# Diagnostics and treatment of adductor-related groin pain in athletes – new insights

Diagnose en behandeling van adductor-gerelateerde liesklachten bij sporters– nieuwe inzichten,
(met een samenvatting in het Nederlands)

Proefschrift

ter verkrijging van de graad van doctor aan de Universiteit Utrecht op gezag van de rector magnificus, prof. dr. G.J van der Zwaan, ingevolge het besluit van het college voor promoties in het openbaar te verdedigen op donderdag 23 juni 2011 des ochtends te 10.30 uur

door

Adam Weir
geboren op 7 september 1974
te Nottingham, England

**Promotor: Prof. dr. F.J.G. Backx**
**Co-promotor: Dr. J.L. Tol**

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## Manuscripts based on the studies presented in this thesis

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Resting thickness of transversus abdominus is decreased in athletes with long-standing adduction-related groin pain.
Man Ther. 2010 Apr;15(2):200-5.

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Man Ther. 2010 Oct 15. (Epub ahead of print)

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Submitted

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# Chapter 1:

## General Introduction

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# General Introduction

Groin pain is thought to account for around 5% - 18% of all athletic injuries in Western countries (Morelli and Smith, 2001). It is hard to find accurate data for the extent of the problem in the Netherlands. National surveys, such as the Dutch injury registration system (IPAN), do not have a specific code for the groin region (Schmikli *et al.*, 2004). This means that groin injuries will probably have been registered under the upper-leg/ hip region but cannot be counted separately. In published case series examining the incidence of specific groin injuries, adductor injuries have been found to be the most common type of groin injury (Hölmich, 2007). In this Danish series of 207 consecutive patients 58% of all patients and 69% of the footballers presented with adductor-related groin pain. It should be noted that the author is famous for his treatment programme for adductor injuries, which may well result in referral bias. Other researchers have found groin injuries to be common in football with around 9% of all injuries in Dutch football being in the groin region (Stege *et al.*, 2008). With around 930,000 football players in the Netherlands giving rise to more than 430,000 injuries in total yearly, it would seem that there are a substantial number of groin injuries in the Netherlands. Due to the lack of specific injury codes in Dutch healthcare for groin inuries, there is no specific data available on the costs incurred due to athletic groin injuries

While it has previously been noted that the natural history of most groin injuries is favourable after a period of rest or restricted activity (Arnason *et al.*, 2004), some acute injuries and in cases with an insidious onset, groin injury can often become a long-standing problem. When groin pain goes on to become long-standing it often results in long-term absence from sports participation (Renström and Peterson, 1980; Hölmich *et al.*, 1999).

## Anatomy and function of the adductor muscles

The adductor longus muscle is the most commonly injured muscle in the groin region. It arises from the body of the pubis in the angle between the crest and the symphysis. Traditionally it was considered a tendinous origin but recent studies have shown that the majority of the proximal insertion is muscular (Robertson *et al.*, 2009). Some fibres of the adductor longus also continue proximally and insert into the anterior part of the symphysis capsule and the rectus sheath.

The adductor muscles play, beside the function of adduction, an important role acting together with the abdominal muscles to stabilise the pelvis. They counteract rotation of the pelvis and adduct the femur. Recently the adductor muscles have been studied biomechanically during a maximal effort football kick (Charnok *et al.*, 2009). This study showed that the maximal stretch and force generated during kicking occurs as the hip moves from maximal extension into the start of flexion.

## Terminology and differential diagnosis

The groin region has a complex anatomy with a huge number of different structures and organ systems that can give rise to pain. It is generally accepted that there is an extensive differential diagnosis which should be considered when athletes present with groin pain. There are numerous causes of musculoskeletal origin. There is a lack of definitions or consensus as to the terminology used surrounding athletic groin injury. Many of the possible diagnosis around the pubic bone have many similarities and a large degree of overlap. When athletes present with pain around the proximal insertion of the adductor muscles the following terms are commonly used: adductor strain, adductor tendinitis, adductor tendinopathy, adductor enthesiopathy, adductor-related groin pain, adduction-related groin pain, osteitis pubis, athletic pubalgia, pubic bone overload, pubic bone stress injury and athletic groin injury. This large list of possible names for similar pathology gives rise to much confusion and makes comparing research findings difficult. The following table (Table 1.1) is adapted from Brukner and Kahn (2006).

In this thesis the term adductor-related groin pain is used, except in chapter 2. This term was first used by Hölmich, and has since been gathering popularity in the international literature. The choice to use this term was made based on the growing number of research groups that are starting to also use this terminology and definition. Adductor-related groin pain is a clinical diagnosis which makes it suitable for use in a wide range of settings because further investigations are not needed to make the diagnosis. As there are a rather small number of research groups working on athletic groin pain world wide it is advantageous to use well defined clinical patterns to report outcomes in clinical or diagnostic studies so that results can easily be compared and interpreted.

**Table 1.1:** Causes of long-standing groin pain.

| Common | Less common | Not to be missed |
|---|---|---|
| Adductor-related | Hip joint:<br>Osteoarthritis<br>Chondral lesion<br>Labral tear<br>Snapping hip | Hip joint<br>Slipped capital femoral epiphysis<br>Perthes disease (adolescents)<br>Avascular necrosis of femoral head |
| Iliopsoas-related<br>Neuromyofascial tightness<br>Tendinopathy<br>Bursitis | Stress fracture:<br>Neck of femur<br>Pubic ramus<br>Acetabulum | Spondyloarthropathies<br>Ankylosing spondylitis |
| Abdominal wall-related<br>Posterior inguinal wall weakness<br>Tear of external oblique aponeurosis<br>"Gilmore's groin" | Nerve entrapment:<br>Obturator<br>Ilioinguinal<br>Genitofemoral | Intra-abdominal abnormality<br>Prostatitis<br>Urinary tract infection<br>Gynaecological conditions |
| Rectus abdominus tendinopathy | Referred pain:<br>Lumbar spine<br>Sacroiliac joint | |
| Pubic bone-related<br>Pubic bone stress | Apophysitis:<br>Anterior superior iliac spine<br>Anterior inferior iliac spine | Tumour<br>Testicular<br>Osteoid osteoma |

## Diagnostics

In the past 20 years there have been a huge number of publications on groin complaints in athletes. There are many reviews and expert opinion based articles on how to diagnose groin injuries. A recently published high quality, stuctured, systematic review of the field of diagnostics in athletic groin injury, by Jansen *et al.* (2008A), noted that there are many published series examining the findings, using various techniques, although the interpretation is troubled by lack of general consensus on the terminology of groin injury. As stated above the huge array of different diagnostic names given to groin pain in athletes leads to much confusion and makes comparison of research results difficult.

History and clinical examination form the basis for making a diagnosis in athletes presenting with groin pain. Clinical examination of the groin has been shown to be reliable when carried out using a standardised structured method (Hölmich *et al.*, 2004). The role of further imaging and other tests is still unclear. This thesis aims to expand the knowledge base on the role of diagnostics in adductor-related groin pain by presenting new research on this subject.

At a more fundamental diagnostic level some work has already examined the relationship between the lower abdominal muscles and groin injury. It was previously known that the activation of the transversus abdominus (TA) muscle is delayed in athletes with chronic groin pain (Cowan *et al.*, 2004). In a multi-centre study the TA function was measured in a number of cases and controls. Athletes with and without adductor-related groin pain were examined using ultrasound while resting and performing contractions of the adductor muscles. The differences between the groups are reported in **chapter 2**.

In terms of diagnostics at a clinical level it is often suggested that a plain x-ray of the pelvis should be performed prior to the initiation of treatment to "exclude bony abnormalities". Previous studies already noted that abnormalities around the pubic symphysis were found in 45% of asymptomatic athletes (Harris and Murray, 1974). During the recruitment of athletes for participation in the groin studies there was growing interest in the international literature in the field of femoroacetabular impingement (FAI). An increasing number of publications showed that there are many different clinical and radiological ways to examine for the presence of FAI. There were also publications that showed a relationship between reduced hip joint range of motion and the onset of athletic groin injury (Verrall *et al.*, 2007; Ibrahim *et al.*, 2007). As athletes with FAI often present with groin pain it was decided to investigate how prevalent findings of FAI were in athletes presenting to the sports medicine department with adductor-related groin pain. The results of this study are described in **chapter 3**.

When examining injured athletes one should also assess for the presence of risk factors for the injury to see if they can be modified as part of the treatment. It has been hypothesized that athletes who present with groin pain have become injured due to a lack of core stability (Macintyre *et al.*, 2006). It is thus often suggested that the core stability be assessed, to see if there is a deficit which needs to be addressed during rehabilitation (Kachingwe and Grech, 2008; Macintyre *et al.*, 2006). **Chapter 4** presents the results of a study examining the reliability of a number of common clinical tests thought to assess core stability. It was decided to assess the reliability of tests commonly used in clinical practice to study if they would be suitable to go on to perform a case control study on athletes with and without adductor-related groin pain. This would be the first time that this was done in a group of groin-injured athletes. The results of the reliability study were too poor to then progress to the proposed case control study.

## Treatment

Recently two systematic reviews have highlighted the lack of good quality studies on the treatment of groin injuries (Jansen *et al.*, 2008B; Machotka *et al.*, 2009). In fact there has only been one randomised controlled trial performed in the field of athletic groin injury (Hölmich *et al.*, 1999). The lack of clinical trials on treatment is at odds with the number of papers on diagnosis in groin injury. There are almost no studies with mid or long-term follow-up.

In the Netherlands a multi-modal treatment (MMT) programme comprising of heat, Van den Akker manual therapy, stretches and return to running has been used for many years by a number of sports medicine physicians. When Van den Sande, a Dutch sports medicine physician, presented his clinical experience with this programme at a conference on groin injuries for sports physicians and physical therapists in 2005 the first ideas for research leading to this thesis were born. In this thesis new research is presented relating to the treatment and follow-up of adductor-related groin pain in athletes.

In **chapter 5** a case series is presented on the clinical effectiveness of a manual therapy technique, the so called Van den Akker method, in combination with warmth, stretches and a return to running programme in athletes with adductor-related groin pain. This therapy is used fairly often in the Netherlands but is generally unknown outside the Netherlands. It was decided to first investigate its effect retrospectively before a larger prospective trial would be considered.

**Chapter 6** describes the clinical effectiveness of a comprehensive physical therapy programme for the treatment of adductor-related groin pain. This programme is mainly based on active physical training as the core component. The programme was designed and developed at the Royal Netherlands Football Association (KNVB) sports medical center (FIFA-accreditated). The study evaluated the clinical outcome in a retrospective manner.

In **chapter 7** the results of a randomised controlled clinical trial comparing the effects of two different treatment programmes are presented. One group received the MMT programme comprising of heat, Van den Akker manual therapy, stretching and return to running programme. The second group underwent exercise training and then the same return to running programme. The results directly after treatment are presented.
The athletes who had participated in the randomised controlled trial from chapter 7 were contacted again to assess the mid-term outcome in both groups. The results of the mid-term follow-up study are presented in **chapter 8**. In this study the differences

between the groups were once again examined and the rate of recurrences was investigated.

A summary of all the findings in this thesis together with final conclusions is given in **chapter 9**. Clinical implications and directions for future research are included in this final chapter. The references for all chapters are listed at the back of the thesis to avoid duplication.

# Chapter 2:

## Resting thickness of transversus abdominus is decreased in athletes with long-standing adduction-related groin pain

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Jansen J, Weir A, Dénis R, Mens J, Backx F, Stam H.
Manual Therapy. 2010 Apr;15(2):200-5.

**Purpose:**
To compare thickness of the transversus abdominus (TA) and obliquus internus (OI) muscles between athletes with and without long-standing adduction-related groin pain (LAGP).
**Methods:**
42 athletes with LAGP and 23 controls were included. Thickness of TA and OI were measured with ultrasound imaging on the right side of the body during rest. Relative muscle thickness (compared to rest) was measured during the Active Straight Leg Raise (ASLR) left and right, and during isometric hip adduction.
**Results:**
TA resting thickness was significantly smaller in injured subjects with left-sided (4.0± 0.82mm; $P$<0.001) or right-sided (4.3±0.64 mm; $P$=0.015) groin complaints compared with controls (4.9± 0.90 mm). No significant differences between patients and controls in TA or OI relative thickness during the ASLR and isometric hip adduction were found (all cases $P$≥0.15).
**Conclusion:**
TA resting thickness is smaller in athletes with LAGP and may thus be a risk factor for (recurrent) groin injury. This may have implications for therapy and prevention of LAGP.

## Introduction

Injuries to the groin region are a common problem in sports characterised by quick accelerations and decelerations and sudden directional changes such as football, field hockey and tennis. The differential diagnosis can cover a broad area of possibilities such as adductor strain or tendinitis, osteitis pubis and sports hernia. When isometric hip adduction is painful, groin pain is often referred to as adductor tendinitis, which implies pathology of the adductor muscles. Mens *et al.* (2006) evaluated the hypothesis that long-standing adduction-related groin pain (LAGP) in athletes on isometric hip adduction may not be caused by adductor pathology. When comparing isometric hip adduction with and without wearing a pelvic belt, force increased significantly in 39% and pain decreased in 68% of the injured athletes while wearing the belt. Studies on patients with posterior pelvic pain have also shown that pain decreased significantly while wearing a pelvic belt (Ostgaard *et al.*, 1994; Damen *et al.*, 2002). This latter response to a pelvic belt suggests instability of the pelvic ring (Damen *et al.*, 2002; Mens *et al.*, 2006a). Anatomically, the transversus abdominus (TA) and obliqus internus (OI) may function as a internal pelvic belt since their fibers are perpendicular to the sacroiliac joint (Snijders *et al.*, 1998; Hoek van Dijke *et al.*, 1999). TA recruitment, performed by abdominal hollowing, resulted in a significant decrease of sacroiliac joint laxity, even when compared with abdominal muscle co-contraction (Richardson *et al.*, 2002). A recent study using electromyography (EMG) investigated the differences in TA recruitment between healthy athletes and athletes with LAGP (Cowan *et al.*, 2004). A significant delay (10 msec) in TA recruitment in athletes with groin pain was found, although the delay was not similar to the responses found in the population of back pain patients (>50 msec, Hodges *et al.*, 1998; Hodges and Richardson, 1999a; 1999b). Ferreira *et al.* (2004) also studied TA recruitment in persons with low back pain. Using ultrasound imaging, they found significantly smaller relative TA thickness compared to a control group when performing isometric lower extremity tasks. Relative thickness of TA and OI measured by ultrasound imaging has shown to be a valid method to measure low level muscle activity (Hodges *et al.*, 2003; McMeeken *et al.*, 2004). This method is used by paramedical professionals to visualize the abdominal muscles, particularly when specific training of TA is emphasized (McCarthy and Vicenzino, 2003; Wollin and Lovell, 2006). However, it is not known whether ultrasound can be used to identify abnormal abdominal muscle behavior in athletes with LAGP. The purpose of the present study was to compare the resting thickness and thickness relative to rest of TA and OI during lower extremity tasks, between athletes with LAGP and controls using ultrasound imaging.

## Methods

### *Subjects*

Patients were recruited from the Sports Medical Center of the Royal Netherlands Football Association (KNVB, Zeist, the Netherlands) and the Sports Medicine Department of the The Hague Medical Centre (The Hague, the Netherlands). Male subjects were included if they were aged 18-55 years and restricted in sports participation for at least six weeks as a result of adduction-related groin pain. This was defined as experiencing unilateral groin pain during bilateral isometric hip adduction in supine hook lying position (i.e. the squeeze test, Verrall *et al.*, 2005). Subjects were excluded if the pain was bilateral; started after a high-impact trauma; if symptoms were suggestive for fracture of the pelvis or hip, for osteoarthritis of the hip, tear of the labrum of the hip, inguinal or femoral hernia, radicular syndrome, nerve entrapment, bursitis, malignant diseases, vascular pathologies, prostatitis, urinary tract pathology; anatomical abnormalities; systemic diseases; obvious psychopathology, or if subjects were unable to fill in forms. Controls were healthy male athletes with no restriction in sports and were recruited using verbal communication and flyers. Controls were excluded if they experienced groin pain on performing isometric hip adduction. Subjects were checked on inclusion and exclusion criteria by an experienced sports medicine physician using medical history and a complete active and passive physical examination of the hip, pelvis and lumbar spine, after which they were referred to the researcher. After this physical examination, informed consent was signed and measurements were started.
Prior to study start, approval of the local Research Ethics Committee was acquired. The present study was conducted in compliance with the Declaration of Helsinki.

### *Characteristics*

A structured questionnaire was used to record the following information: age, height, weight, type of sports, sports intensity (hours/week), level of sports, side of complaints, duration of complaints, medical history and the presence of pain at isometric hip adduction. Restriction in sports participation (*"To what extent are you restricted in sports participation?"*) was measured using a numeric Likert scale ranging from 0 (*"I can participate at my own level of sports"*) to 10 (*"I can not participate in sports at all"*). To measure impaired load transfer through the lumbo-pelvic area, the active straight leg raise (ASLR) test was performed according to Mens *et al.* (1999, 2001, 2002). The ASLR test was performed in a supine position with straight legs. The test was performed after the instruction: *"Try to raise your leg above the couch 20 cm while keeping your leg straight"*. The left leg was always tested first, followed by the right leg. The patient was asked to score impairment for each leg on a 6-point scale: not difficult at all = 0; minimally difficult = 1; somewhat difficult = 2; fairly difficult = 3; very difficult = 4; unable to lift the leg= 5. The scores of both sides were added, so the summed score ranged from 0 to 10. Score

0 was defined as negative, and scores 1 to 10 as positive.
Maximum adduction force was measured in Newtons with a hand-held dynamometer (Microfet, Biometrics BV, the Netherlands) in supine hook-lying position. The researcher's hand and the dynamometer were placed between the knees of the subject. The subject was asked to squeeze the knees together with maximum effort. Subjects performed a minimum of three attempts. If the score of the last attempt was the highest of the series, another attempt was allowed. Subjects were verbally encouraged to perform at their upmost. Maximum force was measured within five seconds. In these force measurements, the score of the highest attempt was used for analysis. Immediately after the final attempt, severity of the groin pain was measured using a numeric Likert scale ranging from 0 (no pain) to 10 (unbearable pain).

***Ultrasound measurements***

Ultrasound imaging (5 cm linear transducer 7.5 Mhz, B-mode, Honda Electronics, HS-2000, Dynamic BV, the Netherlands) was used to measure the thickness of the two abdominal muscles TA and OI. The transducer was placed in the transverse plane on the right side of the subject on the mid-axillary line midway between the inferior angle of the rib cage and the iliac crest. The position of the transducer was adjusted until the medial junction of the TA with OI was visualized in the far left of the screen. Thickness of TA and OI was measured from the point where the superficial fascial line of the muscle crosses the midline of the ultrasound image, perpendicular on the superficial fascial line, to the deeper fascial line. Measurements were made using the on-screen callipers. Firstly, the thickness of the abdominal muscles was measured during rest with the subject in supine hook lying position.
Secondly, thickness of TA and OI was measured during ASLR left and right. The subject was asked to perform an ASLR test as described above.
The fourth and final measurements were performed during maximum isometric hip adduction. Again, the subject was positioned in a supine position with the hips flexed 45 degrees and knees flexed to 90 degrees. A soft rubber football was placed between the knees of the subject. The ankles were placed together. The subject was verbally encouraged to squeeze the ball with maximum effort. All measurements were taken at the end of expiration as determined by visual inspection of the abdominal wall. This was done in order to standardise the influence of respiration (Hodges *et al.*, 1997; Teyhen *et al.*, 2005). The average of three repetitions per task and condition was used for analysis.

### *Statistical Analysis*

The number of subjects needed for this study was based on the study of Ferreira *et al.* (2004), investigating TA function in a population of patients suffering low back pain. Given an effect size of 28% and $p<0.05$, a power of 80% was reached by using a number of at least 10 subjects per group. However, given the smaller difference in abdominal muscle recruitment found by Cowan *et al.* (2004) compared with studies on subjects with low back pain, this was considered too low; therefore, at least 15 subjects per group were included.

Patients were divided into subgroups based on complaints laterality (left or right). ANOVA or the non-parametric alternative (Chi-square or Kruskall Willis test) were used to evaluate differences between groups on population characteristics.
Intra-rater reliability of ultrasound imaging measurements per task was analyzed using intraclass correlation coefficient ($ICC_{intra}$ model 3,1) for single measures. ANOVA was used to evaluate differences between patients and controls in abdominal muscle resting thickness and relative thickness during the tasks, calculated as percentage increase (or decrease) relative to rest. Scheffé was used for post-hoc testing between groups. $P<0.05$ was considered statistically significant. All statistical analyses were performed using SPSS statistical software (version 15.0. SPSS Inc. Chicago, USA)

## Results

### *Characteristics*

A total of 53 patients were referred for inclusion and 28 controls were contacted. All subjects were competitive amateur athletes. Four controls experienced adduction pain during testing and were excluded; one female control was also excluded. Of the 53 patients, six patients did not experience adduction-related groin pain and four patients had bilateral complaints during testing by the researcher and were also excluded from analysis. One female was also excluded. A total of 18 athletes had left-sided and 24 right-sided groin complaints. Table 2.1 presents the characteristics of the study population.

There were no significant differences between groups for most of the variables assessed, except for clinical characteristics (*i.e.* pain and restriction in sports). For adduction force, post-hoc testing revealed a significant difference between controls and subjects with left-sided complaints ($P=0.01$) and no difference between subjects with right-sided complaints and controls ($P=0.73$), or between subjects with left or right-sided complaints ($P=0.06$).

**Table 2.1:** Characteristics of the study population.

| | Controls (n=23) | Patients' complaints left (n=18) | Patients' complaints right (n=24) | P-value |
|---|---|---|---|---|
| Age in years; mean (SD) | 23.9 (4.7) | 28.2 (10.4) | 24.8 (6.9) | P=0.18 |
| Weight in kg; mean SD) | 78.9 (6.8) | 76.4 (11.8) | 80.0 (9.2) | P=0.45 |
| Height in cm; mean (SD) | 183.7 (6.7) | 181.4 (6.5) | 184.4 (6.8) | P=0.36 |
| Usual sports participation before injury in hours/week; mean (SD) | 5.9 (2.3) | 5.5 (1.8) | 6.1 (2.8) | P=0.67 |
| **Sport** | | | | |
| Soccer | 15 | 11 | 20 | |
| Running | 3 | 4 | 1 | |
| Field hockey | 2 | 0 | 0 | |
| Cycling | 1 | 0 | 1 | |
| Korfball | 1 | 0 | 0 | |
| Fitness | 1 | 0 | 1 | |
| Rugby | 0 | 1 | 0 | |
| Swimming | 0 | 1 | 0 | |
| Speed skating | 0 | 1 | 1 | |
| Duration of complaints in weeks; mean (SD) | 0 | 37 (32) | 45 (58) | P<0.001* |
| Force isometric adduction in Newton; mean (SD) | 355 (45) | 290 (60)# | 340 (80) | P =0.07 |
| Restriction in sports participation (Likert 0-10); median (range) | 0 (0-0) | 6 (3-10) # | 7 (2-10) # | P<0.001* |
| ASLR score sum of left and right; median (range) | 0 (0-0) | 0 (0-4) # | 0 (0-3)# | P<0.001* |
| Adduction pain (Likert 0-10); median (range) | 0 (0-0) | 4 (2-8)# | 5 (1-9)# | P<0.001* |

*p-values according to simple ANOVA unless indicated otherwise.*
* According to the Kruskall-Wallis test
# Significant difference compared with controls using the post-hoc Scheffé or Mann-Whitney U test

***Ultrasound measurements***

Intra-rater reliability for single measures of TA and OI thickness measurements ranged from moderate to good over the conditions (ICC 0.77-0.97; SEM 0.15-0.51 mm). Right-sided TA resting thickness was significantly smaller in injured subjects with left-sided (4.0± 0.82mm; *P*<0.001) or right-sided (4.3±0.64 mm; *P*=0.015) complaints compared with controls (4.9± 0.90 mm). There were no significant differences (*P*=0.54) between subjects with left-sided complaints and subjects with right-sided complaints. For right-sided OI, resting thicknesses were 11.8 (1.3 mm) for controls, 12.6 (1.8) mm for subjects with right-sided complaints, and 10.9 (2.3) mm for subjects with left-sided complaints. A significant difference was found only between subjects suffering right-sided and left-sided complaints (*P*=0.02).
There was no significant difference between controls and subjects with right or left-sided groin complaints on right-sided TA or OI relative thickness during the tasks evaluated (Figure 2.1; in all cases *P*≥0.15).

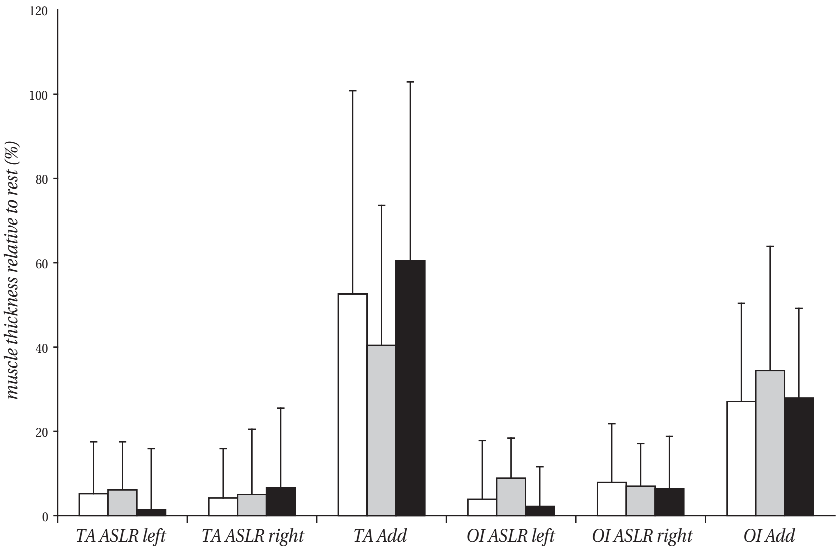


Figure 2.1: Relative thickness of the transversus abdominus (TA) and obliquus internus (OI) during Active Straight Leg Raise (ASLR) left and right, and hip adduction (Add). White bars represent controls; grey bars subjects with left-sided complaints, and black bars subjects with right-sided complaints.

## Discussion

The transversely-oriented abdominal muscles and especially TA are considered to play an important role in contributing to active stability of the pelvis (Richardson *et al.*, 2004). Since pain provocation in LAGP during adduction is associated with pubic symphysis-related abnormalities seen on MRI (Verrall *et al.*, 2005), it was suggested that a dysfunction might exist in the pelvic stabilizing muscles in athletes with LAGP. The aims of the present study were to compare the resting thicknesses of TA and OI between athletes with and without LAGP, and to compare TA and OI relative thickness during simple lower extremity tasks. For both aims, ultrasound imaging was used. Our results showed a significantly smaller right TA resting thickness in patients with LAGP. No significant differences between patients and controls in OI resting thickness or relative thickness of both muscles during ASLR and isometric hip adduction were found.
The reliability of ultrasound imaging ranged from moderate to good (ICC =0.76 to 0.97), which is consistent with reported values (Hides et al., 2007; Teyhen et al., 2005; Teyhen et al., 2007). The small variations in measurements are probably due to the variability within subjects, since intra-rater reliability of measuring the same image is high (ICC>0.97; Hides et al., 2007). TA and OI resting thicknesses in healthy controls were slightly higher than average values reported in a study on reference values for healthy subjects (4.5 ±0.13 mm, Rankin *et al.*, 2006) but comparable with values measured on an active military population (4.7±0.16 mm, Teyhen *et al.*, 2008), suggesting that our measurements are valid. A significantly smaller right-sided TA resting thickness was found in patients with LAGP, independent of the side of complaints. Physical characteristics such as height, weight, and (pre-injury) sports intensity were similar between all groups. A less active lifestyle due to the injury could theoretically lead to decreased muscle thickness, but a smaller resting thickness was not found for OI. The smaller right-sided TA resting thickness and similar OI resting thickness might also be the result of inhibitory reflexes and muscle substitution patterns.
In back pain patients more superficial abdominal muscle activity is observed when compared with healthy controls (van Dieen *et al.*, 2003). A similar mechanism might explain the present findings in patients with LAGP. However, women with pregnancy-related pelvic girdle pain, who are thought to have a similar underlying pathological mechanism, appear not to have a smaller TA resting thickness compared with matched controls (Stuge *et al.*, 2006), and neither do back pain patients (Critchley and Coutts, 2002; Ferreira *et al.*, 2004; Hides *et al.*, 2008). Localised muscle atrophy (due to physical inactivity and/or inhibitory reflexes and muscle substitution patterns) may be more pronounced in subjects who are more active than average, such as the athletic population described in the present study. Consequently, the smaller right-sided TA resting thickness found in our patients might be a predisposing factor for recurrent groin injury for athletes, and might require attention in terms of strength and/or recruitment train-

ing in rehabilitation and prevention (McCarthy and Vicenzino, 2003; Wollin and Lovell, 2006; Maffey and Emercy, 2007). Previous groin injury is known to be a significant predictor for developing a new groin injury (Arnason *et a*l., 2004; Hagglund *et al.*, 2006). For therapists active in the field of rehabilitation or prevention of LAGP, ultrasound imaging of the deep abdominal muscles could be considered when designing individual training programmes; lower values of TA resting thickness might require specific preventative or rehabilitative exercises. Our research group recently showed (unpublished data) that a programme aiming at 'core stability' can improve TA resting thickness in patients with LAGP.

Patients and controls showed no difference in the relative thickness of the right TA during the lower extremity tasks. This was unexpected because Ferreira *et al.* (2004) showed decreased TA relative thickness on ultrasound in subjects with back pain known to have delayed TA recruitment on EMG, similar to groin pain patients (Cowan *et al.*, 2004). Several explanations for this finding can be proposed. Instead of timing, thickness (change) of abdominal muscles is measured by ultrasound. It is possible that only the onset of TA is different, and not the relative thickness. In the study by Cowan *et a*l. (2004), the subjects were only measured on the symptomatic side of the body. The side of measurements (symptomatic or not) has been shown to influence data on abdominal muscle recruitment on EMG (Hungerford *et al.*, 2003). However, in the present study, a comparison of subjects with right-sided complaints with healthy subjects also showed no significant differences. Furthermore, relative thickness of TA is similar independent of the lower extremity task laterality (Hides *et al.*, 2007). This was confirmed since our further analysis showed that TA relative thickness in healthy subjects was similar during ALSR left and right. Several studies have shown no significant side-to-side-differences in TA resting thickness (Stuge *et al.*, 2006; Hides *et al.*, 2008) or relative thickness during lower extremity tasks (Hides *et al.*,2007; Teyhen *et a*l., 2009). This suggests that any possible difference in TA resting or relative thickness between our patients and controls should also be found on one side. On the other hand, research has shown that considerable side-to-side differences in resting muscle thickness can exist within individuals. These intra-individual differences can be masked when comparing group means (Rankin *et al.*, 2006; Mannion *et al.*, 2008). Therefore, the possibility that the thicker side was measured in controls whereas the thinner side was measured in patients can not be excluded. Future research should measure thickness on both sides.

The low ASLR scores in the symptomatic group might also be an explanation for the present findings. The ASLR score is positively associated with mobility of the pelvic joints (Mens *et al.*, 1999) and disease severity in pregnancy-related pelvic girdle pain (Mens *et al.*, 2002). De Groot *et al.* (2008) showed increased external oblique (OE) activity in post-partum women suffering pelvis-related complaints who had an average ASLR score of 3.9 (2.0), whereas controls had a score of 0.9 (1.1).This latter value is similar to that found in patients in the present study. Activity of OE was not measured in the present study given the lack of association between OE relative thickness and EMG activity (Hodges *et al.*, 2003). It is plausible that patients try to stabilise their pelvis using more superficial abdominal muscle contraction (Richardson *et al.*, 2002). Decreased TA function is associated with increased superficial abdominal muscle activity to maintain task performance (Moseley and Hodges, 2005). However, generalised superficial abdominal co-contraction raises intra-abdominal pressure, which may be disadvantageous for pelvic ligaments and predispose for (recurrent) pelvis-related complaints (Mens *et al.*, 2006B). Unfortunately this theory could not be verified in the present study and should be tested prospectively. In the present study, right-sided OI resting thickness and relative thickness during the tasks were not significantly different between patients and controls. This is in line with other ultrasound studies on abdominal muscle thickness in back and pelvic pain patients (Ferreira *et al.*, 2004; Stuge *et al.*, 2006). A significantly smaller OI resting thickness was found for patients with left-sided complaints compared with subjects with right-sided complaints. The side of dominance may serve as an explanatory variable (Hides *et al.*, 2008), but this was not controlled for.

***Limitations***

Results reported in present study have to be interpreted in the light of several limitations. The ultrasound probe was placed between the iliac crest and anterior iliac spine; a place commonly used in ultrasound studies on abdominal muscle recruitment (Ferreira *et al.*, 2004; Teyhen *et al.*, 2005; Stuge *et al.*, 2006). Cowan *et al.* (2004) placed needle electrodes below the level of the anterior iliac spine. Research has shown that activity of TA varies between regions of TA (Urquhart and Hodges, 2005; Urquhart *et al.*, 2005). Consequently, these regional differences might explain the different findings.

It was suggested that ultrasound can be used as a valid measure of TA and OI activity during low-level contractions (Hodges *et al.*, 2003). However, ultrasound's sensitivity to change might not be sufficient to detect small differences in activity (Hodges *et al.*, 2003). It might therefore be possible that stabilising activity of TA and OI is slightly higher in patients than in controls, as illustrated by significantly higher ASLR score in patients. This indicates that the ultrasound data should be interpreted with caution with respect to muscle activity. As measurements were made in a clinical setting, blinding of ultrasound image judging was not performed. Theoretically, this might have influenced the reliability of the ultrasound data. Given that the reliability results found in this study correspond with values reported in the literature (Hides *et al.*, 2007; Teyhen *et al.*, 2005), it is suggested that this methodological flaw will not have influenced the results.

Another limitation was that force was not standardised and controlled for during the ultrasound measurements in the isometric hip adduction task. Possibly, patients and controls might have behaved differently during this task and this may have confounded results.

## Conclusion

In this study, patients with LAGP pain had a smaller right-sided TA resting thickness compared with healthy athletes. No differences between patients and controls were found for TA and OI relative thickness during ASLR or isometric hip adduction. This information can be useful in rehabilitation and prevention programmes for athletes with LAGP.

## Chapter 3:

# Prevalence of radiological signs of femoroacetabular impingement in patients presenting with long-standing adductor-related groin pain

# Chapter 3:
# Prevalence of radiological signs of femoroacetabular impingement in patients presenting with long-standing adductor-related groin pain

Weir A, de Vos RJ, Moen M, Hölmich P, Tol JL.
British Journal of Sports Medicine. 2011 Jan;45(1):6-9.

**Objective:**
A decreased range of motion (ROM) of the hip joint is known to predispose to athletic groin injury. Femoroacetabular impingement (FAI) of the hip leads to a reduced ROM. This study examined the prevalence of radiological signs of FAI in patients presenting with long-standing adductor-related groin pain (LSARGP).
**Design:**
Prospective case series.
**Setting:**
Outpatient Sports Medicine Department.
**Patients:**
34 athletes with LSARGP defined as pain on palpation of the proximal insertion of adductor muscle and a painful, resisted adduction test.
**Assessment:**
A clinician blinded to the results of the radiological assessment performed a physical
**examination:**
iliopsoas length, hip ROM and anterior hip impingement test. Anteroposterior pelvic radiographs were examined by a second blinded clinician for the presence of: pistol grip deformity, centrum-collumdiaphyseal angle, femoral head neck ratio, coxa profunda, protrusio acetabuli, lateral centre edge angle, acetabular index and cross-over sign.
**Results:**
The prevalence of radiological signs of FAI was 94% (64/68). The mean number of radiological signs in hips with LSARGP was 1.84 (range 0–4, SD 1.05) and 1.96 (range 0–5, SD 1.12) in asymptomatic groins (p=0.95). The anterior hip impingement test was positive in nine cases. There was no relationship with the number of radiological signs (p=0.95). There was no correlation between hip ROM and the number of radiological signs (p=0.37).
**Conclusion:**
Radiological signs of FAI are frequently observed in patients presenting with LSARGP. Clinicians should be aware of this fact and the possible lack of correlation when assessing athletes with groin pain.

### *Introduction*

Long-standing adductor-related groin pain (LSARGP) is common in sports such as football and rugby involving cutting and kicking. The annual frequency of groin injuries is 8% to 18% in football (Ekstrand and Hilding, 1999; Hölmich 1998). LSARGP can be difficult to treat, and there is a lack of consensus as to the diagnostic criteria that apply in groin pain. Many authors have noted that multiple diagnoses are common (Ekberg *et al.*, 1988; Lovell, 1995; Hölmich, 2007). LSARGP is a diagnostic term used to describe pain at the proximal attachment of the adductor muscles on the pubic bone on sporting activities (Hölmich, 2007). The pain can be felt on palpating the proximal attachment of the adductor muscles and can be reproduced when resisted hip adduction is performed. It is termed long-standing when symptoms have been present for more than two months (Hölmich *et al.*, 1999). It has long been noted that patients with long-standing groin pain appeared to have a reduced hip joint range of motion (ROM) (Williams, 1978). Recent prospective studies confirmed this association (Verrall *et al.*, 2007; Ibrahim *et al*,. 2007). The cause of this reduced ROM is unclear (Verrall *et al.*, 2007). One possible explanation may be that the reduced ROM could be due to a hip disorder. Femoroacetabular impingement (FAI) is a hip condition which is considered by some authors to be due to subtle developmental disorders of the hip (Ganz *et al.*, 2008). FAI is caused by abnormal contact between the femur and the acetabulum. It is clinically characterised by a reduced hip joint ROM and pain when the hip impingement test is performed (Keogh and Batt, 2008). FAI has two subtypes: cam and pincer impingement. In cam impingement, there is an abnormality of the femoral head or neck, and pincer impingement occurs when the acetabulum is abnormal. At the time of writing, at least eight different radiological signs have been reported to show the presence of FAI (Ganz *et al.*, 2003; Siebenrock *et al.*, 2004; Tannast *et al.*, 2007; Jager *et al.*, 2004; Murphy *et al.*, 1995).

The natural history of this condition is unknown, although population studies are being performed to evaluate this (Ganz *et al.*, 2003). The current suggested treatment for FAI is conservative with activity modification, analgesia of anti-inflammatories and possibly modification of technique (Keogh and Batt, 2008). If conservative therapy is unsuccessful, then surgical treatment with correction of the abnormal shape of the femur (cam impingement), acetabulum (pincer impingement) or both can be performed (Ganz *et al.*, 2003; Ganz *et al.*, 2008).

This study aims to examine the relationship between LSARGP and FAI. First, the clinical findings of the hip joint ROM, the hip impingement test and the length of the iliopsoas muscle were examined in athletes presenting with LSARGP. Second, the prevalence of radiological signs of FAI in these athletes was examined. Third, the relationship between physical and radiological findings of FAI was examined.

## Methods

### *Patients*

Patients with groin pain were seen at the Sports Medicine Department of a large general hospital. Patients were referred by their general practitioner or a physical therapist. The diagnosis was made based on history and a standardised clinical examination (Hölmich *et al.*, 2004). All patients who presented were included in the study after they gave their informed consent. The regional medical ethics committee approved the study. The type of sport, frequency of sports activities and Tegner activity score were recorded. The inclusion and exclusion criteria are shown in Table 3.1.

**Table 3.1:** Inclusion and exclusion criter

| Inclusion criteria | Exclusion criteria |
|---|---|
| Groin pain for at least 2 months | Palpable inguinal or femoral hernia or pain felt above the conjoint tendon |
| Pain located at the proximal insertion of the adductor muscles on the pubic bone | Clincal signs or symptoms of prostatitis or urinary tract infection |
| Pain felt at the proximal insertion of the adductor muscles on the pubic bone when performing resisted adduction | Back pain felt from T10 to L5 |
| Groin pain during or after sporting activities | Clinical suspicion of a nerve entrapment of the ilioinguinal, genitofemoral or lateral cutaneous nerves |
| Age 18-50 years | Known malignant disease |

### *Physical examination*

All patients were examined by a single experienced sports medicine physician (AW) blinded to the results of the radiological assessment using a standard protocol and the physical examination that has been shown to be reliable (Hölmich *et al.*, 2004). The iliopsoas length was assessed using the modified Thomas test as reported by Hölmich *et al.* (2004). The iliopsoas was considered to be shortened when the thigh was horizontal or above horizontal. The length was considered to be normal when the thigh was below horizontal.

Hip joint ROM was measured using a goniometer with the patient lying supine with the knee and hip flexed to 90°, which has been shown to be reliable (Boone *et al.*, 1978). The internal and external rotation was measured separately, and the total rotation was calculated by adding the ROM for internal and external rotation.

The anterior hip impingement test (also called the flexion internal rotation-adduction impingement test) was performed with the patient lying supine. The hip is passively flexed to 90°, and progressive internal rotation and adduction are then applied until an end point is reached (Ganz *et al.*, 2003). The test is positive if the groin pain is reproduced.

***Radiological evaluation***

In all patients, a plain anteroposterior radiograph of the pelvis was obtained. The film focus distance was 1.2 m, and the central beam was directed to the midpoint between a line connecting the both anterosuperior iliac spines and the superior border of the symphisis (Tannast *et al.*, 2005). Digitalised radiographs were evaluated using a computer imaging system (Magic View; Fa.Siemens, Munich, Germany). All measurements were performed by a single experienced examiner, who was blinded to the clinical findings. The radiographs were assessed for signs of cam impingement using the following three signs: pistol grip deformity defined as a flattening of the usually concave surface of the lateral aspect of the femoral head (Siebenrock *et al.*, 2004; Tannast *et al.*, 2007). The centrum-collumdiaphyseal (CCD) angle was measured. A CCD angle of less than 125° has been reported to show cam impingement (Tannast *et al.*, 2007). The femoral head neck index of Heymann and Herndon was calculated (Jager *et al.*, 2004). The normal range for the femoral head neck index is 150–190 and was scored as being abnormal when it was less than 150.

Pincer impingement was assessed using the following five signs: Coxa profunda was said to be present when the ilioischial line touches or overlaps medially with the floor of the fossa acetabuli (Tannast *et al.*, 2007). Protrusio acetabuli is said to be present when the head of the femur overlaps medially with the ilioischial line (Tannast *et al.*, 2007). The lateral centre edge angle is the angle formed by a vertical line and a line connecting the femoral head centre with the lateral edge of the acetabulum. An angle of less than 25° defines a dysplasia (Murphy *et al.*, 1995). An angle greater than 39° is an indicator for acetabular overcoverage (Tonnis and Heinecke, 1999). The acetabular index is the angle between a horizontal line and a line connecting the medial point of the sclerotic zone with the lateral centre of the acetabulum. A value of 0° or a negative value is said to be a sign of pincer impingement (Tannast *et al.*, 2007). In a normal acetabulum, the anterior rim line projects medially to the posterior wall due to anteversion (Siebenrock *et al.*, 2003). Focal over coverage of the anterosuperior acetabulum was assessed using the cross-over sign. The cross-over sign is present when the line of the anterior acetabular rim is lateral to the line of the posterior acetabular rim in the cranial part of the acetabulum (Tannast *et al.*, 2007).

In total, each hip was radiologically assessed for eight different signs for the presence of femoroacetabular impingement. These criteria are summarised in Table 3.2.

**Table 3.2:** Criteria used to assess the presence of femoroacetabular impingement on anteroposterior radiograph.

| Type of impingement | Sign |
|---|---|
| Cam | Pistol grip deformity |
| Cam | CCD angle < 125° |
| Cam | Femoral head neck index < 150 |
| Pincer | Coxa profunda |
| Pincer | Protrusio acetabuli |
| Pincer | Lateral center edge angle > 39° |
| Pincer | Acetabular index ≤ 0 |
| Pincer | Cross over sign |

### *Statistical analysis*

Statistical analysis was performed using SPSS (version 14.0; 2005 SPSS, Chicago, Illinois, USA). Descriptive statistics were used for the patient demographics and the radiological score. The results are presented as means with SD when the data were parametric and medians with inter-quartile ranges (IQR) when the data were non-parametric. The relationship between variables was examined with the Spearman test, the  2 test or the t test according to the type of variable examined.

## Results

### *Patient demographics*

Between September 2006 and June 2007, 44 consecutive patients were seen with groin pain. Six patients were excluded because they had pain above the conjoined tendon or a palpable inguinal hernia. Four patients were excluded as they also had current lower back pain.

Thirty-four patients (68 groins) were suitable for inclusion and were assessed. There were 10 patients with bilateral pain, 13 with right-sided pain and 11 with left-sided pain. This meant that of the 68 groins evaluated, 44 had LSARGP. The patient demographics for the patients included in the study were as follows: the average age was 30 (range18–45, SD 8.3) years. The mean body mass index was 24.3 (range 20–29, SD 2.2) kg/m$^2$. The median duration of symptoms was 22 (range 8–250, IQR 36) weeks with an average duration of abstinence from sport of 15 (range 0–130, SD 24) weeks. The patients were involved in the following sports: 23 (68%) football, 2 (6%) rugby, 2 (6%) distance running, 2 (6%) field hockey and 5 (16%) other sports. Frequency of sports activities was: 4 (12%) once or twice weekly, 23 (68%) three to four times weekly and

7 (21%) more than five times a week. The mean Tegner activity score was 8.74 (range 7–10, SD 0.62). There were no dropouts or incomplete datasets.

***Physical examination***

The iliopsoas was noted to be shortened in 40% (27/68) of all groins. The average ROM in the hip joint was 22 (SD 12) degrees of internal rotation, and 60 (SD 18) degrees of total rotation. The hip joint total range of rotation or the range of internal rotation was not reduced in hips where adductor-related groin pain was felt when compared to hips where no groin pain was felt (p=0.69, p=0.79). The anterior hip impingement test was positive in nine hips (13%), all of which were symptomatic for LSARGP.
There was no significant relationship between the iliopsoas being shortened and a painful hip impingement test (p=0.68). The ROM in the nine hips with a positive anterior hip impingement test (56°) was not significantly different from the 59 hips with a negative test (60°, p=0.53).

***Radiological examination***

In total, there were 128 abnormal radiological signs observed in the 68 hips of the 34 patients with LSARGP. The prevalence of different signs observed is shown in Table 3.3.

**Table 3.3:** Prevalence of abnormal radiological signs.

| Sign | Number of times observed in 68 hips |
|---|---|
| Pistol grip deformity | 27 (40%) |
| CCD angle < 125° | 2 (3%) |
| Femoral head neck index < 150 | 0 |
| Coxa profunda | 23 (34%) |
| Protrusio acetabuli | 0 |
| Lateral center edge angle > 39° | 20 (29%) |
| Acetabular index ≤ 0 | 31 (46%) |
| Cross over sign | 25 (37%) |

The prevalence of radiological signs for FAI was 94% with only four hips (6%) without any signs of FAI. The number of signs for each hip is shown in Table 3.4.

**Table 3.4:** Number of radiological signs per hip.

| Number of radiological signs | Number of hips (total = 68) |
|---|---|
| 0 | 4 (6%) |
| 1 | 18 (27%) |
| 2 | 26 (38%) |
| 3 | 12 (17%) |
| 4 | 6 (9%) |
| 5 | 2 (3%) |

There was no association between the number of radiological signs and the anterior hip impingement test being positive (p=0.95). In fact, the two hips with the highest number of radiological signs of FAI had a negative anterior hip impingement test. The mean number of radiological signs in sides with LSARGP (n=44; 1.84, range 0–4, SD 1.05) was not significantly different from the number in the asymptomatic hips (n=24; 1.96, range 0–5, SD 1.12, p=0.95). There was no correlation between hip ROM and the number of radiological signs (p=0.37).

## Discussion

In this study, there was a high prevalence of radiological signs of FAI in athletes presenting with LSARGP. Ninety-four percent (64/68) of the hips assessed showed radiological signs of FAI. The fact that only 6% of the hips were found to be radiologically normal is concerning, and it raises a number of questions. In the literature, at the time of writing, eight different signs were found that have already been reported to show the presence of FAI. There are a growing number of publications on the different signs that can be observed on additional imaging investigations for making the diagnosis of FAI. As the number of possible signs used to make the diagnosis increases, the prevalence of the disorder will also increase. At present, there is no clear consensus as to when the diagnosis of FAI can be made, and a gold standard is missing. This is a problem in clinical practice and has been noted by other authors (Standaert *et al.*, 2008). Many studies reporting on the treatment of patients with FAI have no clear inclusion criteria (Peters and Erickson, 2006; Beck *et al.*, 2004). This may be due to bias as all the patients did in fact have groin pain. There are no studies at present that report the prevalence of abnormalities in asymptomatic populations. Ganz *et al.* (2008) have reported that a study is in progress, and these results will be welcome to enable the definition of normal values. This may help to create clear diagnostic criteria for FAI which can serve as a gold standard for making the diagnosis. At the present time, it is unclear as to whether hips with radiological signs of FAI but no pain should be diagnosed as having FAI or not.

There was no association between a positive anterior hip impingement test and reduced ROM or a higher number of radiological signs of FAI. The anterior hip impingement test that involves moving the hip into flexion, internal rotation and adduction is cited in many papers as being positive in FAI. In this study, nine hips (13%) had pain in the groin on performing the test. It could be argued that these nine patients all have FAI as they all also had at least one radiological abnormality. They did, however, present with pain located at the proximal insertion of the adductor muscles on the pubic bone and had recognisable tenderness on palpation. This would suggest that their primary pain may be located in the soft tissues and may be of extra-articular origin. These may then be false-positive tests. Recent research on the reliability of the anterior hip impingement test showed that it had a low reliability ( =0.58) when this was examined in a population of patients with different intra-articular hip joint problems (Martin and Sekiya, 2008). In this study, 70 patients with a variety of hip joint conditions (of which 48 were diagnosed with FAI) were examined by an orthopaedic surgeon and a physical therapist. They found the test to be positive in 57 patients suggesting that in some cases, the test was false positive. To our knowledge, the validity has not been examined in patients with extra-articular causes of groin pain. The movement performed during the test could also cause movement and stress at the pubic symphisis, which is one of the possible sources of pain in patients with long-standing adductor-related groin pain (Jansen *et al.*, 2008A). The motion may also twist and compress the iliopsoas muscle which has been reported to be a secondary source of pain in many patients presenting with adductor-related groin pain (Hölmich, 2007). Until the validity of the anterior hip impingement test has been further examined, it should be interpreted with caution.

The subject of differential diagnosis in athletes presenting with chronic groin pain has long been a topic of interest. Many authors have reported multiple entities in patients presenting with long-standing groin pain (Ekberg *et al.*, 1988; Hölmich, 2007). The prevalence of different conditions varies greatly between the studies. In one study of 203 athletes presenting with groin pain of more than two months, only one hip problem was diagnosed (Hölmich, 2007). In this study, adductor pain was the primary diagnosis in 58% of cases. In a different study examining 218 athletes presenting with groin pain, the hip was the primary source of pain in 46% of all cases (Bradshaw *et al.*, 2008). While this may be due to differences in referral patterns that would seem unlikely, considering that the study with the far lower prevalence of hip disorders was performed by an orthopaedic surgeon, the study with the high prevalence was performed by a sports physician.

It is hypothesised that the differences may well be due to varying diagnostic criteria.

At present, there are no generally accepted diagnostic criteria for the different entities causing groin pain. This is in part due to a lack of understanding about the underlying pathology and partly due to the confusing scientific taxonomy surrounding groin pain. It is clear that there is great need for clear diagnostic criteria in cases of groin pain and that these criteria should also cover intra-articular hip pathologies.

As mentioned above, multiple diagnoses can coexist, and indeed, Bradshaw *et al.* (2008) reported that 10 of the 218 athletes did have coexisting osteitis pubis and hip joint pathology, although these conditions are not further defined.
It may also be that the relationship between the hip joint and long-standing adductor-related groin pain is more complex. Prospective studies have shown that athletes with a reduced hip joint ROM have a higher risk of developing chronic groin injury. It was hypothesised that the reduced ROM may cause increased loading and mechanical stress on the pubic symphisis and surrounding structures (Verrall *et al.*, 2007). In previous studies, it was stated that it was unclear as to which structures limit the hip joint range of rotational motion (Verrall *et al.*, 2007). A possible explanation may be that an underlying FAI predisposes to chronic groin injury through a reduced ROM. Other authors have suggested that inflammation as a response to loading may cause capsular tightness leading to a reduction of ROM (Verrall *et al.*, 2005). This mechanism has been noted to cause a restriction of the range of shoulder rotation in overhead athletes (Bach and Goldberg, 2006). As this study is not prospective, no cause–effect relationship can be established, and future studies will be necessary to examine this further. A possible shortcoming of this is the fact that the ROM of the hip joint was measured once using a goniometer with the hip in 90° of flexion. Although the use of a single measurement has been shown to be reliable (Boone *et al.*, 1978), it has also been suggested that multiple measures should be taken for joints with a large ROM (Bovens *et al.*, 1990). The choice to measure the hip joint ROM in flexion has also been noted by others to be questionable as most loading during sports activities occurs at a much lesser degree of flexion (Verrall *et al.*, 2007). Future studies are needed to provide clear diagnostic criteria for causes of groin pain and to examine the relationships between these pathologies.

## Conclusion

Radiological signs of femoroacetabular impingement are frequently observed in patients presenting with long-standing adductor-related groin pain. Radiological findings of hip impingement are often present without the anterior hip impingement test being painful. The anterior hip impingement test may not be specific for femoroacetabular impingement. Clear diagnostic criteria for femoroacetabular impingement and other causes of groin pain are needed.

# Chapter 4:

## Core stability: Inter- and intraobserver reliability of six clinical tests

## Chapter 4:
## Core stability: Inter- and intraobserver reliability of six clinical tests

Weir A, Darby J, Inklaar H, Koes B, Bakker E, Tol JL.
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**Objective:**
Core stability is a complex concept within sports medicine and is thought to play a role in sports injuries. There is a lack of reliable and valid clinical tests for core stability. The inter and intraobserver reliability of six tests commonly used to assess core stability was determined.
**Design:**
A video of the tests was shown to six observers. A second observation took place five weeks later with the same observers.
**Setting:**
Sports medicine department of a hospital.
**Participants:**
Forty male athletes.
**Assessment of variables:**
Core stability was rated as poor, moderate, good, or excellent by each observer for each of the six tests.
**Main outcome measures:**
Inter- and intraobserver reliability.
**Results:**
The mean score of all tests was 13.4% poor, 33.3% moderate, 40.1% good, and 13.2% excellent. The intraclass correlation coefficients (ICCs 2,1) for the interobserver reliability for frontal, sagittal, and transverse plane evaluation were 0.09, 0.32, and 0.51, respectively. The ICCs for the unilateral squat, the lateral stepdown, and the bridge were 0.41, 0.39, and 0.36, respectively. The ICCs for the intraobserver reliability for frontal, sagittal, and transverse plane evaluation were 0.31, 0.40, and 0.55, respectively. The ICCs for the unilateral squat, the lateral step-down, and the bridge were 0.55, 0.49, and 0.21, respectively.
**Conclusions:**
The six clinical core stability tests are not reliable when a 4-point visual scoring assessment is used. Future research on movement evaluation should be focused on more specific rating methods and training for the observers.

### *Introduction*

Core stability is a complex and very popular concept within sports medicine. One of the most common definitions was proposed by Kibler *et al.* (2006): "The ability to control the position and motion of the trunk over the pelvis and to allow optimum production, transfer, and control of force and motion to the terminal segment in integrated athletic activities." Although core stability is thought to play a crucial role in sports medicine, there are no widely accepted reliable tests for testing core stability in the clinic (Borghuis *et al.*, 2008). Chmielewski *et al.* (2007) were the first to study the observer reliability of two clinical tests. In this study, two testing methods of functional tasks for the lower extremity were evaluated and levels of agreement were descriptively compared. The two functional tasks were the lateral step-down and the unilateral squat. Both inter- and intraobserver reliability were low.

Kibler *et al.* (2006) described a three-plane testing model. Three core stability tests were described. A recent comprehensive review on core stability stated that the use of these tests could give useful information, although it was noted that the reliability and validity had not been studied (Borghuis *et al.*, 2008). The aim of this study was to investigate the inter- and intraobserver reliability of six clinical core stability tests described and recommended in the literature.

## Materials and methods

### *Subjects*

The reliability of six clinical tests was assessed in 40 male volunteers. To avoid bias based on kinematical differences between men and women,(Jacobs and Matacolla, 2005; Zeller *et al.*, 2003) only men were included. Male subjects (>18 years of age) were eligible for inclusion. All subjects were recruited in an outpatient sports medicine department in a large district general hospital. When they attended for preparticipation screening examinations, the subjects were informed about the aim and background of the study. After obtaining their written informed consent, a researcher instructed the subjects in detail on performing the core stability tests. The local medical ethics committee approved the study protocol.

Subjects were excluded if they reported pain on performing the trial of the six clinical tests from the testing protocol.

### *Testing Protocol*

The six tests are described and recommended in the literature and are commonly used in clinical decision making and patients' follow-up (Kibler *at al.*, 2006; Chmielewski *et al.*, 2007). All of the tests have a good written description of how they should be performed (and observed), and all of these tests are thought to be related to core stability.

All observers met four months before the start of the first observation to agree on which tests would be used so that they could practice them in a clinical setting to allow familiarisation. The tests were all performed in single-leg stance (right leg) to be sufficiently demanding for the subjects. All subjects were given verbal instructions on how to perform the test, followed by a visual demonstration. Subjects were allowed a first trial of six repetitions. Verbal feedback was given if the test was performed incorrectly. The subjects then performed the definite trial. Subjects all wore the same clothing during the video recordings to increase uniformity. With each test, two trials were performed that consisted of six repetitions.

***The Tests***

***Unilateral Squat***

The starting position for the unilateral squat was standing on the test leg with the hip and knee in a neutral anatomical position. The trunk was upright, without rotation or lateral flexion, and the contralateral leg was positioned with the hip in neutral position and the knee in 90° of flexion. Subjects moved at a self-selected pace into a squat position and then returned to the starting position (Figure 4.1).

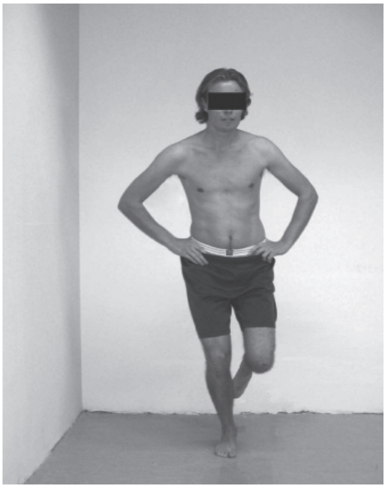

*Figure 4.1: Unilateral squat.*

***Lateral Step-Down***

For the lateral step-down, subjects stood on the test leg, which was positioned on the edge of an adjustable step, with the hip and knee in a neutral anatomical position. The trunk was upright without rotation or lateral flexion, the iliac crests were level, and the contralateral leg was unsupported, with the hip in a slightly flexed position and the knee extended. Subjects lowered themselves at a self-selected pace until the contralateral heel contacted the ground and then returned to the starting position (Figure 4.2).

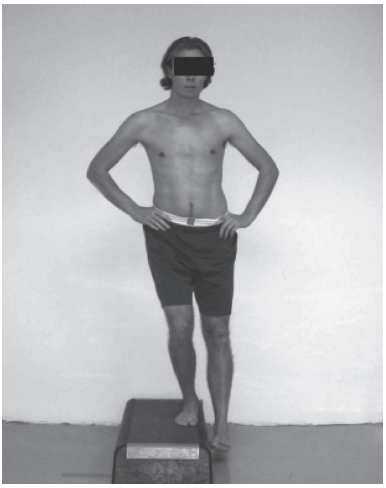

*Figure 4.2: Lateral step down.*

*Figure 4.3: Frontal Plane Testing.*

Three plane core tests were done with the subjects standing at 8 cm from the wall.

### *Frontal Plane Testing*

The subjects stood with one side of the body toward the wall and with their shoulder 8 cm away from the wall, while standing on the inside leg, they were asked to lightly touch the wall with their shoulder. The head and pelvis were kept in the neutral position (Figure 4.3).

### *Sagittal Plane Testing*

The subjects stood on one leg with their back toward the wall. The shoulders were 8 cm from the wall. They were asked to slowly move their body backward and lightly touch the wall with their head. The head and pelvis were kept in the neutral position (Figure 4.4).

*Figure 4.4: Sagittal Plane Testing.*

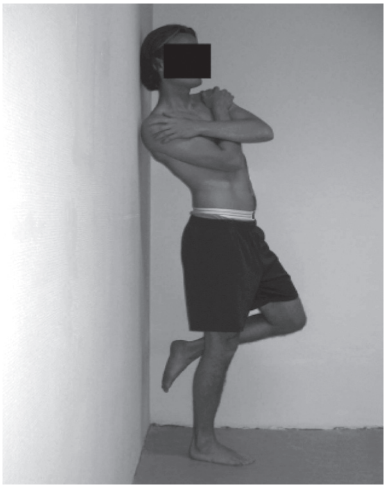

*Figure 4.5: Transverse Plane Testing.*

***Transverse Plane Testing***

The subjects stood with their back toward the wall with their shoulders 8 cm away, in a single-leg position, and alternately lightly touched one shoulder and then the other against the wall. The head and pelvis were kept in the neutral position (Figure 4.5).

***The Bridge***

The bridge was performed with the body in horizontal prone position, supported by the underarms, with the arms directly under the shoulders and the toes of the feet. A straight line from head to toe had to be formed and maintained for 10 seconds (Figure 4.6).

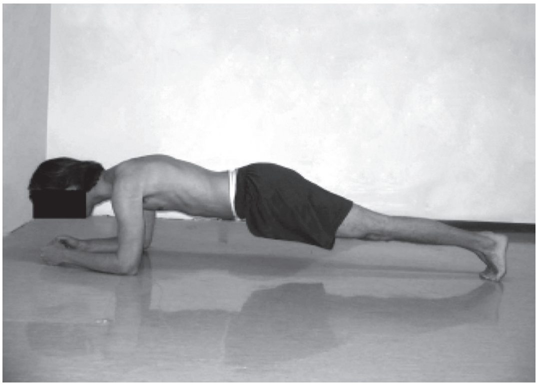

*Figure 4.6: The bridge.*

The tests were recorded with a digital camcorder (JVC Digital Handycam GR-DVL167EG; JVC, Japan). Both trials were recorded, and the second trial was used for the observation.

### *Observation*

There were six experienced observers: four experienced sports physicians who worked with athletes at an international level and two experienced sports physical therapists. Before the observation, they received instructions on scoring the test performance. All the observers used a number of the tests in their current clinical practice when assessing core stability. The criteria for scoring the tests are shown in Table 4.1.

**Table 4.1:** Score and criteria for core stability tests.

| Score | Criteria |
|---|---|
| Excellent | No deviation from neutral alignment |
| Good | A small magnitude* or barely observable movement out of a neutral position and/or low frequency of segmental oscillation^ |
| Moderate | A moderate or marked movement out of a neutral position and/or moderate frequency segmental oscillation |
| Poor | Excessive or severe magnitue of movement out of a neutral position and/or high frequency segment oscillation |
| * A single movement out of the neutral alignment<br>^ Multiple movements out of the neutral alignment | |

For each separate test, all subjects were subsequently scored according to the 4-point scale. The observers scored the recordings of all 40 subjects in a random order for each single test. After they had evaluated and scored one test, they were shown the recordings for all 40 subjects in a different random order for the second test. The second observation was carried out in the same manner as the first. The time window between the two observations was five weeks.

### *Statistical Analysis*

Data for each clinical test were analysed separately. The statistical analysis performed was done by a 2-way random model to calculate the interobserver reliability for general use, not only to investigate the observer reliability between colleagues. For the inter- and intraobserver reliability, the intraclass correlation coefficient (ICC 2,1) was calculated. Frequency ratings were calculated for all the tests and all the observers per scoring category. Data analysis was done using SPSS 15.0 (SPSS Inc, Chicago, Illinois).

## Results

Forty subjects were included. The mean age of the subjects was 25.4 years (range 18-44 years). The average height was 182.0 cm (SD 7.3 cm), and the mean weight was 74.9 kg (SD 12.1). The percentage of subjects who preferred to stand on the left leg was 75.7%. The mean weekly sports participation time was 7.9 hours per week (SD 4.8). Thirty-one subjects (86%) were involved in soccer. The mean score of all tests was 13.4% poor, 33.3% moderate, 40.1% good, and 13.2% excellent.
Percent agreement of all observers between the two observations was 0.46, 0.51, and 0.58 for the frontal, sagittal, and transverse plane tests, respectively, and 0.49, 0.47, and 0.53 for the unilateral squat, the lateral step-down, and the bridge, respectively. The ICCs for the interobserver and intraobserver reliability are shown in Tables 4.2 and 4.3 respectivley.

**Table 4.2:** ICC (2,1)for inter-observer reliability of six tests rated by six observers with a four point scale.

| Test | Inter-observer reliability (ICC 2,1) | 95% Confidence interval |
|---|---|---|
| Unilateral Squat | 0.41 | 0.26-0.58 |
| Lateral Step-down | 0.39 | 0.23-0.57 |
| Frontal Plane Evaluation | 0.09 | 0.01-0.21 |
| Saggital Plane Evaluation | 0.32 | 0.19-0.49 |
| Transverse Plane Evaluation | 0.51 | 0.35-0.66 |
| Bridge | 0.36 | 0.22-0.53 |

**Table 4.3:** ICC for intra-observer reliability of six tests rated by six observers with a four point scale.

| Test | Intra-observer reliability (ICC 2,1) | 95% Confidence interval |
|---|---|---|
| Unilateral Squat | 0.55 | 0.45-0.64 |
| Lateral Step-down | 0.49 | 0.39-0.59 |
| Frontal Plane Evaluation | 0.31 | 0.17-0.43 |
| Saggital Plane Evaluation | 0.40 | 0.29-0.51 |
| Transverse Plane Evaluation | 0.55 | 0.46-0.64 |
| Bridge | 0.21 | 0.07-0.35 |

The data were also analysed with the score dichotomised (poor and moderate compared with good and excellent), which did not lead to an improved intra- and interobserver reliability.

## Discussion

This study showed a poor inter- and intraobserver reliability of the six clinical core stability tests when assessed with a 4-point visual evaluation score. The six tests examined in this study are widely used and have been recommended in the literature as being suitable to assess core stability (Kibler *et al.*, 2006; Borghuis *et al.*, 2008). The results of this study indicate that the use of these tests in clinical practice should be questioned. Other investigators have also shown poor reliability of clinical tests used for core stability. Chmielewski *et al.* (2007) examined inter- and intraobserver reliability for the lateral step-down and the unilateral squat tests. In their study, 25 uninjured subjects were scored, on two occasions five weeks apart, using a specific and a general scoring method. In the specific method, trunk, pelvis, and hip were scored separately. The general method used a 3-point scoring system similar to that used in this study. The interobserver reliability using both the general method (weighted kappa 0-0.55) and the specific method (weighted kappa 0.23-0.53) was poor. The intraobserver reliability for the unilateral squat and the lateral step-down was also poor (0.13-0.68). The intraobserver reliability was better when the specific scoring system was used (0.38-0.68) when compared with the general scoring method (0.13-0.50). The slightly better results of this study should be interpreted with caution as a weighted kappa was used to express the intraobserver reliability, which can result in a better outcome.
Piva *et al.* (2006) investigated the interobserver reliability for movement quality assessment during a lateral step-down. Thirty patients with patellofemoral pain were scored

by four observers. A special rating system was created for this study. Five rating criteria included trunk, pelvis, and knee position; use of arms for balance; and the loss of balance. Each criterion was scored dichotomously, except for knee position, for which severity in deviation was rated based on anatomical reference points. Total scores were then categorised into three groups. A kappa coefficient of 0.67 was reported for the interobserver reliability.

At present, there are unfortunately no other studies available on clinical core stability tests. There are at present no reliable clinical tests with which core stability can be assessed. Other studies have looked at the clinical assessment of movement patterns in other areas. Hayes *et al.* (2007) investigated the reliability of five methods for assessing shoulder range of motion in eight patients with shoulder complaints. A visual estimation of passive range of motion was done using three static tests and two dynamic tests. The tests were scored by four observers. For the intraobserver reliability, only one observer was used. The time between the observations was within 48 hours, and nine patients were included. The interobserver reliability was calculated with the ICC ranging from 0.57 to 0.70 for the static tests. The two dynamic tests had poor interobserver reliability (0.26 and 0.39). The author explained the poor reliability as a reflection of the complexity of the movement itself. Harrison *et al.* (1994) described interobserver reliability for evaluating single-leg stance in 78 uninjured subjects and 17 anterior cruciate ligament rupture patients. A 3-point scale was used, and specific guidelines were provided to the two observers. A weighted kappa of 0.70 was found for this static test.

It would seem that a static test results in a better reliability when compared with dynamic tests. It may be the case that reliable assessment of complex dynamic movement patterns is not possible using clinical judgment and the naked eye alone and that other objective tests are needed (Borghuis *et al.*, 2008). Many studies on core stability have used complex objective tests that require specialised apparatus and are time consuming to perform (Borghuis *et al.*, 2008; Cholewicki *et al.*, 2005).

A shortcoming of this study that needs discussion was the use of video for the interobserver reliability. It is possible that important visual information is lost by observing the subject two dimensionally and only from one viewpoint. The choice to use video, however, was based on creating less bias in intraobserver reliability and for logistical reasons. The use of video ensured that exactly the same movement was observed at both moments by all the observers. Any differences observed must have been due to differences in the way the observer scored the test and cannot have been due to two observers seeing different movement patterns. The video was projected onto a screen life sized to make the observation as lifelike and detailed as possible. The possibility that fatigue of the observers during the long duration of the assessment may have affected the reliability cannot be excluded. In this study, the ICC was used to examine the inter- and intraobserver reliability. In many studies, the kappa is used or the weighted kappa in those with multiple observers. It has been noted that there is no real difference between

the ICC and weighted kappa for multiple observers (Norman and Steiner, 2000).
The tests were scored separately and not after seeing the whole battery. As such, there was no general score given to the whole battery of tests. It may be that this would lead to an improved reliability, but as the scores were not recorded in this manner, it was not possible to analyse this. In this study, no attempt was made to measure the core stability objectively using more complex movement analysis systems or electromyography as this was not the aim. The study also provides no insight as to what these tests do measure as the test performance was too poor to go on to examine the validity of the tests.

## Conclusions

This study shows that all six clinical tests for core stability have a poor inter- and intraobserver reliability when assessment is done with visual evaluation and the use of a 4-point scoring system. Based on these results, the clinical tests are not reliable enough to be used in the clinical setting. This indicates a need to develop more reliable clinical tests for evaluating core stability.

# Chapter 5:

## A manual therapy technique for chronic adductor-related groin pain in athletes: a case series

# Chapter 5:
# A manual therapy technique for chronic adductor-related groin pain in athletes: a case series

Weir A, Veger SAS, Van de Sande HBA, Bakker EWP, de Jonge S, Tol JL.
Scandinavian Journal of Medicine and Science in Sports. 2009 Oct;19(5):616-20.

**Aim:**
The objective was to retrospectively examine whether a manual therapy technique is effective in the treatment of chronic adductor-related groin pain in athletes.
**Methods:**
Thirty-three athletes with chronic adductor-related groin pain were approached. Thirty patients gave their consent to participate in the study. Patient satisfaction, return to activity and numeric pain score were recorded. Patients were treated after prewarming of the muscles; one hand is used to control the tension in the adductor muscles and the other hand is used to move the hip into abduction and external rotation. This flowing, circular motion stretches the adductor muscle group. The movement is repeated three times in one treatment session.
**Results:**
Twenty-five out of 30 (83%) athletes reported a good or excellent satisfaction. Twenty-seven out of 30 (90%) athletes had resumed sport at (15/30) or below (12/30) their previous level of activity. The pain score for during or after activity decreased significantly from 8.7 to 2.2 after the treatment ($P$<0.01).
**Conclusion:**
This study shows that the manual therapy treatment might be a promising treatment for chronic adductor-related groin pain in athletes.

### *Introduction*

Chronic adductor-related groin pain is a common entity in athletes. Sports that involve frequent kicking such as football and Australian football have a high incidence (Orchard and Seward, 2002; Arnason *et al.*, 2004). There are few studies about the conservative management of chronic groin injuries. In the only high-quality randomized-controlled study, Hölmich *et al.* (1999) showed that an active physical training programme consisting of supervised exercises three times weekly for 90 minutes was shown to be more effective than physical therapy modalities. The use of compression shorts was shown to be effective in reducing the pain felt during sports in a small group of patients with chronic osteitis pubis without negatively affecting the performance (McKim and Taunton, 2001). The use of corticosteroid injections has been recommended for the treatment of osteitis pubis (Holt *et al.*, 1995). In this study, use of one or two injections in the pubic symphisis allowed seven out of eight athletes to return to sporting activities after conservative treatment with rest, oral anti-inflammatory medication and hip stretching exercises had failed. A recent non-randomised study examining the effects of an entheseal pubic cleft injection with a local anesthetic and corticosteroid reported good results up to one year in a group of patients without magnetic resonance imaging (MRI) abnormalities at the adductor enthesis (Schilders *et al.*, 2007). Recently, a series of injections with hypertonic dextrose prolotherapy were found to be effective in a series of 24 football and rugby players with chronic osteitis pubis and adductor-related groin pain (Topol *et al.*, 2005). After a mean of 2.8 injections, 20 of the 24 athletes were pain free and 22 of the 24 had returned to sports participation when assessed 17 months after receiving the injections.

All of the above treatments, with the exception of the corticosteroid injections, require a lengthy period of treatment before return to sport is possible. This was confirmed recently in a study of 27 Australian rules football players with pubic bone stress injury confirmed with MRI studies (Verrall *et al.*, 2007). The treatment involved 12 weeks rest from all weight-bearing sports activities followed by a graded running programme. In this study, only 41% of athletes were symptom free at the start of the following playing season.

Pierre Van den Akker, who was the physical therapist of the Dutch national football team at the beginning of the 1980s, developed the manual therapy technique reported here. Feed-back from health care professionals using the technique suggests that the results might be promising in terms of success rate, time to recovery, frequency and duration of the treatment. Whether this approach is an effective intervention should be examined in controlled studies. The costs involving a full-scale randomised controlled trial are considerable. Before a controlled study could be justified, the feed-back of athletes treated with this intervention should be assessed scientifically. The purpose of this study was to retrospectively evaluate the effectiveness of the manual therapy technique.

## Materials and methods

### *Study design*

The design is a retrospective study of consecutive athletes treated with a manual therapy treatment for chronic adductor-related groin pain. Thirty-three athletes were approached 6–12 months after the treatment. The local Medical Ethics Board gave permission for the study.

### *Subjects*

All athletes were treated consecutively in a hospital sports medicine outpatient department of a large district hospital. Local general practitioners, physiotherapists and other sports medicine physicians referred all athletes.

The inclusion criteria were the same as those described by Hölmich *et al.* (1999): a minimum of 2 months of pain in the groin during or after sport together with pain during or after sports at the proximal insertion of the adductors; together with pain on palpation at the proximal insertion of the adductors and a positive-resisted adduction test. These tests were conducted in the manner described previously by Hölmich and were shown to be reproducible and reliable (Hölmich *et al.*, 2004). Athletes with suspicion of inguinal or femoral hernias, prostatitis or urinary tract infections, lumbar spine pathology, hip arthritis or impingement, bursitis, nerve entrapment or knee ligament instability were excluded. All athletes who presented at the department with adductor-related groin pain were treated with the manual therapy technique. No other concomitant treatment was given parallel to the manual therapy treatment.

### *Treatment*

All athletes were treated by one of two sports medicine physicians (H.S., S.V).

Before the manual technique, the adductor muscle group is warmed using paraffin packs for 10 min. The paraffin is heated in a kettle to 60 °C. This is then wrapped in a towel and placed on the proximal insertion of the adductor muscles while the athlete lies in a semi-supine position.

After the pre-warming, the athlete is instructed to relax. Then using the contralateral hand to control the tension in the adductor muscles, the ipsilateral hand is used to move the hip from neutral position into abduction and external rotation, with the knee in full extension (see Figures 5.1 and 5.2).

*Figure 5.1.:The manual therapy technique. The contra-lateral hand controls the tension.*

*Figure 5.2: The manual therapy technique. Maximum tolerable stretch is applied to the adductors using the ipsilateral hand.*

The treating physician controls the tension subjectively. This flowing, circular motion is used to apply the maximum tolerable stretch to the adductor muscle group. After performing the movement, the athlete stays lying on the table and the adductor muscle compartment is compressed using one hand while the other hand moves the hip into adduction and slight flexion. This circular movement followed by compression lasts approximately 25 seconds, and is repeated three times in one treatment session.
After the treatment, the athletes are instructed to perform a 5-minute warming up each day using slow jogging or cycling. After the warming up, stretches of the adductors are

performed for both legs. The athletes perform a standing adductor stretch and a sitting stretch. They are instructed to hold the stretch for 30 seconds, and perform each stretch three times. After performing the stretches, they lie in a warm bath for ten minutes.
After 14 days of stretching they were allowed to commence training activities, and if no pain or discomfort was felt they could progress to competitive sports. If pain or discomfort was felt on commencing sports then the athletes were treated a second time in the same manner. If after two treatments no benefit was found then no further treatment was performed.

### *Outcome measures and data collection*

For each athlete, the age, sex, side of injury, date of onset of injury and nature of onset (acute or chronic) were recorded from the medical notes. Previous additional investigations and treatments were also gained from the medical notes. This was done to minimise recall bias at the time of retrospective interview. All athletes were approached to participate in the study in August and September 2006. After informed consent was obtained, the athletes were questioned using a previously made form to enter all data in a standard and structured manner.
A single investigator recorded the subjective athlete satisfaction (poor, fair, good, excellent), a numeric pain score (ranging from 1 to 10) for the level of pain or discomfort during activities of daily living (ADL) and during or after sports activities, return to sports activities (complete, partial or none) and the pre-injury Tegner activity score.

### *Analysis*

All analyses were carried out in SPSS 14.0. First, the demographical data of the subjects at baseline treatment are presented with their mean and standard deviation (SD). In case of skewed distributions, median and interquartile range (IQR) were used. For the pain scores pre- and post-treatment, the Wilcoxon signed rank test was used to analyze the significance. Significance was assumed if the P-value was less than 0.05. For the subjective athlete satisfaction, poor or fair were considered to be unsuccessful and good or excellent were considered to be successful outcomes.

## Results

### *Patient characteristics*

Thirty athletes gave consent to participate in the study. The median age of the athletes was 20.5 years (IQR 17.75–29.75). Twenty-seven (90%) of the athletes were men. Twenty-three (77%) of the athletes were football players, four (13%) tennis players, two (7%) speed skaters and one (3%) distance runner. Ten (33%) athletes trained or played more than five times weekly before the onset of the symptoms. Fourteen athletes (47%)

participated in sport three to four times a week and six (20%) athletes participated once to twice weekly. The average Tegner activity score was 7.3 (SD 1.97) before the onset of symptoms.

In 22 (73%) athletes the symptoms had a gradual onset, and eight (27%) athletes recalled an acute moment of onset. They did not report any hematoma formation. Fourteen athletes (47%) had right-sided symptoms, nine (30%) had left-sided symptoms and seven (23%) had bilateral groin pain. The median duration of symptoms before the treatment was nine months (IQR 3–24). The median absence from sport was two months (IQR 0.38–4.2). Seventeen (57%) athletes had totally ceased all sporting activity and 12 (40%) had reduced their level of participation. One professional football player had not reduced his level of participation.

Many athletes had already undergone previous treatments for their groin pain and many had had multiple therapies. These are shown in Table 5.1.

**Table 5.1:** Previous treatments already undergone by athletes.

| Previous therapy | Number of athletes |
|---|---|
| Physiotherapy modalities | 20 (67%) |
| Structured exercise programme | 6 (20%) |
| Osteopathy | 2 (7%) |
| Compression shorts | 2 (7%) |
| NSAID's | 2 (7%) |
| Extracorporal Shock wave | 2 (7%) |

***Outcomes***

Twenty-five (83%) athletes were treated once and five (16%) athletes had undergone a second treatment. There were no complications reported by any of the athletes.

### *Athlete satisfaction*

Eighty-four percent (25/30) athletes reported a good or excellent satisfaction (see Table 5.2).

**Table 5.2:** Subjective athlete satisfaction after the treatment.

| Level of satisfaction | Number of athletes (n=30) |
|---|---|
| Excellent | 14 (47%) |
| Good | 11 (37%) |
| Fair | 3 (10%) |
| Poor | 2 (6%) |

### *Pain score*

In 24 (80%) of the athletes, the pain during ADL score was decreased at follow-up. During sports, this figure was 93% (28/30). The average pain score during ADL was 5.7 (SD 2.75) before the treatment. After the treatment, the mean score was 1.7 (SD 1.36). This difference was statistically significant ($P<0.01$). The mean pain score during or after sports activities was 8.7 (SD 1.09) before the treatment, and reduced significantly ($P<0.01$) to 2.2 (SD 2.0) after the treatment.

### *Sports activities*

The results for return to sporting activities are shown in Table 5.3. There was no association between the preinjury level of activity and the success of the treatment.

**Table 5.3:** Return to sports after treatment.

| Level of return to sporting activities | Number of athletes (n=30) |
|---|---|
| Return at pre-injury level | 15 (50%) |
| Return under pre-injury level | 12 (40%) |
| No return to sports | 3 (10%) |

## Discussion

The results of this study show that the manual therapy technique might be effective in the treatment of chronic adductor-related groin pain in athletes. Ninety-three percent (28) of the athletes reported a reduction in groin pain during sports after the treatment. Fifty percent (15/30) of the athletes reported a return to sporting activities at the pre-injury level after the treatment.

In this study, the manual therapy was performed as a stand-alone therapy. This may result in inferior results when compared with combination therapies that aim to restore the athlete to full functioning using a number of methods. There have been two studies examining the use of corticosteroid injections as a single-use therapy (Holt *et al.*, 1995; Schilders *et al.*, 2007). Both of these studies reported good results but were lacking methodological quality and had no control group. Until now only the therapy that has been shown to be effective in a high-quality randomised trial is an active physical training programme (Hölmich *et al.*, 1999). Performing the manual therapy technique would not prevent athletes from going on to perform a physical training programme afterwards. Future studies should compare the effectiveness of the manual therapy technique to a physical training programme or examine the effects of combined therapies.

Because of the lack of understanding of the underlying pathology in these injuries, it is difficult to make a hypothesis as to why the manual therapy treatment might be effective. An increase in adductor muscle tone is suggested by some authors to play a role in the pathogenesis of chronic groin injury and pubic bone overload (Brukner and Khan, 2006). The presence of an increased muscle tone in the adductor group is often not mentioned in the literature. One recent case series on the treatment of osteitis pubis in four young football players reported that three of the players complained of groin tightness as well as pain (Wollin and Lovell, 2006). An increased adductor muscle tone was found on examination in three of the four players. There is no generally accepted way to measure muscle tone in clinical practice. The reduction of an increased muscle tone in the adductor compartment has been suggested as a treatment by other authors, although they recommend massage therapy or dry needling to achieve this (Brukner and Khan, 2006). Resting muscle tone is often thought to be due to an increased electrical activity. However, it has been shown that muscles have viscoelastic properties even when there is no background electrical activity (Simons and Mense, 1998). This viscoelastic stiffness is referred to as thixotropy and means that muscle resistance to movement decreases after movement. This decrease in viscoelastic stiffness has been shown by some authors to still be detectable up to 24–30 hours after movement (Lakie and Robson, 1988). The factors influencing the rate of restiffening remain unknown. It may be that the manual therapy technique with application of maximal tolerable stretch results in decreased viscoelastic stiffness and thus decreases pubic bone load.

A reduced hip joint range of motion has been shown to be associated with chronic groin pain in athletes (Williams, 1978; Verrall *et al.*, 2005, 2007). There is little information about the structures that may limit the hip joint rotation in patients with chronic groin injury. The ischiocapsular and iliofemoral ligaments have been suggested along with stiffness of the internal and external rotators (Pickering and Howden, 1977; Verrall *et al.*, 2005). The manual therapy treatment, which involves a forceful external rotation movement, may improve a restricted range of motion.

This study has several weaknesses. The retrospective design and lack of a control group are a significant problem. The lack of long-term follow-up also means that little is known about the chance of recurrence of symptoms. Follow-up was performed using a questionnaire without a clinical examination. The inclusion criteria used were clinical and no additional investigations were requested before performing the treatment. This approach was chosen because of the lack of clear definitions and consensus about the diagnosis in chronic groin pain. According to a traditional differential diagnosis approach, there are often multiple diagnoses possible and the diagnosis is dependant on the examining specialist (Ekberg *et al.*, 1988). The term adductor-related groin pain was first used by Hölmich (1997), and in his randomised trial (Hölmich *et al.*, 1999) all the 68 patients had characteristic pain in the adductor region, with local tenderness on palpation and pain on resisted adduction testing. Sixty-six percent had radiographic changes and 85% were found to have positive bone scintigraphy for osteitis pubis. This suggests a large degree of overlap between clinical entities. Lovell (1995) examined the different diagnoses present in a case series of 189 patients presenting with chronic groin pain. Adductor lesion, defined as pain along the upper medial thigh with local tenderness at the origin and reproduction of the pain on resisted adduction, was the primary diagnosis in 19 cases. Fourteen patients had osteitis pubis, defined as pubic bone pain and local tenderness with a positive uptake using bone scintigraphy. Fifty-one of the 189 patients had a second diagnosis, and this was an adductor lesion in 21 of the cases showing again that there is often overlap when attempts are made to use a traditional single-diagnosis paradigm. In a recent study using well-defined criteria, 69 of the 207 patients examined had multiple clinical entities (Hölmich, 2007).

Orchard *et al.* (2000) propose, in their extensive review, that a single-diagnosis paradigm is ignorant of the common coexisting pathology. They propose using the term pubalgia when non-pubic causes of groin pain have been excluded. In cases of pubalgia, insertional tendinopathy, bony overload and weakness of the posterior abdominal wall can all be presumed to be present and coexisting. This approach reduces the need for extensive additional investigation before commencing with conservative treatment. The term chronic adductor-related groin pain is used descriptively and makes no attempt to explain the poorly understood underlying pathology.

## Perspectives

There are few good-quality studies that have investigated the treatment of chronic groin pain, and our understanding of the pathogenesis is limited. This study, despite its weaknesses, suggests that the manual therapy technique used may be effective in the treatment of chronic adductor-related groin pain. The treatment is non-invasive, quick and may help athletes to return to sports activities without lengthy rehabilitation programmes that are time consuming and demand a high level of motivation from the athlete to complete.

These results indicate that the manual therapy treatment might be a promising treatment for chronic adductor-related groin pain in athletes. Further investigation of the effectiveness of this treatment in randomised controlled studies is justified.

# Chapter 6:

## Short and mid-term results of a comprehensive treatment programme for long-standing adductor-related groin pain in athletes: A case series

# Chapter 6:
# Short and mid-term results of a comprehensive treatment programme for long-standing adductor-related groin pain in athletes: A case series

Weir A, Jansen J, Van Keulen J, Mens J, Backx F, Stam H.
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**Objective:**
To evaluate short and mid-term results of active physical therapy in athletes with long-standing groin pain.
**Design:**
Case series.
**Setting:**
Primary care physical therapy practice.
**Participants:**
A total of 44 athletes suffering long-standing adductor-related groin pain.
**Intervention:**
A combination of passive (joint mobilisation) and active (exercises) physical therapy **interventions.**
Main outcome measurements:
Return to (the same level of) sports, restriction in sports, and recurrence.
**Results:**
Directly after treatment, return to the same level and type of sport was successful in 38 athletes (86%), and without symptoms in 34 athletes (77%). At 6.5-51 months follow-up, 10/38 (26%) of those that returned to sports had experienced a relapse; 22 (50%) athletes were able to participate in sports without any restrictions at the mid-term follow-up.
**Conclusions:**
For athletes with long-standing groin pain, short-term results of physical therapy seem positive, whereas mid-term results are moderately positive. The risk for recurrence is high.

***Background and purpose***

In football about 5-13% of all injuries per year occur in the groin region (Arnason *et al.*, 2004). In general acute groin injuries have a good prognosis and heal after a period of rest or restricted activity (Arnason *et al.*, 2004). Some acute injuries and in cases with an insidious onset groin injury can often become a long-standing problem. A recent review found only one good quality study published on the treatment of long-standing adductor-related groin pain (LSARGP) in athletes (Jansen *et al.*, 2008B). This study showed that an active physical training programme aiming at stability of the hip and pelvis resulted in a return to sports in 79% of the patients after 18.5 weeks of training (Hölmich *et al.*,1999). Since the publication of this trial several new findings led to the development of a new treatment protocol for LSARGP at the Royal Netherlands Football Association (KNVB).

The programme was based primarily on the active physical training programme shown to be effective by Hölmich *et al.* (1999). In addition to the physical training, specific motor control training for the transversus abdominus (TA) muscle function was given. This was included after reports that TA function is altered in patients with LSARGP (Cowan *et al.*, 2004) and that pelvic instability may play a role in LSARGP (Mens *et al.*, 2006). Recruiting the TA has been shown to improve stiffness of the pelvic ring (Richardson *et al.*, 2002) and improved clinical outcome in women with pelvic girdle pain (Stuge *et a*l., 2004). The programme also included manual therapy for the hip joint and SI-joints. It has long been known that reduced range of motion in the hip is often found in cases of athletic groin pain (Williams, 1978). Recent small prospective studies confirmed that the reduced range of motion preceded the onset of groin injury (Ibrahim *at el.*, 2007; Verrall *et al.*, 2007).

Manual therapy for the SI-joint has been shown to improve the feed forward activation of the TA in cases where its activation is delayed (Marshall and Murphy, 2006). This study reports the effectiveness of the new treatment programme in athletes undergoing treatment at the national treatment centre of the KNVB. The study also examined the number of recurrences as this has not been previously reported and nearly all current published studies on treatment for LSARGP have a short follow-up. The number of treatments needed was also studied.

## Methods

The study was a retrospective case series.

***Subjects***

Athletes with LSARGP were included in the study. LSARGP was diagnosed when there was pain at the proximal insertion of the adductor muscles on the pubic bone on palpation and this pain was felt on resisted adduction testing (Hölmich *et al.*, 2004). The pain was said to be long-standing if it had lasted more than four weeks. Patients with pain felt above the conjoined tendon, hip joint pathology, concurrent lower back pain, urinary tract infections, prostatitis, rheumatic disorders, clinical findings of a nerve entrapment syndrome or prior treatment with an active exercise rehabilitation programme were excluded. The diagnosis was made clinically and additional investigations were only performed if there was suspicion of a different problem. Approval from the local Ethics Committee was acquired and all participants gave informed consent. Due to the retrospective nature of the study no records were kept of patients who were excluded from the treatment programme and so there is no data on excluded cases.

### *Outcome*

For follow-up, athletes were given a structured telephone interview to assess recurrence rate and current sports participation.

### *Treatment programme*

The treatment programme is outlined in Table 6.1.

**Table 6.1:** Treatment programme.

| | |
|---|---|
| Phase 1 | Advice and information<br>Mobilisation for hip, sacroiliac joints and lumbar spine<br>Basic TA recruitment |
| Milestone | Normal physical findings on hip Rom and sacroliliac joint dysfunction (Gillet test)<br>Selective TA recruitment without abdominal bracing |
| Phase 2 | TA recruitment combined with core stability exercises<br>Low load hip adduction exercises |
| Milestone | Normative values for core stability endurance exercises<br>Low load hip adduction exercises without pain |
| Phase 3 | General whole body stabilising exercises<br>Increase in hip adduction strength exercise intensity with decreased number of repititions while experiencing no adduction pain<br>Start running |
| Milestone | No pain during squeeze test and modified Thomas test and bent knee fall out test<br>Running for 15 minutes without pain |
| Phase 4 | Agility drills and sport-specific exercises |
| Milestone | 80% of subjectivley estimated performance capacity |
| Phase 5 | Return to sports |

In the first phase the athletes were informed about the potential mechanisms of the injury, and the treatment programme was outlined. They were instructed to cease competitive sports for a minimum of three weeks. In contrast with Hölmich *et al.* (1999), the programme's criteria to move on to the next phase were not based solely on time but on the achievement of clinical milestones. Mobilisation techniques for the hip were used if there was decreased hip range of motion on the symptomatic side compared with the asymptomatic side. In bilateral cases the hips were mobilised if the range of motion was asymmetric. For the sacroiliac joint and lumbar spine the overtake phenomenon during the Gillet test (Levangie, 1999), and decreased spinal flexion and rotation range of motion during inspection were used to determine the need for manipulations. These were performed at each treatment session until the physical findings were subjectively felt to be normal. Exercises were started with the basic TA motor control exercises (abdominal hollowing) using palpation medial to the anterior superior iliac spine and observation of the abdomen as bio-feedback. Abdominal bracing with Valsalva manoeuvre was not allowed. Progressing to phase two of stabilising exercises was allowed when the athlete was able to selectively contract the TA without bracing and maintaining a normal breathing pattern. In the second phase, TA tension had to be integrated in common core stability exercises like prone bridge, lateral bridge, oblique and straight sit-up exercises. The subject's exercise performance was evaluated using endurance tests described by McGill *et al.* (1999) for the core stability exercises Low load exercises for the adductor muscles using the seated adductor machine and one leg pulley exercise in stance were also performed in phase two. Performance level was considered sufficient to progress to phase three if endurance times of bridging exercises exceed average values plus one standard deviation described by McGill *et al.* (1999) and low load adductor exercises could be executed without pain.

In phase three, stabilising exercises for the whole kinetic chain, using the wobble board or Swiss ball as a support surface were added. Numbers of repetitions and load were modified to the individual's capacity to perform the exercises without pain and started with three sets of 15 repetitions with a decreasing number of repetitions and increasing load over time. Before athletes could progress to the next phase, groin pain had to be absent during the squeeze test, the femur was horizontal or lower during the modified Thomas test (Hölmich *et al.*, 2004), and the Bent Knee Fall Out test (Hogan and Lovell, 2002) had to be normal. The test was considered normal if the knee could fall 50 degrees while the pelvis did not tilt.

Progression to running was allowed in phase three when swimming or biking could be performed without pain or stiffness the next day. The first run lasted five minutes, increasing with one minute per run. If the athlete was able to run for 15 minutes without pain, progression to the next phase was allowed.

In phase four, agility drills and sports-specific exercises were initiated under supervision by the physical therapists. These exercises were started at a low intensity: jumping at

30% of maximal capacity; sprinting, cutting and turning at a subjectively estimated 30% of maximum running speed, kicking a ball at 30% of maximum force. An increase in sports specific exercise intensity was always initiated under supervision of the treating physical therapist using the athletes (lack of) pain and/or fatigue response as a marker to increase intensity by a maximum of 10-20%. If a subjectively estimated 80% of the athlete's maximum capacity was reached without symptoms, the athlete was allowed to return to sports at the own club in phase five. A gradual progression from training to match was stipulated. Furthermore, subjects were encouraged to continue exercises from phases three and four at home.
During phases one till four, athletes attended the physiotherapist once a week and performed exercises twice a week without supervision. Each exercise session lasted about 90 min.

### *Statistical analysis*

Descriptive statistics were used to describe short- and mid-term results. Where data was normally distributed it is presented as a mean with standard deviation. If the data was non-parametric it is presented as a median together with an inter-quartile range. Non-parametric tests (independent t-test and Mann-Whitney U test) were used to compare risk factors in athletes with and without recurrence. SPSS software (SPSS Inc, Chicago, IL version 15.0) was used for analysis. A p-value $<0.05$ (two-sided) was considered significant.

## Results

In total 44 consecutively treated patients were included in the study and all consented to give a telephone interview for the mid-term follow-up assessment. The characteristics are shown in Table 6.2.

**Table 6.2:** Baseline characteristics of the athletes.

| | |
|---|---|
| **Total n=44** | |
| Gender | 37 male; 7 female |
| Age (mean; sd) | 27 (10.8) |
| **Sports** | |
| Soccer | 31 |
| Running | 3 |
| Field hockey | 3 |
| Tennis | 2 |
| Other sports | 5 |
| **Duration of complaints** | |
| >4 to ≤ 10 weeks | 11 |
| >10 to ≤ 26 weeks | 11 |
| >26 to ≤ 52 weeks | 9 |
| >52 weeks | 13 |

### *Short-term follow-up*

In total, 40 athletes returned to their preferred sports directly after treatment. 34 returned to their pre-injury level without any symptoms at the time of return to sports. Four returned to their pre-injury level but still had some mild symptoms. Two athletes had to reduce their level of sporting activities and in four cases persisting groin complaints prevented return to their preferred sports. The 38 athletes who successfully returned to the same level of sports did so in median (IQR) 142 (70-221) days.
The athletes' median (IQR) score for treatment satisfaction was 8 out of 10 (7-9). The athletes underwent a median (IQR) of 21 (13-31) treatments during their rehabilitation.

### *Mid-term follow-up*

Median time to mid-term follow-up was 22 (range 6.5-51) months. After completing the treatment and returning to sports, 33 athletes had continued to perform the home exercises for a median (IQR) period of 9.5 (4.5-23.5) months. Of the 38 athletes who had

returned to the same level of sport at short-term follow-up, 11 experienced a recurrence, preventing them from competing at the desired level, after median (IQR) 8 (3.5-13) months. Six athletes had attended physical therapy for a second time. The median (IQR) recurrent episode of symptoms lasted 2.5 (1-17) months. At mid-term follow-up, 77% (34/44) of athletes still participated in their preferred sport. A total of 23 athletes were active at their previous level of sports; 5 were active at a higher level and 7 at a lower level (but only 3 in this latter group because of persisting groin complaints). Six athletes had switched to another type of sport, but mostly because of personal reasons (e.g. their work, birth of a child). Three ceased sporting activities due to persisting groin complaints. On average sports intensity was 5.25 (range 0-16) h/week.
Age, duration of complaints, duration of treatment period, number of treatment visits, time to follow-up and type of sport were considered as possible risk factors for recurrence (Table 6.3).

**Table 6.3:** Differences between patients that did and did not experience a recurrence.

| | Relapse | n=41 | Mean (sd) | p-value |
|---|---|---|---|---|
| Age (years) | Yes | 10 | 29.9 (13.4) | |
| | No | 31 | 25.0 (9.3) | 0.271 |
| Treatment visits (n) | Yes | 10 | 27.7 (20.2) | |
| | No | 31 | 23.9 (17.5 | 0.571 |
| Duration of treatment (days) | Yes | 10 | 186.7 (159.7) | |
| | No | 31 | 149.7 (96.3) | 0.378 |
| Time to follow-up (months) | Yes | 10 | 20.3 (7.7) | |
| | No | 31 | 23.1 (10.5) | 0.444 |

No significant differences were found (p> 0.27).

## Discussion

After completing the comprehensive treatment programme 34/44 (77%) of the athletes returned to the pre-injury level of sports without symptoms. The athletes who returned to sports activities did so in an average of 20 weeks. At mid-term follow-up 26% (10/38) athletes had experienced a recurrence of their groin pain. At mid-term follow-up 70% of the athletes were still competing in their preferred sports at the original or a higher level than before the injury. The 77% success after the treatment is comparable with the 74% effectiveness reported by Hölmich *et al.* (1999) The median time to return to sports of 20 weeks in this study is also similar to the 18.5 weeks reported by Hölmich *et al.* (1999).

This shows that recovery from long-standing groin pain is a long process and in this study the time to return to sport was not reduced by including the treatments other than active physical therapy. Patients in the current study required approximately 50% more treatment sessions. Although the short-term results are positive in the study by Hölmich *et al.* (1999) and in the present study, Verrall *et al.* (2007) found different results; 63% of their patients returned to sports but only 41% were able to participate at the pre-injury level seven months after start of treatment. The treatment in this programme comprised of rest, swimming, stationary biking, stepping and physiotherapy assisted core stability exercises. A possible explanation for the latter result is that most of their subjects were professional Australian football players, whereas all the subjects in the other two studies were amateur athletes. Professional athletes generally have a higher intensity of sports participation compared with amateur athletes, making their return to the pre-injury level more complex. The differences in the treatment programmes may also account for the differences in outcome.

The addition of specific motor control training for the TA was based on the study of Cowan *et al.* (2004) showing a significant delay of TA recruitment in athletes suffering longstanding groin pain. It may be that the motor control training for the TA has no additional benefit when compared to trunk muscle exercises without specific attention to the TA. This was found to be the case in a recent RCT comparing general exercise with general exercise plus additional TA exercises in subjects with recurrent low back pain in which both programs were equally effective (Koumantakis *et al.*, 2005). It would be interesting to measure if the TA function improved after treatment for LSARGP and if this improvement would be associated with recovery.

The use of manipulations and mobilisations for the hip was due to the fact that decreased hip range of motion may be a relevant factor in groin injury (Williams,1978), which was later confirmed in small prospective studies (Ibrahim *et al.*, 2007; Verrall *et al.*, 2007). Mobilising techniques for the SI-joint and lumbar spine were used because of its relation with TA function (Gill *et al.*, 2007; Marshall and Murphy, 2006) and hip range of motion (Cibulka *et al.*, 1998). It was hoped that the treatment of the hip, SI joint and lumbar spine alongside the specific TA training would improve outcome and decrease the risk of recurrence. One of the problems associated with the clinical milestones approach chosen in this treatment programme is the lack of a reliable test to assess the SI joint mobility and the subjective character of a number of the milestones. If new tests become known in the future it is suggested that these be used instead of the current tests.

The cause of the restricted hip joint range of motion in adductor-related groin pain is not clear. It has recently been noted that hip impingement is commonly found in these cases (Weir *et al.*, 2010). Hölmich *et al.* (1999) reported that the hip joint range of motion did improve significantly in both treatment groups in the randomised trial

performed. The reasons for these improvements were not mentioned.
In the present study, the risk for developing a recurrence of the groin injury within the period of 6.5-51 months was 26%. It would thus seem that the treatment was not highly effective at preventing re-injury. Previous groin injury is known to be a risk factor for developing groin injury. Arnason *et al.* (2004) reported that the risk for developing groin injury after previous groin injury was 9% (10/109) compared with a risk of only 2% (7/414) in subjects without previous groin injury. In the other studies, the reported risk for recurrent injury ranged from 31 to 50% (Hagglund *et al.*, 1999). It may well be that there are other factors that are important in the development of groin injuries that were not addressed during the treatment and a recent review noted the lack of good prospective studies on this subject (Maffey and Emery, 2007).
The mid-term results reported in present study are fairly positive and despite the high recurrence rate 79% of the athletes still participated in their pre-injury sport. Only three who were still active had been forced to a lower level of competition by their groin injuries. It should be noted that the duration of the preventative exercises was not standardised.
Age has been suggested to be an independent predictor of injury in general (Arnason *et al.*, 2004). In the present study, although athletes that suffered a recurrence were slightly older, age was not a significant risk factor for recurrent groin injury. A similar lack of association between age and groin injury has been reported by others (Hölmich *et al.*, 2009).

### *Study limitations*

Firstly, data was collected retrospectively and using a phone interview whereby accuracy of the information tends to be decreased compared with data collected prospectively (Hallquist and Jansson, 2005). This means that, for some subjects, recall bias is a significant factor that might have influenced the results by underestimating or overestimating some of the parameters. Secondly, because there was no control group, no definite conclusions can be drawn as to whether our results are solely related to the intervention described. Thirdly, because only subjective data was collected and no physical function tests were performed, no objective data on physical functioning in sports are available.

## Conclusion

The present study shows that the short-term results of a comprehensive physical therapy intervention for long-standing adductor-related groin pain are positive. The mid-term results are fairly positive but there was a 26% chance of recurrence. The treatment programme warrants further study in a prospective trial with a control group.

***Acknowledgements***

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# Chapter 7:

## Manual or exercise therapy for long-standing adductor-related groin pain: A randomised controlled clinical trial

## Chapter 7:
## Manual or exercise therapy for long-standing adductor-related groin pain: A randomised controlled clinical trial

Weir A, Jansen JACG, van de Port IGL, Van de Sande HBA, Tol JL, Backx FJG.
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**Hypothesis:**
A multi-modal treatment programme (MMT) is more effective than exercise therapy (ET) for the treatment of long-standing adductor-related groin pain.
**Study design:**
Single blinded, prospective, randomised controlled trial.
**Patients:**
Athletes with pain at the proximal insertion of the adductor muscles on palpation and resisted adduction for at least two months.
**Interventions:**
**ET:** a home based ET and a structured return to running programme with instruction on three occasions from a sports physical therapist. MMT: Heat, Van den Akker manual therapy followed by stretching and a return to running programme
**Primary outcome:**
Time to return to full sports participation.
**Secondary outcome measures:**
Objective outcome score and the visual analogue pain score (VAS) during sports activities.
Outcome was assessed at 0, 6, 16 and 24 weeks.
**Results:**
Athletes who received MMT returned to sports quicker (12.8 weeks,SD 6.0) than athletes in the ET group (17.3 weeks, SD 4.4. p=0.043). Only 50-55% of athletes in both groups made a full return to sports. There was no difference between the groups in objective outcome (p=0.72) or VAS during sports (p=0.12).
**Conclusions:**
The MMT programme resulted in a significantly quicker return to sports than ET plus return to running but neither treatment was very effective.

## Introduction

Groin pain is a frequent complaint in athletes. It occurs commonly in sports involving repeated sprinting, twisting, kicking and cutting such as football, rugby, Australian rules football and (ice-) hockey (Bradshaw and McCrory, 1997; Jansen *et al.*, 2008a). In football groin injuries have been reported to account for about 10% of all injuries (Hawkins *et al.*, 2001). Most of these injuries will recover quickly and in one study only three of 22 groin injured athletes still had complaints after three weeks (Arnason *et al.*, 2004).
When groin pain does go on to be long-standing it can be hard to treat, with a relatively long period for return to full sports activity (Hölmich *et al.*, 1999). Adductor-related groin pain has been reported to account for 58% of groin injuries in all sports and 69% of groin injuries in footballers (Hölmich, 2007).
Exercise therapy (ET) is recommended as the first line of treatment after a period of rest or restricted activity (Jansen *et al.*, 2008b). In a recent systematic review (Machotka *et al.*, 2009) on the effect of exercise therapy only one randomised controlled trial (Hölmich *et al.*, 1999) was identified. Both reviews noted the lack of randomised controlled studies on the treatment of athletic groin injuries and recommended that more trials be performed in this area. The study of Hölmich *et al.* showed the value of ET (level 1 evidence) for athletes with long-standing adductor-related groin pain was shown. Seventy nine percent of athletes who underwent ET were able to resume sports at their pre-injury level. The median time to return to sport was 18.5 weeks (range 13-26). At present ET can be considered the therapy with the highest level of evidence (usual care) for the treatment of adductor-related groin pain.
The results of a multi-modal treatment programme (MMT) using heat, Van Den Akker manual therapy method, stretching and a return to running programme have been studied previously retrospectively (Weir *et al.*, 2008). The study reported promising results with 27 of the 30 athletes (90%) being able to return to sporting activities after treatment. A weakness of the study was the retrospective design and the lack of a control group. The aim of the study was to compare the new therapy (MMT programme) to the current therapy with the highest level of evidence (ET (usual care)), for the treatment of long-standing adductor-related groin pain, in a single blinded prospective randomised clinical trial.

## Methods

### *Subjects*

Athletes were referred to the sports medicine department of a large district hospital by local physiotherapists, general practitioners and sports medicine physicians. All athletes were assessed for suitability to participate by a single sports physician, experienced in the field of athletic groin injuries, who used a structured examination protocol. The inclusion and exclusion criteria are shown in Table 7.1. Physical examination was used to assess for the presence of adductor pain, and has been shown to be reliable (Hölmich *et al.*, 2004). All athletes who attended the department were included if they met all the inclusion criteria and consented to participate.

**Table 7.1:** Inclusion and exclusion criteria.

| Inclusion criteria | Exclusion criteria |
|---|---|
| Age 18-50 years | Palpable inguinal or femoral hernia or pain felt above the conjoint tendon |
| Groin pain for at least two months | Clinical signs or symptoms of prostatitis or urinary tract infection |
| Groin pain during or after sporting activities | Back pain felt from T10 to L5 |
| Desire to return to active sports participation at pre-injury level | Osteoarthritis of the hip |
| Pain located at the proximal insertion of the adductor muscles on the pubic bone | Clinical suspicion of a nerve entrapment syndrome |
| Pain felt at the proximal insertion of the adductor muscles on the pubic bone when performing resisted adduction | Inability to perform the active physical training programme<br><br>Use of anti-coagulant medication<br><br>Instability of the medial collateral ligament of the ipsilateral knee |

Abbreviations: T = thoracic; L = lumbar

### *Design*

The study was a single blinded randomised controlled clinical trial. The local medical ethics committee gave permission for the study (METC-Zuid West Holland 05-109). After informed consent and inclusion the athletes were randomized using sealed envelopes. The athlete chose one of 100 opaque envelopes in the presence of the department's secretary. Appointments for starting the allocated treatment were arranged and treatment was started within one week of randomisation. The examining physician was not involved in the randomisation process and remained unaware of the treatment allocation. Athletes were instructed not to reveal their treatment allocation to the physician at follow-up appointments.

***Treatment***

***Exercise therapy***

Athletes were seen by one of two sports physical therapists in the hospital. The physical therapists both received training to ensure a standardised treatment. No treatment other than the ET was given. The athletes were instructed to perform the ET three times a week at home. The ET is described in detail in Table 7.2 and the exercises are the same as in the study of Hölmich *et al.* (1999).

**Table 7.2:** Exercise therapy.

| Module 1 – 1st two weeks | | Module 2 – from 3rd week | |
|---|---|---|---|
| Exercise | Amount | Exercise | Amount (all performed twice) |
| Static adduction against soccer ball placed between feet lying supine. | 10 repetitions of 30 sec | Leg abduction and adduction exercises performed in side lying | 5 series of 10 repetitions of each exercise |
| Static adduction against soccer ball placed between knees when lying supine | 10 repetitions of 30 sec | Low-back extension exercises prone over end of couch | 5 series of 10 repetitions |
| Abdominal sit-ups both in straightforward direction and in oblique direction. | 5 series of 10 repetitions | One-leg weight pulling abduction/adduction standing | 5 series of 10 repetitions for each leg |
| Combined abdominal sit-ups and hip flexion, starting from supine position and with soccer ball between knees(folding knife exercise) | 5 series of 10 repetitions | Abdominal sit-ups both in straightforward direction and in oblique direction | 5 series of 10 repetitions |
| Balance training on wobble board | 5 minutes | One-leg coordination exercise with flexing and extending knee and swinging arms in same rhythm ( cross country skiing on one leg ) | 5 series of 10 repetitions for each leg |
| One-foot exercises on sliding board, with parallel feet as well as with 90 degree angle between feet | 5 sets of 1 min continuous work with each leg and in both positions | Training in sideways motion on a mini-skateboard | 5 min |
| | | Balance training on wobble board | 5 min |
| | | Skating movements on sliding board | 5 sets of 1 min continuous work |

Athletes received instructions from the physical therapists on performing the first module on their first visit. After two weeks they attended again and received instructions from the physical therapist on the second home-based module. At six weeks they were seen again and received instructions on the return to running programme. During the first six weeks only cycling was allowed. At six weeks the return to running programme was started. The return to running programme is outlined in Table 7.3.

**Table 7.3:** Return to running programme (Hogan, 2006).

| Return to running programme | | |
|---|---|---|
| Phase 1<br><br>Slow jogging | Phase 2<br><br>Straight sprints | Phase 3<br><br>Cutting |
| Alternate day jogging beginning with 5 minutes and increasing with 5 minutes per run to a total time of 30 minutes. | 100m sprints. 1st 10m for acceleration and last 10m for deceleration.<br><br>First 6-8 repetitions at 60% of maximum speed. | Sport specific sprints involving changing directions. Beginning with 6-8 repetitions at 60% of maximum speed. |
| Slow running at easy pace. | First increase speed and later repetitions. Build up to 15-20 repetitions. | First increase speed and later repetitions up to 15 repetitions. |
| Can progress to phase 2 when 30 minutes of jogging provokes no pain. | Can progress to phase 3 when 15 straight sprints provoke no pain. | Can progress to sports when 15 cutting sprints can be performed without provoking pain. |

At all times athletes were instructed to stop exercising if they experienced groin pain. The exercises were continued for a minimum of eight weeks. They could be stopped when there was no pain felt during or after performing the exercises or running. Compliance was measured using a self completed training diary which was filled in after each exercise session.

***Multi-modal treatment programme***

The MMT programme comprised heat followed by manual therapy after which stretches were performed and then the return to running programme. The manual therapy treatment was performed by one of three sports medicine physicians. Before the manual therapy the adductor muscle group is warmed using paraffin packs for 10 minutes. The paraffin is heated to 60 °C. This is then wrapped in a towel and placed on the proximal insertion of the adductor muscle while the athlete lies semi-prone. The contra lateral hand is then used to control the tension in the adductor muscles while the ipsilateral hand is used to move the hip from a neutral position into flexion, external rotation and abduction while keeping the knee in extension. (See Figures 7.1 and 7.2)

*Figure 7.1: The contralateral hand holds the adductor muscles to control the tension.*

*Figure 7.2: The ipsilateral hand moves the hip into external rotation and abduction to stretch the adductor muscles.*

The treating physician controls the tension subjectively and applies the maximum tolerable stretch to the adductor muscles. After the movement has been performed the adductor muscle group is compressed with one hand while the other hand moves the hip into adduction and slight flexion. This circular motion followed by compressions

lasts about 25 seconds and is repeated three times in one treatment session.
After the treatment the athletes are instructed to perform a five minute warming-up each day using slow jogging or cycling. After warming-up the athlete performs stretches of the adductors of both legs. A standing and sitting adductor stretch is performed and each stretch is performed statically three times for duration of 30 seconds. After the stretches the athlete lies in a warm bath for ten minutes. After 14 days of stretching if no pain or discomfort was felt the athlete began using the same return to running programme as in ET group (See Table 7.3). If athletes did not improve after one treatment with MMT then the treatment was repeated once more. If after a second treatment there was no improvement the treatment was not repeated again.

***Outcome and follow-up***

The athletes were assessed by a single experienced blinded physician at baseline, 6 and 16 weeks after the start of treatment. If the athlete was not fully recovered at 16 weeks but still felt improvement a further assessment at 24 weeks was done. If athletes were recovered at 16 weeks they did not attend follow-up after this. At these times the standardised history and physical examination was repeated (Hölmich *et al.*, 2004). The Tegner activity score pre-injury was recorded (Tegner and Lysholm, 1985). The range of motion of the hip joint was measured using a goniometer with the patient lying and the hip and knee flexed to 90 degrees. This method has been shown to be reliable (Boone *et al.*, 1978; Bovens *et al.*, 1990).
In cases where athletes fully resumed their sporting activities in the same sport and at the previous level then the time to return to sports in weeks from commencement of the treatment was recorded. The objective outcome measures for successful treatment were: no pain on palpation of the adductor tendons at the pubic bone insertion, and no pain during resisted adduction; no groin pain during or after sporting activities performed at the same level as prior to the injury; return to the same sport at the same level without groin pain. If all three measures were achieved the objective outcome was considered excellent, if two measures were achieved the outcome was good, if one measure was achieved then outcome was fair and if none were achieved the outcome was poor (Hölmich *et al.*, 1999). Visual analogue scores (VAS) for maximum pain during sports were recorded on a scale from 0-100.

***Statistical analysis***

A double data entry process was used. The statistician was blinded to the treatment outcome until the analysis was performed. All data analysis was performed using SPSS 15.0 (SPSS inc, Chicago, USA). The demographic data is presented with their means and standard deviations (SD). In cases of skewed distribution the median and inter-quartile range (IQR) are presented. The baseline characteristics, VAS for pain and time to return to sports were compared between groups using the independent T-test or the non-parametric Mann-Whitney U test if the data was not normally distributed. The objective outcome score was dichotomised with excellent and good being considered a success and fair or poor being a failure. The difference between the groups was examined with the Fisher's test. The sample size was calculated using an alpha level of 0.05 and a power of 0.8. The previous published results of Hölmich *et al.* (1999) showed a mean time to return to sport of 18.5 weeks (SD7). Clinical experience with the MMT estimated the time to return to sports at 12 weeks. A dropout rate of 10% was assumed. Based on these calculations then a least 21 athletes had to be included in both groups to be adequately powered to detect a difference in the time to return to sporting activities. Outcome was assessed using a per-protocol analysis.

## Results

One hundred athletes were referred for inclusion. Forty six athletes were not suitable for inclusion (hip joint problem 12, primary iliopsoas pain 10, pain above the conjoined tendon 10, current lower back pain 8, unwilling to participate 6). There were 53 males and one female included in the study. Figure 7.3 shows the allocation of the athletes in the study.

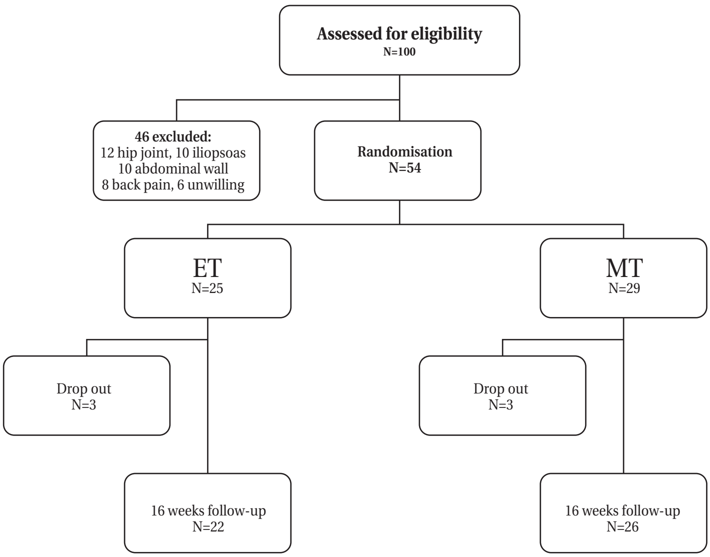


*Figure 7.3 Allocation of the athletes in the study.*

Thirty seven (69%) played football, three (6%) played rugby, three (6%) did distance running, three (6%) played field hockey, two (4%) were speed skaters, two (4%) played squash and there were four athletes who played other sports (tennis, basketball, track-and-field and handball).

The athletes had received many different treatments prior to their inclusion in the study. Only 7 athletes (13%) had undergone no previous treatment. Fifteen had had one treatment (5 physical therapy with massage and stretches, 5 physical therapy with exercise therapy, 3 manipulative therapy for back and pelvis, 2 anti-inflammatory medication). Twenty-five had had two prior treatment modalities (physical therapy with massages or exercises (20), manual therapy with manipulations (15), anti-inflammatory medication (13), injections (2)). Seven athletes had undergone three or more previous treatments prior to inclusion. None of the athletes who had undergone previous exercise therapy had performed more than 10 sessions prior to the inclusion.

Six (11%) athletes dropped out during the study (three in each group). The baseline data of these six did not differ significantly from the athletes who completed the study. Three athletes dropped out before starting with treatment as they did not want to receive the allocated treatment, one athlete injured his ankle, one athlete developed lower back pain and decided to change sport and one athlete was lost to follow-up. Six athletes in both groups had returned to sports at the 16 weeks follow-up appointment. These athletes did not attend follow-up at 24 weeks.

The baseline characteristics of the athletes in both groups are shown in the Table 7.4 below. There were no significant differences between the two groups at baseline ($p > 0.16$).

**Table 7.4:** Baseline characteristics of the two groups at baseline.

| | Exercise therapy n=25 | Multi-modal n=29 |
|---|---|---|
| Age (years) | 27.4 (7.3) | 28.7 (8.2) |
| Weight (kilograms) | 80.8 (9.7) | 82.3 (10.6) |
| Height (cm) | 182 (7) | 185 (8) |
| BMI (kg/m$^2$) | 24.4 (2.5) | 24.1 (2.6) |
| Duration of symptoms (weeks) | 32 (IQR 17.5-81.0) | 32 (IQR 16.0-72.0) |
| Absence from sport (weeks) | 8 (IQR 4.0-19.0) | 14 (IQR 8.0-17.5) |
| Onset of injury | | |
| Acute | 5 | 9 |
| Gradual | 20 | 20 |
| Location of injury | | |
| Left | 7 | 11 |
| Right | 11 | 12 |
| Bilateral | 7 | 6 |
| VAS pain (0= no pain, 100 maximum pain) during sports | 58.5 (26.2) | 58.9 (21.3) |
| Level of athletic activity prior to injury. | | |
| Elite (>5 times per week.) | 6 | 9 |
| Competitive (3 or 4 times a week) | 16 | 18 |
| Recreational (1 or 2 times a week) | 3 | 2 |
| Sports activities at baseline | | |
| Ceased | 18 | 18 |
| Reduced | 7 | 11 |
| Unchanged | 0 | 0 |
| Tegner activity score pre-injury | 8.7 (0.5) | 8.7 (0.6) |

(No significant differences p>0.16)

### *Time to return to sports*

Fifty percent (13/26) of athletes treated with the MMT programme who returned to full sports participation did so in an average of 12.8 weeks (SD 6.0). In the ET group 55% (12/22) returned to full sports participation in 17.3 weeks (SD 4.4). This difference in time to return to sport was statistically significant (p=0.043). The difference in percentage of athletes making a full return to sport was not significant (p=0.78)

***Objective treatment outcome***

The objective treatment outcome in the two groups is shown in Table 7.5. There was no significant difference in objective outcome between the two groups. (p=0.72)

**Table 7.5:** Distribution of objective treatment outcome in the two groups.

| | | Treatment | |
|---|---|---|---|
| | | ET | MMT |
| Objective outcome | Poor | 6 | 11 |
| | Fair | 4 | 1 |
| | Good | 7 | 7 |
| | Excellent | 5 | 7 |
| Total | | 22 | 26 |

Of the athletes treated with MMT 11 received one treatment and 15 received two treatments. There was no correlation between the number of treatments and the outcome. (p=0.40). In the ET group the mean number of sessions performed was 75% (IQR 60% – 90%). There was no correlation between the compliance and the outcome (p=0.32).

***VAS pain score during sports***

The VAS pain scores at 0 and 16 weeks during sports improved significantly in both groups. In the MMT group the VAS score during sport improved from 58.9 (SD 21.3) before treatment to 36.1 (SD 30.1) after treatment (p=0.01). In the ET group the VAS during sports improved from 58.5 (SD26.2) before treatment to 21.0 (SD 27.0) after treatment (p=0.000). The difference in VAS during sport between the two groups was not significant (p=0.12).
The mean hip rotation at baseline was: internal 25° (SD11), external rotation 39° (SD12) and total 64° (SD 17). The range of motion of the hip joint did not alter significantly after treatment in both groups or between the two groups (p=0.45, p=0,65).

***Complications***

No complications or side effects of the treatments were reported during the study.

## Discussion

In this study the athletes (50%) who were successfully treated with the MMT programme were able to return to sporting activities more quickly (12.8 weeks) when compared to those treated with the ET (55%) programme (17.3 weeks). There was no significant difference in the number of athletes able to return to sporting activities between the two treatment groups. The objective treatment outcome and pain scores during sporting activities did not differ between the two treatment groups.

The results of the MMT in this study are worse than those published in a previous retrospective case series examining the effectiveness of this treatment (Weir *et al.*, 2008). This difference may well to be due to the differences in study design (prospective randomised controlled vs. case series) as the treating physicians and the work setting are the same in both studies. The athletes in this study were also involved in sporting activities at a higher level (Tegner score 8.7 (SD 0.5) vs. 7.3 (SD 1.97)) before injury and were older (28.7 vs. 20.5 years) than those in the case series, which may have affected outcome. The outcome results in the ET group are less positive than those previously published by Hölmich *et al.* (1999) in a randomised controlled trial. In the study of Hölmich *et al.* (1999) which used the same objective outcome measures, 79% of the athletes who completed the ET returned to full sporting activities without groin pain. In this study only 55% (12/22) of the athletes treated with ET had a good or excellent outcome and a full return to the pre-injury activity level. This difference may be due to the effect of supervision. In the study by Hölmich *et al.* (1999) the ET was performed under supervision of a physical therapist although compliance was not reported. In this study the athletes were instructed on how to perform the ET by a physical therapist on three separate occasions and the technique on performing the exercises was checked at these appointments. The athletes were however not supervised while performing the ET. In a recent randomised trial on the effects of an exercise programme for lateral elbow tendinopathy the group with supervision had significantly larger improvements than the group performing the same exercises without supervision (Stasinopoulos *et al.*, 2009). The athletes in this study who had successful outcomes had a comparable time to return to sporting activities as those published by Hölmich *et al.* (1999) (17.3 vs. 18.5 weeks). These times are longer than times published in some case series although these times (4 (Rodriguez *et al.*, 2001) -10 weeks (Wollin and Lovell, 2006)) should be interpreted with caution due to the methodological considerations of the study designs.

The exact working mechanism of the MMT is unknown. The programme comprises different modalities and it is impossible to ascertain which components contribute to the treatment effect. The addition of a third study group in the trial comprising only certain components would have enabled more detailed analysis of the contributions of the component parts of the MMT. A lack of this control group is a weakness of this trial and is suggested as a topic for future investigation.

It has been suggested that the MMT may work by reducing the viscoelastic muscle stiffness in the adductor muscles and thus reduce loading of the insertion and the pubic bone (Weir *et al.*, 2008). Most athletes report a subjective feeling of reduced muscle tension directly after the Van den Akker manual therapy treatment. At present there is no generally accepted simple and reliable method to measure muscle stiffness and as such it was not measured during this study. It was also hypothesized that the MMT treatment may have affected the hip joint range of motion. The range of motion in this study (internal rotation 25°, external rotation 39° is comparable to the range found in the recent study of Manning and Hudson (2009) who found 25° of internal rotation and 44° degrees of external rotation in asymptomatic football players of a similar age. The 25° of internal rotation found in this study is greater than the 15.5° observed in a previous study of athletes who went on to develop chronic groin injury (Verrall *et al.*, 2007). In this study the hip joint range of motion did not alter after treatment in the MMT group and it would seem that this is not the mechanism through which the MMT may work.

It may also be that the MMT influences core stability. Core stability is often considered to play a role in athletic groin injuries. The transversus abdominus (TA) muscle has been shown to have a later onset of action in athletes with long-standing groin pain (Cowan *et al.*, 2004). A recent structured critical review on groin pain in athletes suggested that exercises aimed at stabilising the pelvis are important and that the TA may need some specific attention (Jansen *et al.*, 2008b). It has been shown that a manipulation of the sacro-iliac joint can improve the feed forward action of the TA (Marshall and Murphy, 2006). A possible hypothesis of the action of the MMT is that it may affect the sacro-iliac joint and thus influence TA function. The TA function was not measured in this study as the technique requires complicated equipment and specialised training. At current there are also no other reliable simple clinical tests for core stability and thus this was not measured.

There are a number of weaknesses of this study that should be taken into account. As the treatments were physically different it was impossible to blind athletes to the treatment, which may have affected outcome. The two treatment protocols are profoundly different with the MMT requiring less time and effort from the athlete than the ET. The return to running programme was started four weeks earlier in the MMT group, which is a structural difference that may well explain the difference in time to return to sports. As mentioned above the lack of a control group examining different components of the MMT makes it impossible to ascertain which part of the programme may help in the treatment and is a weakness. Another weakness is that in this study both of the treatments were given in isolation while in clinical practice often many treatments are combined. These weaknesses should be taken into account when interpreting the study results. The study has a relatively short follow-up period of 16 weeks. This makes it difficult to assess whether or not there were recurrences of the adductor pain after completion of the treatment. The addition of an extra follow-up at 24 weeks was used in cases where patients were not recovered at 16 weeks. The fact that not all patients were followed up at 24 weeks is a weakness. A longer standardised follow-up period would have been preferable and allowed for an assessment of recurrence rate. In future studies longer follow-up periods should be used to assess for longer term results and recurrence rates.

## Conclusion

This single blinded randomised controlled clinical trial showed that the MMT programme was safe and equally effective treatment for athletes with long-standing adductor-related groin pain as an ET programme. After four months both groups showed significant decrease of VAS pain scores during sport. The athletes in the MMT group who made a full return to sports did so significantly quicker than those who performed ET. Further studies should evaluate if a combination of all treatments would improve effectiveness and reduce the time to return to sporting activities and should include a control group.

***Acknowledgements***

Many thanks to Aad Scheffer for making the balance boards for the ET group. Many thanks to Ton Kraan and Marcel Thomas for instructing the athletes in the ET group. Many thanks to Cora Van der Heijden, Ank de Vries and Pauline Verschoor for coordinating athletes through the study.

# Chapter 8:

## Manual or exercise therapy for long-standing adductor-related groin pain: Mid-term follow-up of a randomised controlled clinical trial

# Chapter 8:
# Manual or exercise therapy for long-standing adductor-related groin pain: Mid-term follow-up of a randomised controlled clinical trial

Weir A, Jansen N, Dijkstra SD, Backx F, Tol JL.
Submitted

**Background:**
The effect of exercise therapy (ET) versus multi-modal treatment programme (MMT) for adductor-related groin pain was previously compared in a single blind prospective randomised controlled trial.
**Methods:**
**Patients:**
48 athletes with adductor-related groin pain.
**Interventions:**
**ET:** A home based ET and a structured return to running programme
**MMT:** Heat, Van den Akker manual therapy followed by stretching and a return to running programme.
**Primary outcome:**
Objective treatment success.
**Secondary outcome:**
Recurrence.
**Results:**
39 /48 athletes (81%; 22 MMT, 17 ET) were followed up (29 months). 23/39 (59%) were able to do their sport symptom free (MMT 68%, ET 47%, p 0.184). Six (30%) of 20 athletes who were symptom free at short-term follow-up had a recurrence (2 MMT 22%; 4 ET 36%, p 0.47)
**Conclusion:**
Neither treatment had a better outcome and there was no significant difference in recurrence rate at mid-term follow-up.

## Introduction

Adductor-related groin pain is common in athletes. It occurs in sports involving repeated sprinting, twisting, kicking and cutting such as football, rugby, Australian rules football and (ice-) hockey (Jansen *et al.*, 2008 B). In football, groin injuries have been reported to account for about 10% of all injuries (Hawkins *at al.*, 2001). Adductor-related groin pain has been reported to account for 58% of groin injuries in all sports and 69% of groin injuries in footballers (Hölmich, 2007). Most of these injuries will recover quickly and in one study only three of 22 groin injured athletes still had complaints after three weeks (Arnason *et al.*, 2004). When groin pain does go on to be long-standing, it can be hard to treat, with a relatively long period for return to full sports activity (Holmich *et al.*, 1999). In the current literature there are no randomised studies examining long-term effectiveness after treatment for adductor-related groin pain in athletes. A recent systematic review (Jansen *et al.*, 2008 B) found only one prospective study that had recorded recurrence frequency up to two years after treatment (Verrall *et al.*, 2007). In this study of athletes with pubic bone stress injury 100% of the athletes had returned to play after two years. After the first year 41% were symtpom free and 67% after two years. In a recent randomised controlled trial the effect of exercise therapy (ET) versus multimodal treatment programme (MMT) for adductor-related groin pain in athletes was compared in a single blind prospective study (Weir *et al.*, 2010). The follow-up of that trial was four months and showed that the MMT group had a quicker return to sports. In this study the group of athletes that had participated in the short-term follow-up were re-evaluated. The aims were to measure effectiveness of treatment and the recurrence frequency at mid-term follow-up. The third aim was to examine the data looking for prognostic factors.

## Methods

### *Design*

The study was a single blinded randomised controlled clinical trial. The local medical ethics committee gave permission for the study (METC-Zuid West Holland 05-109). After informed consent and inclusion the athletes were randomised using sealed envelopes.

### *Participants*

Forty eight athletes who had previously completed a randomised controlled trial for adductor-related groin pain, were sent a structured questionnaire in which they were asked about the course of their adductor injury and invited for an appointment to perform physical examination. They were asked to return the completed questionnaire.

Long-standing adductor-related groin pain was diagnosed when there was pain at the proximal insertion of the adductor muscles on the pubic bone on palpation and this pain was felt on resisted adduction testing (Hölmich *et al.*, 2004). The pain was said to be long-standing if it had lasted more than eight weeks.

***Interventions***

***Exercise therapy***

Athletes were seen on three occasions by sports physical therapists in the hospital. No treatment other than the ET was given. The athletes were instructed to perform the ET three times a week at home. The ET is described in detail in the origional study (Weir *et al.*, 2010) and the exercises are the same as in the study of Hölmich *et al.* (1999). During the first six weeks only cycling was allowed. At six weeks the return to running programme was started (Hogan, 2006). At all times athletes were instructed to stop exercising if they experienced groin pain. The exercises were continued for a minimum of eight weeks. They could be stopped when there was no pain felt during or after performing the exercises or running.

***Multi –modal treatment programme***

The MMT programme comprised heat, followed by Van den Akker manual therapy after which stretches were performed and then the return to running programme. It has been described in detail elsewhere (Weir *et al.*, 2008; 2010). The manual therapy treatment was performed by one of three sports medicine physicians. Before the manual therapy the adductor muscle group is warmed while the athlete lies semi-prone. The contra lateral hand is then used to control the tension in the adductor muscles while the ipsilateral hand is used to move the hip from a neutral position into flexion, external rotation and abduction while keeping the knee in extension.

The treating physician applies the maximum tolerable stretch to the adductor muscles. After the movement has been performed the adductor muscle group is compressed with one hand while the other hand moves the hip into adduction and slight flexion. This circular motion followed by compressions is repeated three times in one treatment session.

After the treatment the athletes are instructed to perform a five minute warming-up each day using slow jogging or cycling. After warming-up the athlete performs stretches of the adductors of both legs. After the stretches the athlete lies in a warm bath for ten minutes. After 14 days of stretching if no pain or discomfort was felt the athlete began using the same return to running programme as in ET group. If athletes did not improve after one treatment with MMT then the treatment was repeated once more. If after a second treatment there was no improvement the treatment was not repeated again.

***Questionnaire and appointment.***

After returning the structured questionnaire, the athletes were contacted by phone to make an appointment at the hospital. Athletes who consented attended for a follow-up physical examination. The current intensity of sports participation, current adductor-related complaints during or after sport, recurrence of origional groin injury, duration of recurrence, new groin injury, location, new treatment after completion of study, presence of pain on resisted adduction testing and subjective athlete satisfaction were recorded by an independent examiner.

***Outcome measures.***

The primary outcome measure was the objective treatment success. This measure was also used in the original study and that of Hölmich *et al.* (1999) and examines three measures: no pain during resisted adduction; no groin pain during or after sporting activities performed at the same level as prior to the injury; return to the same sport at the same level without groin pain. If all three measures were achieved the objective outcome was considered excellent, if two measures were achieved the outcome was good, if one measure was achieved the outcome was fair and if none were achieved the outcome was poor. The physical examination that was used to assess for the presence of adductor pain has been shown to be reliable (Hölmich *et al.*, 2004). The examination was the same as that done in the original randomised trial. (Weir *et al.*, 2010).

The secondary outcome measures were the visual analogue pain scores (VAS) for maximum pain during sports were recorded on a scale from 0-100, the Tegner activity score and recurrence of groin injury.

***Statistic analysis.***

All data analysis was performed using SPSS 17.0 (SPSS inc, Chicago, USA). The chi-squared test was used to detect a difference in outcome between the MMT and ET group for categorical data. The Fisher's exact test was used to analyse data concerning recurrence of injury, because of the small group. For numeric data the independent t-test was used. The local medical ethics committee gave permission for the study (METC-Zuid West Holland 05-109).

## Results

***Flow of athletes in the study***

The 48 athletes who completed the RCT were sent a letter and questionnaire for the mid-term follow-up study. Thirty-nine athletes returned a completed questionnaire. After two weeks all athletes, including the ones who had not responded, were contacted by phone for an appointment. Nine athletes could not be tracked down for follow-up, despite repeated attempts and contacting their general practitioners for new address information. Seven athletes did not consent to a mid-term follow-up physical examination. In total there were 39 completed questionnaires and 32 data sets for questionnaires plus physical examination for the analysis. Of the total group of 39 athletes, 22 had received MMT and 17 had received exercise ET. Of the 32 athletes who had a physical examination, 19 had received MMT and 13 had received ET. The flow of athletes in the study is shown in Figure 8.1.

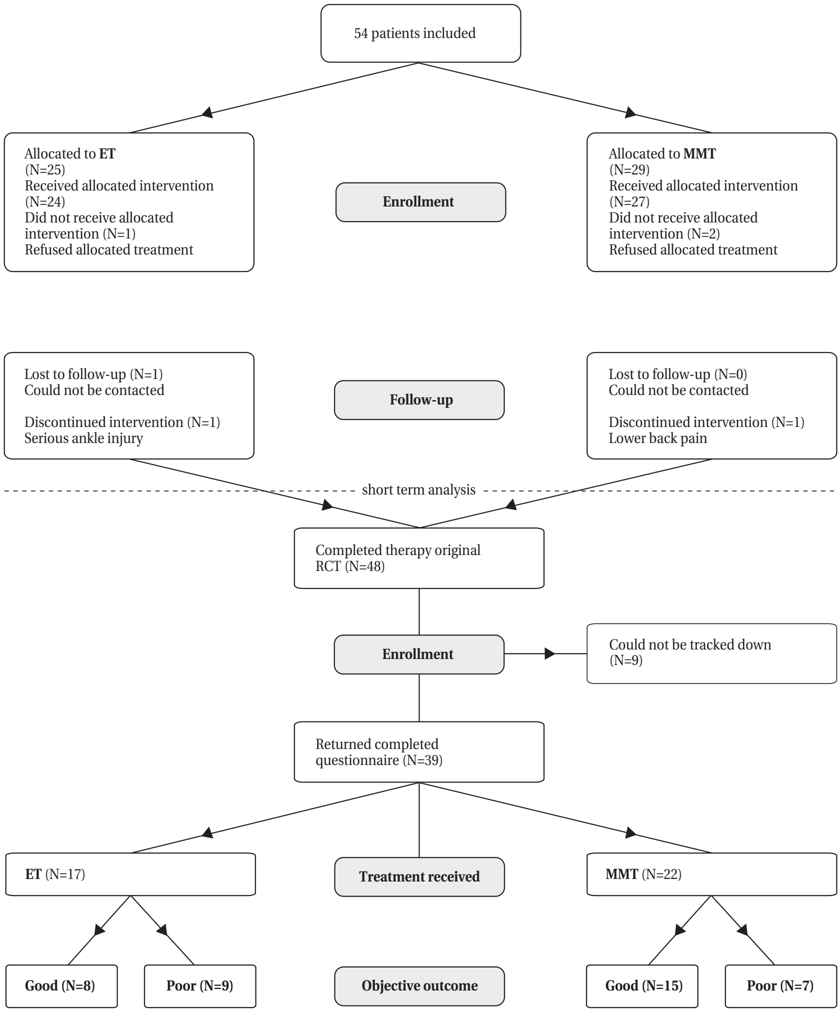


*Figure 8.1: The flow of athletes in the study.*

### *Athlete characteristics*

The average age of the 39 athletes was 27.5 (SD 7.6). The group was composed of 38 men and 1 woman. Their sports were 24 football, 3 cyclists, 2 tennis, 2 long distance running, 2 squash, 1 hockey, 1 basketball and 1 handball. Three athletes had ceased all sporting activities. The mean Tegner score at mid-term follow-up was 7.0 (SD 2.0). Six athletes performed sports five or more times weekly, 19 athletes three to four times weekly and

11 athletes one to two times a week. There were no significant differences between the two groups at baseline. The mean follow-up duration was 28.8 months (SD 10.3).

### *Primary outcome*

At short-term follow-up 13 out of 26 (50%) of the athletes in the MMT group and 12 out of 22 (55%) of the ET group had a good or excellent objective outcome and had fully returned to sports. At mid-term follow-up 23 of the 39 athletes (59%) were able to do their sport symptom free. In the MMT group the percentage of patients who were able to perform sports symptom free had increased to 68% and in the ET group 47% were still able to perform sports symptom free. The difference between the two groups was not significant (p 0.184). (See Table 8.1)

**Table 8.1:** Distribution of objective treatment outcome in the two groups.

| Objective outcome | Short-term | | Mid-term | |
|---|---|---|---|---|
| | MMT | ET | MMT | ET |
| Poor | 11 (42%) | 6 (27%) | 6 (27%) | 7 (41%) |
| Fair | 1 (4%) | 4 (18%) | 1 (5%) | 2 (12%) |
| Good | 7 (27%) | 7 (32%) | 10 (45%) | 2 (12%) |
| Excellent | 7 (27%) | 5 (23%) | 5 (23%) | 6 (35%) |
| Total | n=26 | n=22 | n=22 | n=17 |

### *Secondary outcome*

In the MMT group the mean VAS score for pain during sports had decreased from 32 (SD 28) at short-term to 25 (SD 30) at mid-term follow-up. In the ET group the mean VAS score at both short-term and mid-term was 19 (SD 23). There was no significant difference in VAS score between MMT and ET (p=0.31). Nine patients in the MMT group and 11 in the ET group were completely symptom free at short-term follow-up. In total 6 (30%) of these 20 athletes had a recurrence. There were two recurrences (22%) in the MMT group and four (36%) in the ET group. This difference was not significant (p=0.47). At short-term follow-up 22 of the 39 athletes included for follow-up had a poor or fair outcome. At mid-term follow-up five of these athletes had recovered and were able to return to their sport. In four of these athletes a long period of rest was beneficial to recovery from their injury. In one athlete the use of compression shorts had had an immediate positive effect. Fourteen athletes who had a poor outcome at short-term follow-up still had not recovered and two athletes who had a good outcome at short-term now had a poor outcome. Twelve athletes had switched to less intensive sport and three athletes had ceased all sporting activities because of their adductor-related groin pain.

There were no complications reported.

***Predictors of outcome***

No significant relationship could be found between manner of onset of injury (acute/gradual) and final outcome of treatment (p=0.48). Nor between VAS score at baseline and final outcome (p=0.45). No significant relationship between manner of onset and recurrence frequency was found (p=0.77). No significant relationship was found between unilateral or bilateral groin injury at baseline and treatment outcome (p=0.81). Eight out of 26 athletes (30.7%) who had had a groin injury for less than one year at baseline still had a groin injury at mid-term follow-up. Of the 13 athletes who had had a groin injury for more than one year at baseline, eight (61.5%) still had a groin injury at mid-term follow-up. This difference was not significant (p=0.066).

## Discussion

At mid-term follow-up there was no difference in objective outcome score between the two groups. At mid-term follow-up 65% of the MMT group and 47% of the ET group were able to perform sports symptom free. There were two recurrences of groin injury in the MMT group and four in the ET group. These differences between the two groups were not significant. The pain scores during sporting activities did not differ between the two treatment groups.

This is the first prospective randomised trial describing the effectiveness of treatment and recurrence frequencies after mid-term follow-up (mean 29 months). The outcome results of ET are less positive than those previously published by Hölmich *et al.* (1999). That study used the same objective outcome measures and was of similar design. At four months follow-up 79% of the athletes in that study who completed the ET returned to full sporting activities without groin pain. In the present study this was only 55% at short-term and this percentage has decreased to 47% at mid-term follow-up. In the MMT group this percentage increased from 50% at short-term to 65% at mid-term follow-up. This difference was not significant. There are no other studies reporting the short- and mid-term effects of the Hölmich protocol. Clinically this might suggest that the MMT can be preferred over exercise therapy, because of the significant shorter "time to return to sports" that was found in the RCT at short-term follow-up (12.8 vs 17.3 weeks, p=0.048) (Weir *et al.*, 2010).

The difference in ET outcome results between Hölmich *et al.* (1999) and this study may be due to the effect of supervision. In the study by Hölmich *et al.* the ET was performed under supervision of a physical therapist, although compliance was not reported. In this study the athletes were instructed on how to perform the ET by a physical therapist on three separate occasions and the technique on performing the exercises was checked at these appointments. The athletes were however not supervised while performing the ET. A recent study comparing the effects of a home exercise programme and a supervised exercise programme for the management of lateral elbow tendinopathy showed a significant better outcome of treatment in the supervised programme group (Stasinopoulos *et al.*, 2009). The results of the MMT programme were not as promising as those published in a previous retrospective case series examining the effectiveness of this treatment (Weir *et al.*, 2008). This difference may well to be due to the differences in study design (prospective randomised controlled vs. case series) as the treating physicians and the work setting, are the same in both studies. This is an important point in the field of groin injuries and in sports medicine in general. In the field of groin injury there have only been two randomised controlled clinical trials to date. All other treatments reported, and often with very high success rates, are case series. Readers of these case series need to be acutely aware of this fact when interpreting the literature to guide their clinical practice.

In total 6 out of 20 athletes (30%) who had a good outcome at short-term follow-up had a recurrence. Two out of 9 (22%) in the MMT group and 4 out of 11 patients (36%) in the ET group. A large prospective epidemiological study of injuries in Australian football, following more than 600 players for four seasons, reported a recurrence rate of groin injuries of 21% (Orchard and Seward, 2002). The results are comparable to the results in the present study. The small difference in outcome can probably be explained by the relatively small sample size of this study. This relatively small sample size may also contribute to the fact that none of the differences in outcome between the MMT and ET group were significant. This follow-up study was subject to the willingness of the patients to participate. Thirty nine out of 48 athletes (81%) responded, which may have lead to response bias. If the nine missing athletes, four in the MMT group and five in the ET group, are added in a best case, worst case scenario analysis, then MMT has a possible outcome of treatment range of 58% - 73% and ET a possible outcome of treatment range of 36% - 59%. If all missing athletes in the MMT group would have had a good outcome and all missing athletes in the ET group a poor outcome (73% vs 36%), then there would be a statistically significant difference in outcome between the groups (p=0.01). If all the missing athletes in the MMT group would have had a poor outcome and all missing athletes in the ET group a good outcome (59% vs 58%) then clearly there would not be a significant difference in outcome (p=0.92). This shows the possible influence on the difference in outcome caused by the absence of the nine athletes.

Another weakness in this study was the difference in duration of follow-up between the different athletes. The mean duration of follow-up was 28.8 months (SD 10.3). This is due to fact that no mid-term follow-up appointments were planned in the design of the origional randomised controlled trial. All athletes were evaluated for mid-term follow-up in a two month period. The fact that for some athletes there was a four year interval between short-term and mid-term follow-up might have caused recall bias.

Time also plays a role in the healing process of injuries. Four out of 5 athletes that had a poor outcome at short-term and a good outcome at midterm follow-up had a long period of rest before they were able to return to sports. After a longer follow-up period the use of long rest periods may cause a treatment bias and it is unclear what part of recovery can be attributed to therapy and what part to the natural healing process.

In this study no standard questionnaire for the assessment of groin injury could be used. There is a general consensus that Patient-Reported Outcome (PRO) questionnaires should serve as a gold standard in the assessment of musculoskeletal conditions (Thorberg *et al.*, 2009). Today however, no consensus exists on which questionnaire to use for assessment of groin disability. A recent systematic review showed that a new validated PRO questionnaire focussing on the evaluation of groin injury in young and physically active patients is needed (Thorberg *et al.*, 2009).

The relatively big difference in ET outcome between this study and Hölmich *et al.* (1999) (47% vs 79%) calls for future research of the effect of supervision on exercise therapy and on the combination of MMT and ET. As the outcome of the present study might be influenced by the small sample size, in future studies a bigger group would be preferable. Standardised follow-up at mid-term in future studies will contribute to better understanding of treatment effects beyond short-term. Further research on factors predicting outcome and recurrence is needed.

## Conclusion

There is no significant difference in outcome and recurrence rate between the MMT programme and ET at mid-term follow-up (mean 29 months).

# Chapter 9:

## General discussion and implications for current practice and future research

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# General discussion and implications for current practice and future research

In the discussion the results of the individual chapters are first discussed and discussed in the light of the thesis as a whole. Following this advice is given for clinical practice. Future directions for research are also presented.

## Summary of chapters

In chapter 2 an observational study is presented in which many of the athletes included in the clinical treatment studies were examined using ultrasound to determine the thickness of the transversus abdominus muscle (TA). This was part of a series of studies on the use of ultrasound, which lead to the recent thesis by Jansen (2010) entitled "Long-standing adduction-related groin pain in athletes". In this study the injured athletes were found to have significantly less thick TA muscles when compared to non-injured controls.

There is a large differential diagnosis for the possible causes of groin pain in athletes. During the course of the clinical studies presented in this thesis the diagnosis femoroacetabular impingement (FAI) was gaining attention in the literature. Many of the athletes who were included in the studies had had x-rays performed as part of their diagnostic work up. On examining these x-rays it became obvious that there was a high prevalence of radiological findings of FAI in the group presenting with adductor-related groin pain. The study presented in chapter 3 examined this FAI phenomenon using blinded physical and x-ray examinations. In fact, 94% of all athletes had radiological signs of FAI. It became clear that a lack of clear diagnostic criteria for this relatively new condition is a large problem.

The final diagnostic study included in chapter 4 of this thesis is also an observational study on tests used to assess core stability in clinical practice. It is often stated that groin injuries (and many other injuries) are the results of poor core stability. The aim of the study was to examine the inter- and intra-observer reliability of six commonly used and often recommended tests. The idea was that after this study differences could be assessed in a case control fashion between injured and non-injured subjects. The study however showed that the six tests had too poor a reliability to progress to further studies using them.

Before the publication of the work in this thesis there was only one randomised controlled clinical trial on the treatment of groin injury in the athletic population (Hölmich *et al.*, 1999). This landmark study served to establish the role of active physical training in the treatment of adductor-related injuries.

Chapter 5 is a retrospective case series of the results of the multi-modal treatment (MMT) programme. This study was set up to examine the clinical effectiveness to see whether the MMT (comprising heat, Van den Akker manual therapy, stretching and return to running programme) would warrant further investigations in more rigorous scientific studies. These initial results were very promising indeed, with 83% reporting a good or excellent satisfaction, and gave an extra impulse to go on and further investigate the MMT programme. As is often the case with retrospective series the treatment effect was far less when the patients were prospectively included. The study of higher quality described in chapter 7 where the same MMT programme was evaluated prospectively. This is a clear example of why the results of case series should be interpreted with caution and do not lead to high levels of evidence.

This fact should be kept in mind when interpreting at the results of the case series in chapter 6. This case series examined the effect of an intensive physical and manual therapy treatment programme in athletes. In this series the programme also showed promising results with 86% returning to sport at short-term follow-up and 77% still at the original level at mid-term follow-up. It is interesting to note that the addition of several other components in this programme, besides the exercises already published in 1999 by Hölmich *et al.*,did not lead to an improved outcome. As the trials were performed on athletes with the same injury, it is tempting to conclude that the addition of specific stabilising work for the TA muscle and manual therapy for pelvis and hip had no additional benefit. This conclusion cannot however be drawn with certainty as the two programmes have never been directly compared in a randomised study.

In chapter 7 the MMT programme is compared with the exercise therapy (ET) in a prospective controlled randomised trial. In this study 54 athletes with long-standing adductor-related groin pain were randomised to the two treatment groups. At 20 weeks follow-up there was no difference between the two groups in the number of athletes who had returned to sport. The athletes in the MMT group were significantly quicker in their recovery (12.8 weeks) than those in the ET group (17.3 weeks).

The results in both groups were less effective than those published in chapter 5 for the MMT and those in the previous RCT by Hölmich *et al.* (1999) on ET. The reasons for this may be the fact that the study designs between the retrospective case series and prospective controlled trial are different for the MMT. It is also possible that the type of athlete included was different, and the baseline characteristics in the RCT MMT group were different, with older athletes competing at a higher level than those in the case series. The ET difference may be due to the effect of supervision. In the RCT in chapter 7 supervision was given on three occasions compared to all sessions in the RCT by Hölmich (1999).

After the completion of the RCT in chapter 7 it became clear that a number of athletes reported a recurrence of symptoms. On examining the literature it was apparent that very little is known about the mid to long-term effects of adductor-related groin pain and what happens after finishing treatment. The mid-term follow-up study presented in chapter 8 examines this question. It became clear that is was difficult to track down all the participants from the origional study. It is a young population who changed address and contact number frequently. Despite vigorous attempts only 81% could be contacted after a follow-up of 29 months. The results of the mid-tem follow-up were that there was still no difference in treatment outcome between the two groups. In total 30% of the athletes had had a recurrence with no difference in incidence between the two groups. This study shows that recurrence is common regardless of the type of treatment given and the mid-term outcome is also the same in both groups.

## Discussion of the results

A number of findings in the research in this thesis warrant further discussion. The most important points of discussion are the differing nomenclature, the lack of validated outcome scores, the high prevalence of FAI reported, the fact that the clinical tests for core stability were not reliable, the differences between case series and prospective studies and the difference in outcome between the RCT here and the previous outcome of the only other RCT in this field. These points are discussed below.

A lack of consensus in the use of the terminology surrounding groin injuries is a large problem in research in this field. This has been noted to be a problem in a recent systematic review of diagnosis in groin injuries (Jansen *et al.*, 2008A). The type of injury described as adductor-related groin pain can also be given many other names. In fact the astute reader will have observed that the title of chapter 2 refers to adduction-related groin pain instead of adductor. This new term started to be used after the observation of Mens *et al.* in 2006 that some athletes with adductor-related groin pain have a reduction of the pain felt on resisted adduction and an increase in adduction strength when wearing a pelvic belt. They stated correctly that this would suggest that the pain is due in part to a pelvic problem and not entirely to an adductor muscle injury. As the publication of chapter 2 was the result of a collaboration, the term of Mens *et al.* was used in this chapter. It later became obvious that the addition of yet another term into the already confusing world of groin injuries made the picture less clear.

It is recognised that there is a subgroup of athletes who improve when wearing a pelvic belt, and this improvement has also been noted with the use of compression shorts (although this study used the term osteitis pubis which once again highlights the confusion around the diagnostic terminology) (McKim and Taunton, 2001). The clinical meaning of this observation has yet to be tested in other studies and as such the addition of another possible diagnosis into the current multitude is not advised in this thesis. The term adductor-related groin pain is preferred as this term is currently in use by several other research groups around the world and makes the comparison of results easier. It is suggested that studies looking at prognosis assess whether the sub-group with improvement wearing a belt to better or worse with differing treatments in the future.

It is also important to consider that while both the RCT in this thesis and that of Hölmich *et al.* (1999) used the same treatment outcome assessment measures, despite these measures have not been validated. The use of time to return to sports to assess outcome, while tempting because of its relevance to athletes, has some major drawbacks. In practice many athletes with long-standing injuries will be satisfied to return at a slighlty lower level of competition. Some may also alter their position or style of play and yet compete at the same level as prior to the injury. The length of treatment and rehabilitation programmes can also influence the time needed for recovery. These subtleties are not accounted for with the simple measurement of the number of weeks before athletes return.

There is at present no validated outcome measure suitable for use in assessing outcome in groin injuries in the athletic population. This problem was highlighted in a recent review on the subject (Thorborg *et al.*, 2009). The study group of Hölmich is currently busy validating a patient reported outcome measure for use in athletic groin injuries. The publication of their results is awaited eagerly and is much needed in this field. A universally used outcome score would allow for much reliable comparison of results between groups researching in this field around the world. A lack of consensus in reporting of outcomes in groin injuries is a real problem in this field.

In chapter 3 it was found that the prevalence of radiological findings of femoroacetabular impingement (FAI) was high in athletes who present with adductor-related groin pain. When interpreting these results a number of findings are important. As stated above there is no clear definition as to when one should make the diagnosis of FAI.

There are a growing number of signs reported that are said to show that FAI is present. Until recently no studies on healthy control groups had been performed. It has been stated in previous studies that population studies are ongoing in Switzerland (Leunig *et al.*, 2009), the results have yet to be published and as such there is no good normative data on which to define the normal limits. An innovative study on trauma victims using CT scans of the pelvis has recently looked at the prevalence of five different radiological findings of FAI in trauma patients (Kang *et al.*, 2010). This study found a prevalence of 31% in women and 48% in males with 74% of femoral heads being also deemed to be aspherical. This study shows that the current use of certain radiological signs should be done only with caution. Another interesting recent study examined the inter and intra-observer reliability of the interpretation of plain x-ray films for the detection of 15 different radiological signs of hip disorders (Clohisy *et al.*,2009). All examiners were orthopaedic surgeons specialised in the treatment of hip complaints. This study demonstrated that the inter and intra-observer reliability of nearly all the tests was poor. The highest Kappa value for the inter-observer reliability was 0.61 (acetabular inclination) and all others were below 0.55. This can cast doubt on the findings presented in chapter 3 and also demonstrates again the problem of trying to establish clear diagnostic criteria for the condition.

In the athletic population it is important to also remember that certain types of sports, such as combat sports and gymnastics, need a large range of motion of the hip joint to perform the sport properly. It is very likely in these cases that even a hip joint with a normal bony anatomy could impinge if the athletic activity demands very large range of motion activities whereby the femur can impinge against the acetabulum. In these cases surgical correction will not be possible as the anatomy is normal and a change in the movements made to restrict the need for excessive range of motion would seem the only way to relieve the problem. In two small prospective studies an decreased hip joint range of motion was found to be a risk factor for developing athletic groin injury (Verrall *et al.*, 2007; Ibrahim *et al.*, 2007), which supports the idea that there is a relationship between the hip joint and groin injury. It is at the current time, however, unclear as to what the precise nature of this relationship is. The idea of soft tissue impingement has received no real interest in the literature and has yet to be investigated.

In chapter 4 the results of the reliability study on clinical tests for core stability showed that they are not reliable enough to use in clinical practice. This is not in keeping with current clinical practice where many people involved in the treatment of injured athletes perform clinical testing of core stability in the consulting room to base their treatment decisions on. The tests are also used to monitor recovery and assess improvements after interventions. Until now all studies that have looked at the reliability of simple assessment (with the naked eye) of complex movement patterns have shown that this is unreliable. There are many different ways in which core stability has been measured for research purposes but all involve more complex measurements than simply looking and judging clinically. This research used video analysis of the movements which is a possible weakness as it is unclear whether this affects the interpretation.

With the current knowledge, there are good grounds to advise athletes with adductor-related injuries that they should perform active physical training for their injuries (Hölmich *et al.*, 1999; Weir *et al.*, 2010) yet no simple tests to measure if stability is poor or not.It is suggested that practitioners refrain for stating that athletes stability poor is unless they perform more advanced, validated measurements that make use of electronic devices.

This thesis shows clearly the fact that retrospective case series can overestimate the treatment effects. This is an important factor in the field of groin injuries and in sports medicine in general. In the domain of groin injury there have only been two randomised controlled clinical trials to date. All other treatments reported, and often with very high success rates, are case series. Readers of these case series need to be acutely aware of this fact when interpreting the literature to guide their clinical practice. It was a little disappointing to observe the lower success rates achieved in the RCT but this information can be used to accurately counsel athletes about their expectations of the treatment. Using the data gained here realistic expectations can be given to injured athletes and this will avoid disappointment.

The fact that the exercise therapy in the RCT presented here was far less effective (55% vs 79%) when compared to the results of Hölmich *et al.(*1999) is also interesting. As stated previously this may be due to the difference in levels of supervision. This phenomenon has been shown to be relevant in a study on the eccentric exercises for lateral extensor tendinopathy (tennis elbow) (Stasinopoulos *et al.*, 2009). In this study both groups performed an eccentric training programme either daily under supervision of with weekly supervision. Both groups have significant improvements in reduction of pain and increases of strength, but the group who were supervised intensively had significantly better improvements. The unsupervised group improved 55% of the VAS score and the supervised group 125%.

When differences between trial outcomes are found it is important to look for differences in the patient populations studied. The baseline characteristics of the two groups are not identical, for example, in the current RCT ET group the average age was 28 years (Hölmich RCT 30 years) and the duration of complaints 32 weeks (Hölmich 38 weeks). Most of the differences are fairly small and most would suggest that the complaints in the Hölmich RCT were more severe. While this makes it unlikely that these baseline differences could explain the outcome differences this possibility cannot be fully excluded.

Another possibility is the fact that many treatments turn out to be less effective when other research groups attempt to replicate the good effects of a newly published treatment. This has been observed in the case of Achilles tendinopathy. The first studies examined the effect of heavy load eccentric training in the treatment of Achilles tendinopathy cited patient satisfaction levels of 82% (Mafi *et al.*, 2001). Numerous other studies that later investigated this treatment using it as the gold standard to compare new treatments to failed to achieve such a high success rate (Rompe *et al.*, 2008; de Vos *et al.*, 2006). It is not yet clear as to what explains these differences. Time and the publication of more research on the field of groin inuries will bring more new insights.

## Advice for clinical practice

### Terminology

As stated in the discussion above the preferred term is adductor-related groin pain. This term is internationally recognised and used by a growing number of research groups. The diagnosis can be made based on clinical findings: a typical history of pain, during or after athletic activity, at the proximal insertion of the adductors on the pubic bone, in combination with pain on palpation of the adductor origin and on resisted adduction testing.

It should be remembered that around one third of groin injured athletes have multiple diagnosis. The clinical patterns approach suggested by Hölmich (2007) has been found to be very practical and suitable for clinical practice. Clear definitions of other types of groin injury are given and can be used to make multiple diagnosis if necessary.

The term adductor-related groin pain does not imply that the pain is only caused by an adductor problem. This term also encompasses the pubic bone which gives pain on resisted adduction. It is suggested that the term osteitis pubis should not be used in athletic groin injuries as this implies and inflammatory component. In the only study performed where biopsies were taken from athletic groin injured patients no evidence of inflammation was found. The pubic bone biopsies from the ten subjects showed new woven bone consistent with a bone stress injury (Verrall *et al.*, 2008).

### Diagnostics and additional imaging

The diagnosis adductor-related groin pain can be made clinically based on history and physical examination. If practitioners request additional investigations in these athletes they should be aware of a number of important facts. Firstly the prevalence of abnormal findings is high in asymptomatic athletic populations. A study on pelvic x-rays in athletes showed a 45% prevalence of abnormalities of the pubic symphysis (Harris and Murray, 1974). The prevalence of abnormalities at the symphysis increased with the amount of physical activity performed. As shown in chapter 3 the prevalence of radiological findings of FAI is also very high and the reliability of interpretation of these x-rays is doubtful (Clohisy *et al.*,2009). It is thus suggested that the routine use of plain pelvic x-rays to exclude other pathology can not be recommended as the prevalence of abnormalities is very high. Furthermore the clinical meaning of these abnormalities is unknown. There have been no studies yet that have evaluated the prognostic value of plain pelvic x-rays in groin injured athletes.

With regard to MRI practitioners should also be aware of the high prevalence of abnormalities found around the pubic symphysis in asymptomatic athletes. A considerable number of studies have evaluated the role of MRI in athletes with groin pain and there are differing conclusions regarding the value. Recently the effect of a heavy training session on bone marrow oedema around the pubic symphysis was evaluated by Paajanen *et al.* (2010). Mild bone marrow oedema was found in 48% of athletes and 50% of non-athletic controls. 20% of footballers and ice hockey players had moderate bone marrow oedema. A repeat MRI in 10 athletic subjects after a heavy 2 hour training session did not show worsening of the oedema. These findings of a high prevalence of bone marrow oedema have been found in a study of 19 elite football players with 11 having moderate or severe oedema (Lovell *et al.*, 2006).

Others have found that groin injured athletes had a higher prevalence of bone marrow oedema in the pubic bone than those without symptoms (Verrall *et al.*, 2001). When clinical tests for groin pain are positive in athletes there is a high likely hood the bone marrow oedema will be present on MRI (Verrall *et al.*, 2005). In a prospective cohort study of 52 Australian rules football players 37% were found to have bone marrow oedema at the start of the season (Slavotinek *et al.*, 2005). Thirty one percent were also found to have a linear hyperintense signal line on T2 weighted images next to the symphysis. This is thought to be more severe than only bone marrow oedema. In the subsequent season the presence of these abnormalities was associated with more missed time in training but not with missed matches due to groin pain. The presence of groin pain at the time of the MRI was associated with the number of matches missed.

***Advice for practice:*** The diagnosis adductor-related groin pain can be made clinically based on history and physical examination If practitioners request additional investigations they should bear the drawbacks listed above in mind. This means that requesting plain pelvic x-rays to exclude pathology should not be performed as it is clear that abnormalities are very common in the athletic population. It is also unclear as to the clinical significance of these abnormalities. A high prevalence of abnormalities on MRI in asymptomatic populations also limits its usefulness. While previous reviews have recommended the use of MRI (Jansen *et al.*, 2008A) its routine use is not advised. The main role of MRI is in eliminating other disorders so when the clinical picture is clear the addition of MRI scanning will not be able to guide treatment more effectively. It is also not possible with the current available evidence to provide accurate prognostic information.

## Treatment

Until the publication of the work in this thesis there was only one good quality randomised controlled trial of the conservative treatment of adductor-related groin pain in athletes (Hölmich *et al.*, 1999). This provided evidence to support the use of active physical training as an effective treatment. This is supported by the findings in chapters 6,7 and 8. It should be noted that the duration of treatment is around five months. It is not easy to define the role of the MMT programme with heat, Van den Akker manual therapy and stretching when compared to active physical training programmes. It is important to bear a number of factors in mind when developing guidelines on the use of new treatments. Firstly the availability is important. While there are a number of practitioners in the Netherlands who currently use the treatment and have gained clinical experience it is not widely used outside the Netherlands. Local availability will thus be important in defining the role of this modality. Secondly the motivation of the athlete is important. While active physical training is effective it makes high demands and requires commitment and dedication. Athletes must perform three training sessions a week, each lasting around 75 minutes, for at least three months. If the resources are available it would be preferable to do this training under supervision. The long treatment duration would then also have implications for costs. A training programme with weekly supervision for five months would entail 20 contacts between practitioners and athlete. The MMT is performed and instructed on a single occasion and then carried out at home. In cases where the treatment is effective the MMT can offer a quicker return to sport.

***Advice for practice:*** the use of active physical training should be regarded as the first line treatment for athletes presenting with adductor-related groin pain. In cases where athlete motivation for training is lacking, active training is not successful or a quick return to sport is paramount then the MMT programme can be advised if available locally.

### Prevention

For effective prevention it is desirable to have a good knowledge of the risk factors involved for any given injury. A comprehensive review on the risk factors for groin injury in sport in 2007 (Maffey and Emery) found evidence that previous groin injury and weakness of the adductor muscles are risk factors. Since the publication of this review a number of other prospective studies showed that weakness of the adductors is a risk factor for groin injury (Engebretsen *et al.*, 2010; Crow *et al.*, 2010). The effect of previous injury was reconfirmed by two prospective studies (Engebretsen *et al.*, 2010; , Gabbe *et al.*, 2010). In two small prospective studies an decreased hip joint range of motion was found to be a risk factor ( Verrall *et al.*, 2007; Ibrahim *et al.*, 2007). A recent review also found that decreased flexibility of the adductors was associated with an increased risk of groin injury (Hrysomallis, 2009).

There is little knowledge on the effect of sports specific technique on the risk of adductor-related groin pain. One recent trial did examine the action of the adductors during kicking actions (Charnok *et al.*, 2009). It found that the maximum strain in the adductors was incurred in the transition for hip extension into hip flexion during kicking. As the movements involved in football are very complex and unpredictable study in this area would be very hard but may give insight as to technique faults. It is an area that may become easier to study as technology improves and biomechanical analyses become easier to perform.

There has been some good quality research on the effect of programmes to prevent groin injury. In a large randomised trial by Hölmich *et al.* the effects of an exercise programme to prevent groin injury in football players were studied (Hölmich *et al.*, 2009). This trial highlighted some of the common problems of research in this field. Firstly the problem of compliance; of the 55 teams who started the trial 11 stopped during the course of the study. Secondly the problem of the large numbers needed to show preventative effects; in the study the treatment group did have 31% less injuries although this was not significant.
A second randomised trial selected athletes at risk of groin injury based on previous history and restricted function and targeted this higher risk group for a preventative intervention comprising of physical training (Engebretsen *et al.*, 2008). Once again compliance was a problem with only 19.4% of the athletes performing the minimum required amount of exercises. This study also found no significant effect on reduction of the number of injuries. The current available evidence does not support the use of a preventative programme specifically designed for groin injuries. Due to the high risk of recurrence the development of effective prevention programmes for those recovered from groin injuries is needed.

## Directions for future research

The experience gained in working on the studies in this thesis has lead to the following recommendations for future research:

1. There is great need for consensus surrounding the terminology used in the field of athletic groin injuries. Agreement on the terminology and diagnosis would allow for easier comparison of research results. It would also aid athletes by reducing confusion which is currently common if they consult multiple practitioners. The use of a system to classify groin injury into sub-groups based on clinical findings should be assessed for reliability. If a reliable system can be developed then this would greatly strengthen the argument for practitioners to all agree to use it.

2. A validated outcome score for athletic groin injury is needed to allow for adequate assessment of treatment effects. This is currently being developed by Hölmich c.s. in Denmark and is eagerly awaited.

3. More insight is needed as to risk factors and mechanisms involved in adductor-related groin injuries. This will require case control studies to identify possible factors which should then be confirmed with prospective studies. Current possibilities are the role of the sacro-iliac joint and pelvic stability, the role of transversus abdominus and work on external factors such as load.

4. More work is needed to assess the prognostic value of additional imaging. The role of MRI in predicting the time to recovery or whether certain treatments work better in certain sub-groups will add knowledge to this area. To achieve this it will probably be necessary for different research groups working in the field of athletic groin injuries to pool data as the numbers involved in any single centre are fairly small. This kind of pooling will also encourage consensus in terms of terminology and assessment of additional investigations.

5. Until now there is very little known about the conservative treatment of other types of groin injury. There are no studies on the treatment of iliopsoas-related groin pain in athletes and no good quality studies on the conservative treatment of sports hernia or rectus abdominus-related groin pain. Research in these field is urgently needed to provide insight into possible treatment options, expected prognosis and predictive factors and to pave the way for later high quality randomised studies. Due to the lower incidence of these injuries it is suggested that future research be undertaken in a multi centre fashion to allow for greater numbers and quicker inclusion periods.

6. In the field of adductor-related groin pain the effects of combinations of treatments can be studied. New research in this field would also benefit from the use of multi centre designs. The two previous randomised controlled trials in this area took around three years to include sufficient numbers and are both still fairly small trials.

7. Due to the high risk of recurrence the development of effective prevention programmes for those recovered from groin injuries is needed.

## Summary

The work contained within this thesis presents new insights into the diagnostics and treatment of adductor-related groin pain in athletes. Adductor-related groin pain is common in athletes and can be difficult to treat, especially when it becomes long-standing. Prior to the work in this thesis there had been one high quality randomised controlled trial on the treatment of long-standing adductor-related groin pain (Hölmich *et al.*, 1999). This trial showed the good effect of using active physical therapy, which gave better results than a passive treatment programme consisting of laser, TENS, massage and stretches. In the Netherlands a novel treatment programme using heat, manual therapy according to Van den Akker, stretching and a return to running programme has been used for many years by a number of sports medicine practitioners. This treatment had never been subjected to research to assess the effects.

In **chapter 1** an introduction to the work in this thesis is given and the background is explained. The anatomy and function of the adductor muscles are discussed. The extensive differential diagnosis in athletic groin injury is highlighted and the value of diagnostic tests and investigations are considered. Recent systematic reviews highlighted the need for more studies on the field of diagnostics and treatment in adductor-related groin pain.

**Chapter 2** is related to the imaging of athletes with adductor-related groin pain. It was previously known that the activation of the transversus abdominus (TA) muscle is delayed in athletes with chronic groin pain. Together with researchers from the department of sports medicine of the University Medical Center Utrecht, who were experienced in ultrasound techniques, the TA and obliqus internus (OI) thickness was measured in a number of cases and controls. Forty two athletes with and 23 without long-standing adductor-related groin pain, were examined using ultrasound while resting and performing active straight leg raising and isometric hip adduction. The resting thickness of the TA was significantly less in those with long-standing adductor-related groin pain. The thickness of the OI in all states and the TA during contractions was not different between the groups. Due to the nature of the study it is not possible to say whether this reduction is a cause of the groin pain or the result of the long-standing complaints.

During the recruitment of athletes for participation in the studies in chapters 5 to 8, there was growing interest in the international literature in the field of femoroacetabular impingement (FAI). An increasing number of publications made known that there are many different clinical and radiological ways to examine for the presence of FAI. As athletes with FAI often present with groin pain it was decided to investigate how preva-

lent findings of FAI were in athletes presenting to the sports medicine department with adductor-related groin pain. The results of this study are presented in **chapter 3**.
In this study 34 athletes were included. They underwent a structured physical examination of the hip and groin and had pelvic x-rays performed. The radiographs were examined by a clinician who was blinded to the results of the physical examination. Eight known radiological signs said to be present in FAI were examined for. One or more radiological signs were found in 94% of the hips examined. The mean number of signs found per hip was 1.84 in symptomatic hips and 1.96 in asymptomatic hips. In nine of the 68 hips examined the anterior hip impingement test was painful but there was no correlation with the number of radiological signs. There was also no correlation between the number of radiological signs for FAI and the range of hip joint rotation.
This study showed that radiological signs of FAI are extremely common in athletes who present with long-standing adductor-related groin pain. Clinicians should bear this in mind if x-rays of the pelvis are requested along with the fact that these abnormalities do not correlate with the physical findings.

**Chapter 4** presents the results of a study examining the reliability of a number of common clinical tests thought to assess core stability. It is often said that athletes that present with groin pain have become injured due to a lack of core stability. It was decided to assess the reliability of tests commonly used in clinical practice to see if they would be suitable to go on to perform a case control study on athletes with and without adductor-related groin pain. Forty male athletes were filmed while performing six different tests said to be used to assess core stability in the clinical setting. These videos were observed by experienced clinicians on two separate occasions in a random order. The tests were rated using a four point scoring system comprising of poor, moderate, good or excellent core stability for each test. The inter and intra-observer reliability were calculated and found to be poor for both inter- and intra-observer reliability for all tests.
These results show that the six commonly recommended tests assessed in this study cannot be reliably assessed even by experienced clinicians. This means that they are not suitable for use in clinical practice to assess whether or not athletes have adequate core stability.

In **chapter 5** the results of a retrospective case study on the effect of the new multi-modal treatment (MMT) programme are presented. This case series evaluated 30 athletes who had previously been treated with the programme. The athletes were on average 20 years old and the majority were football players. They had been injured for nine months prior to treatment and 57% had ceased all sporting activities due to their injury prior to the treatment. After the treatment 50% reported being able to return to sports at pre injury level and 40% at a lower level. Eighty four percent gave a good or excellent subjective patient satisfaction. These positive results showed promise and the need for further evaluation of the technique with better controlled prospective studies.

**Chapter 6** presents the results of a case series evaluating the short and mid-term results of an active physical therapy training programme in athletes with adductor-related groin pain. This is the programme that was devised by the team at the sports medical center of the Royal Netherlands Football Association (KNVB). This comprehensive programme is based around physical training and was augmented with manual therapy techniques early on and a graded return to sport component. The 44 athletes treated were contacted six to 51 months after they completed the programme. At short-term follow-up directly after completing the programme 86% had returned to sport and 77% had no symptoms any more. The athlete's average time to return to sports was 20.3 weeks. Of the 38 athletes who had returned to sport at short-term 11 (29%) experienced a recurrence. At mid-term 77% of the 44 athletes were still participating in the preferred sport. 23 were active at their previous level (52%) and 5 (11%) at a higher level than before the injury occurred. This is the first study to report recurrence rates and mid-term follow-up after completion of an active physical training programme. The short-term results were comparable to those of the previous RCT by Hölmich *et al.*. The study showed that 29% experience a recurrence after completing the programme.

In **chapter 7** the short-term results of a randomised controlled clinical trial comparing the effects of the MMT programme and exercise therapy (ET) in athletes with long-standing adductor-related groin pain, are presented. The trial included 54 athletes who were randomised to receive either the MMT comprising heat, Van den Akker manual therapy, stretching and return to running programme, with an ET group who also performed the same return to running programme. The ET programme was the same as that in the previous RCT of Hölmich although there were fewer visits to the physiotherapist for instruction. 48 athletes (89%) completed the study. They were nearly all males and around 28 years old. The majority played football competitively at least three times a week. They had had symptoms for around eight months and most had ceased sports prior to treatment.

After the treatment 50% of athletes in the MMT group and 55% in the ET group had made a full return to sports. The difference between the groups was not significant. The athletes in the MMT group had returned to sports significantly quicker, in 12.8 weeks, than those in the ET group (17.3 weeks). An objective outcome score also showed no difference between the two treatment groups.

The percentage who were treated successfully in both groups is lower than that found in chapters 5 and 6 and in the previous RCT of Hölmich *et al.*. The reasons for this difference are unclear; it may be due to the differing study designs with chapters 5 and 6 being retrospective case series as compared to this prospective randomised study, it may also be due to the effect of supervision in the ET group with the number of supervision contacts being far lower in this study than those in the RCT of Hölmich *et al.* or the series in chapter 6. The time to return to sports with ET does seem consistent between the studies; chapter 6 (20.3 weeks), chapter 7 (17.3 weeks) and the previous RCT (18.5 weeks).

**Chapter 8** presents the results of mid-term follow-up of the RCT presented in chapter 7. In this study the athletes who had completed the previous trial were contacted again to assess the current situation and whether or not there had been a recurrence after completion of short-term follow-up. Of the 48 athletes who had completed the study 39 were contacted and agreed to follow-up. The average follow-up was 29 months after completion of the treatment. In total 59% were still able to perform their sports symptom free. In the ET group the percentage was 47% compared to 68% in the MMT programme group. The difference between the two groups was not significant although it should be noted that the numbers are now even fewer than in the original study. In total six (30%) of the athletes who had recovered at short-term follow-up had had a recurrence. Two had had the MMT and four had performed ET. The difference between the two groups was not significant.

Just as in chapter 6 this study showed a fairly high recurrence rate (29% chapter 6 and 30% this study) after recovering from the injury at short-term. This shows that athletes should be informed about a high recurrence rate when returning to sports participation. No predictors of outcome or recurrence could be found when the baseline characteristics were analysed.

In **chapter 9** a discussion of the studies presented in chapters 2-8 is given and recommendations for clinical practice are made. In this final chapter suggestions are also made for directions in future research. The new information contained in this thesis will enable clinicians to better inform athletes about the results of ET programmes for the treatment of long-standing adductor-related groin pain. The use of a MMT programme with heat, Van den Akker manual therapy, stretching and return to running offers comparable results. Local availability and athlete preference can help to guide treatment choice.

In the future every effort should be made to help reach consensus on the terminology around athletic groin injuries. Validated outcome scores are sorely needed before more clinical studies on the treatment are performed and future trials should be multi centre if possible to aid recruitment. More research is needed on the value of additional imaging before its routine use can be recommended.

## Nederlandse samenvatting

Dit proefschrift geeft nieuwe inzichten in de behandeling van adductorenklachten bij sporters. Adductorenklachten komen veel voor bij sporters en kunnen met name bij al langer bestaande klachten hardnekkig zijn. Voor het verschijnen van dit proefschrift was er maar één gerandomiseerde studie van hoge kwaliteit naar de behandeling van langdurige adductorenklachten (Hölmich *et al.*, 1999). Deze studie liet een superieur effect zien van actieve oefentherapie vergeleken met een passieve behandeling met laser, TENS, massage en rekken. In Nederland wordt een multi-modale manuele therapie (MMT) al jaren gebruikt door een aantal sportartsen en therapeuten. Deze MMT bestaat uit warmte applicatie, manuele therapie volgens Van den Akker, rekken en een hardloop opbouw programma. Dit programma was nooit eerder wetenschappelijk onderzocht.

In **hoofdstuk 1** wordt een overzicht gegeven van liesklachten en wordt de achtergrond toegelicht. De anatomie en functie van de adductoren wordt beschreven. Er wordt ingegaan op de uitgebreide diferentiaal diagnose van liesklachten bij sporters en de rol van aanvullend onderzoek. Recente systematische reviews onderschrijven dat verder onderzoek op het gebied van diagnostiek en therapie bij adductorenklachten nodig is.

**Hoofdstuk 2** richt zich op de echografische beeldvorming bij sporters met adductorenklachten. Eerder onderzoek heeft aangetoond dat de activatie van de transversus abdominus (TA) spier vertraagd is bij sporters met langdurige liespijn. In dit onderzoek werd de echografische dikte van TA en van obliquus internus (OI) en externus (OE) bepaald bij 42 symptomatische sporters en een controlegroep, bestaande uit 23 mannelijke sporters. Echografische meting van de dikte van TA in rust, tijdens active straight leg raise en isometrische heupadductie was significant minder bij symptomatische sporters. De diktes van OI en TA tijdens activatie waren niet verschillend tussen beide groepen. Door de methodologie van dit onderzoek in het echter niet mogelijk om te concluderen dat verminderde rustdikte een oorzaak of gevolg van de adductorenklachten is.

Na de start van dit promotietraject was er in de internationale literatuur toenemende aandacht voor het onderwerp femoroacetabulaire impingement (FAI). Een groeiend aantal publicaties toonde nieuwe klinische en röntgenologische aspecten voor de aanwezigheid van FAI. Omdat atleten met FAI zich vaak presenteren met liespijn werd besloten de prevalentie van FAI te bepalen bij opeenvolgende sporters met adductorenklachten. De resultaten van dit onderzoek zijn in **hoofdstuk 3** weergegeven.
In dit onderzoek werden 34 sporters geïncludeerd. Zij ondergingen een gestructureerd lichamelijk onderzoek en radiografisch onderzoek van het bekken. De röntgenfoto's werden beoordeeld door een geblindeerde arts. De aanwezigheid van acht verschillende

radiografische kenmerken voor FAI, werd gescoord. Minstens één radiografisch kenmerk voor FAI werd in 94% van de onderzochte heupen aangetoond. Het gemiddelde aantal radiografische kenmerken per heup was 1.84 in symptomatische sporters en 1.96 in de asymptomatische sporters. Bij negen van de 68 onderzochte heupen was de anterior hip impingementtest positief, maar er was geen verband met het aantal radiografische kenmerken. Er werd ook geen verband gevonden tussen het aantal radiografische afwijkingen en de beweeglijkheid van het heupgewricht.
Dit onderzoek toont aan dat radiografische karakteristieken van FAI zeer frequent voorkomen bij sporters die zich presenteren met langdurige adductorenklachten. Clinici moeten er op bedacht zijn dat deze radiologische kenmerken niet altijd correleren met het lichamelijke onderzoek en de aanwezigheid van klachten.

In **hoofdstuk 4** worden de resultaten van een onderzoek naar de betrouwbaarheid van frequent gebruikte klinische core stabilitytesten gepresenteerd. Er wordt vaak beweerd dat atleten met liesklachten geblesseerd raken, omdat hun core stability matig is. Van 40 mannelijke sporters werden videobeelden van zes verschillende testen beoordeeld door verschillende ervaren clinici op twee verschillende momenten in willekeurige volgorde. De testen werden gescoord in vier categorieën: slecht, matig, goed en uitstekend. De inter- en intrabeoordelaarbetrouwbaarheid van alle testen werd berekend. Deze bleek slecht te zijn voor alle testen.
De resultaten laten zien dat de zes vaak aanbevolen core stabilitytesten op videobeelden niet betrouwbaar beoordeeld kunnen worden, zelfs niet door ervaren clinici. Dit betekent dat de testen niet geschikt lijken voor core stabilitybeoordeling in de dagelijkse praktijk.

In **hoofdstuk 5** worden de resultaten van een retrospectieve case serie van het effect van een MMT programma gepresenteerd, waarbij 30 sporters geëvalueerd zijn. De atleten waren gemiddeld 20 jaar oud, de meerderheid speelde voetbal, de duur van de klachten was gemiddeld negen maanden en 57% had zijn sportactiviteiten moeten staken vanwege liesklachten. Na de therapie bereikte 50% het oude sportniveau. Daarnaast scoorde 84% een goede of uitstekende patiënttevredenheid. Deze positieve resultaten waren veelbelovend en gaven aanleiding tot het opzetten van een prospectieve gecontroleerde studie.

**Hoofdstuk 6** beschrijft een case serie van de korte- en middenlange termijn resultaten van een actief oefentherapeutisch programma voor sporters met langdurige adductorenklachten. Dit programma was ontworpen door het behandelteam van het Sportmedisch Centrum van de KNVB. Het is een uitgebreide therapie met de nadruk op actief oefenen, gecombineerd met manuele therapie voor heup- en bekkengewrichten en opbouw van de sportspecifieke belasting. De 44 atleten die de behandeling hadden

ondergaan, werden na zes tot 51 maanden geëvalueerd. Bij de korte termijn follow-up, direct na afronding van de therapie was 86% weer aan het sporten en was 77% volledig klachtenvrij. De gemiddelde tijd tot sporthervatting was 20.3 weken. Van de 36 atleten, die volledige sportterugkeer rapporteerden hebben 11 sporters (29%) binnen 22 maanden een recidief gekregen. Bij de middenlange termijn follow-up was 77% van de 44 atleten nog aan het sporten op het oude sportniveau: 23 (52%) waren actief op hun oude niveau en 5 (11%) op een hoger niveau dan voor de blessure.
Dit is wereldwijd het eerste prospectieve onderzoek dat recidieven rapporteert na een behandeling met actieve oefentherapie. De korte termijn resultaten zijn vergelijkbaar met het gerandomiseerd onderzoek van Hölmich *et al.*(1999). In dit onderzoek kreeg 29% een recidief na beëindiging van de therapie.

In **hoofdstuk 7** worden de korte termijn resultaten van een gerandomiseerd klinisch onderzoek naar het effect van het MMT programma en actieve oefentherapie (OT) gepresenteerd. In dit onderzoek werden 54 atleten gerandomiseerd voor het MMT programma bestaand uit warmte, manuele therapie volgens Van den Akker, rekken en opbouw van hardlopen of OT met dezelfde opbouw van het hardlopen. De OT was hetzelfde als die in de studie van Hölmich *et al.* (1999), behalve dat er minder (gesuperviseerde) fysiotherapeutische instructies werden gegeven. 48 atleten hebben het onderzoek afgerond. Het waren bijna allemaal mannen met een gemiddelde leeftijd van 28 jaar. De meerderheid was voetballer met een sportfrequentie van drie keer per week of hoger. De gemiddelde klachtenduur was acht maanden en de meerderheid had het sporten moeten staken vanwege de klachten tijdens sporten.
Na de behandeling kon 50% van de sporters in het MMT programma en 55% van de OT groep weer op hun oude niveau sporten. Het verschil tussen de groepen was niet significant. De sporters in het MMT programma waren significant sneller hersteld (12.8 weken), ten opzichte van de OT groep (17.3 weken). De primaire uitkomstmaat liet geen verschil zien tussen de twee groepen.
Het percentage succesvolle behandeldingen is aanzienlijk lager dan in de case series van hoofdstuk 5 en 6 en de RCT van Hölmich *et al.*. De reden hiervoor is onduidelijk maar het verschil in onderzoeksopzet, met hoofdstukken 5-6 als retrospectieve case series, zou van invloed kunnen zijn. Daarnaast zou het effect van de gesuperviseerde OT in de RCT van Hölmich *et al.*,in vergelijking met een huiswerkprogramma met drie instructie momenten,ook van invloed kunnen zijn. De tijd tot sportterugkeer voor OT is wel vergelijkbaar tussen de studies; hoofdstuk 6 (20,3 weken), hoofdstuk 7 (17,3 weken) en de RCT van Hölmich *et al.* (18,5 weken).

**Hoofdstuk 8** geeft de resultaten weer over de midden termijn follow-up van de gerandomiseerde studie die in hoofdstuk 7 werd gepresenteerd. In deze studie werden sporters die de studie hadden afgerond (n=48), benaderd om de huidige status en het

aantal recidieven  te beoordelen. De gemiddelde follow-up (n=39) bedroeg 28 maanden na het afronden van de therapie. In totaal was 59% klachtenvrij aan het sporten. In de OT groep was het percentage 47% en 68% in de MMT groep. Het verschil tussen die twee groepen is niet significant maar een type II fout kan niet worden uitgesloten. In totaal hebben zes (30%) van de atleten, die bij korte termijn follow-up geheel klachtenvrij konden sporten, een recidief gekregen. Twee hadden de MMT behandeling ondergaan en vier de OT. Het verschil tussen de twee groepen was niet significant.
Net zoals in hoofdstuk 6 laat deze midden termijn follow-up studie een hoge recidiefkans zien (29% hoofdstuk 6 en 30% in deze studie) na herstel op korte termijn. Sporters moeten dus geïnformeerd worden over het relatief hoge recidiefpercentagebij de sporthervatting. Er konden bij de analyse van de baselinekarakteristieken geen prognostische factoren voor recidiefkans worden aangetoond.

Tot slot worden in **hoofdstuk 9** de belangrijkste resultaten van dit proefschrift beschreven in relatie tot elkaar en vergeleken met de huidige literatuur. Daarnaast worden de beperkingen van de beschreven studies, aanbevelingen voor de klinische praktijk en suggesties voor toekomstig onderzoek beschreven. De nieuwe informatie in dit proefschrift maakt het mogelijk voor clinici om sporters beter te informeren over de resultaten van OT bij sporters met langdurige adductorenklachten. Het MMT programma met warmte, manuele therapie volgens Van den Akker, rekken en opbouw van hardlopen geeft vergelijkbare resultaten. Lokale beschikbaarheid en sportvoorkeur kunnen gebruikt worden in het maken van een therapie keuze.

In de toekomst is het belangrijk dat er consensus wordt bereikt over de terminologie van liesblessures. Ontwikkeling van gevalideerde uitkomstmaten zijn van cruciaal belang voordat meer klinische studies worden verricht. Meer onderzoek naar de waarde van aanvullend onderzoek is nodig voordat routinematig gebruik aanbevolen kan worden. Het effect van gecombineerde behandelingen dient onderzocht te worden met de voorkeur voor multicenter studies om instroom te bevorderen.

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## Curriculm Vitae

Adam Weir was born on the 7th of September 1974 in Nottingham, England, where he grew op together with his parents and brother Alastair. After a care free and sporty upbringing he went to study medicine in 1993 at the University of Newcastle upon Tyne. During his studies he completed electives in sports medicine with prof G. McLatchie in Hartlepool and at the Victorian Institute of Sports in Melbourne, Australia. After graduating with merit in 1998 he began work as a junior house officer at the department of Orthopaedic Surgery at Dryburn Hospital in Durham, England. At his second house job in General Medicine at Wansbeck Hospital in Ashington, England he met Marja van't Spijker his Dutch partner. He then worked in Accident and Emergency in Durham, England and Mount Isa Base Hospital in the Australian outback. After returning to the UK in 2000 he worked for a year in orthopaedics again at Dryburn Hospital. In 2001 he and Marja moved together to live in Amsterdam where he studied Dutch at the University of Amsterdam. After completing his Dutch course he began work in orthopaedics in Gelre hospital in Apeldoorn. While working there he was accepted onto the training programme for sports medicine at the Hague Medical Center (MCH). In 2002 he started work under the supervision of Don de Winter, MD, and later together with Hans Tol, MD PhD, and completed his training as a sports medicine physician at the end of 2006. Since 2007 he has worked at the MCH department of Sports Medicine where he continued his research activities and at the Sports Medical Advice Center in Haarlem. He worked part time at the University of Utrecht- Department of Rehabilitation and Sports Medicine in 2009 to perform data analysis on the work in this thesis under the supervision of Prof Dr F.J.G. Backx, MD PhD. Marja and Adam now have three happy and healthy children; Luke, Mia and Kate and live in Overveen. When not working on his research, he can be found playing tennis or on his allotment tending to his vegetables.

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Now to one of the best read parts of the whole thesis. As many of my friends and family are English I have decided to write this part in English too. After working hard on this project for the last four years it was great to look back and see how many people I have been able to meet and work with as part of the PhD. I have tried to remember everyone who has played a part but in the hectic run up to printing the thesis I may well have forgotten a few – my apologies.

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