbeck BM. Biomechanical comparison of stimulated and nonstimulated skeletal muscle pulled to failure. *Am J Sports Med* 1987; **15**: 448–54.
- Hölmich P. Groin pain in 207 patients in prospective clinical approach. *Scand J Med Sci Sports* 1998; **8**: 332 (abstr).
- Hölmich P, Hölmich LR, Bjerg AM. Clinical examination of athletes with groin pain—a reliability study. *Scand J Med Sci Sports* 1998; **8**: 331 (abstr).
- Taylor DC, Dalton JD, Seaber AV, Garrett WE. Viscoelastic properties of muscle-tendon units. *Am J Sports Med* 1990; **18**: 300–09.
- Wiktorsson-Möller M, Öberg B, Ekstrand J, Gillquist J. Effects of warming up, massage, and stretching on range of motion and muscle strength in the lower extremity. *Am J Sports Med* 1983; **11**: 249–52.
- Möller MHL, Öberg BE, Gillquist J. Stretching exercise and soccer: effect of stretching on range of motion in the lower extremity in connection with soccer training. *Int J Sports Med* 1985; **6**: 50–52.
- Ekstrand J. Soccer injuries and their prevention (thesis). Sweden: University of Linköping, 1982.