

DISSERTATION FROM THE
NORWEGIAN SCHOOL OF
SPORT SCIENCES
2018

Joar Harøy

Groin injuries among football players

- A substantial but preventable problem

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No individual can win a game by himself.

Pelé

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List of publications

This dissertation is based on the following papers, which are referred to in the text by their Roman numerals:

- I. Groin problems in male soccer players are more common than previously reported.
The American Journal of Sports Medicine. 2017;45(6):1304-1308.
doi.org/10.1177/0363546516687539
- II. Including the Copenhagen Adduction exercise in the FIFA 11+ provides missing eccentric hip adduction strength effect in male soccer players: A randomized controlled trial.
The American Journal of Sports Medicine. 2017;45(13):3052-3059.
- III. An Adductor Strengthening Programme prevents groin problems among male football players: A cluster-randomised controlled trial.
British Journal of Sports Medicine. Published Online First: 10 June 2018.
- IV. Implementation of the Adductor Strengthening Programme: Players primed for adoption but reluctant to maintain.
Manuscript submitted to Scandinavian Journal of Medicine & Science in Sports June 2018.

Summary

Background

Groin injuries represent a considerable problem in football and account for 4% to 19% of all time loss injuries among male players. Until now, groin-specific exercise programmes have not shown a significant effect on groin injury rates. However, since the programmes were designed, there have been new data published on hip adduction exercises in the context of both muscle activation and strength effects. The overall aim of this dissertation was to develop and examine the effect of an Adductor Strengthening Programme on the prevalence of groin problems among male football players. We also wanted to test a new method for registering groin problems among players of both sexes and different levels of play. In addition, we wanted to examine the strength and sprint effect of the FIFA 11+ warm-up programme. Finally, we examined players' attitudes towards groin injury prevention and their experiences with the implementation of the Adductor Strengthening Programme.

Methods

The dissertation is based on four different research projects. In the first project (Paper I), we used the Oslo Sports Trauma Research Center Overuse Injury Questionnaire in a six-week prospective registration of groin problems among 240 players during a period with match congestion. In the second project (Paper II), we examined the strength effect of the FIFA 11+ with and without the Copenhagen Adduction exercise, in an eight-week randomised controlled trial among 45 male U19 players. In the third project (Paper III), 632 players were enrolled in a 28-week cluster randomised controlled trial examining the preventive effect of an Adductor Strengthening Programme based on the Copenhagen Adduction exercise. In project four (Paper IV), 501 of the players included in Paper III responded to a survey about their experiences with the implementation of the Adductor Strengthening Programme and their attitudes towards groin injury prevention.

Main results

The average weekly prevalence of any groin problem and substantial groin problems for all male players was 29% (range, 23% to 32% across different levels) and 10% (7% to 13%) respectively. For elite female players, the prevalence of any groin problem was 14%, while the prevalence of substantial groin problems was 4%. Elite male players had an increased risk of groin problems (odds ratio: 3.1, 95% CI: 1.5-6.4, $p=0.03$) compared to elite female players. There was no difference in the risk of groin problems among elite, sub-elite and amateur male players (Paper I). In Paper II,

between-group analyses revealed a significant increase in eccentric hip adduction strength of 0.29 Nm/kg (8.9%, $p=0.01$) in favour of the group performing the Copenhagen Adduction exercise, whereas no within-group change was noted in the group that used the standard FIFA 11+ programme (-0.02 Nm/kg [-0.7%], $p=0.69$). In Paper III, the average prevalence of groin problems during the regular season was 13.5% (95% CI: 12.3% to 14.7%) in the group performing the Adductor Strengthening Programme and 21.3% (95% CI: 20.0% to 22.6%) in the control group continuing normal training. The risk of reporting groin problems was 41% lower for the group performing the programme (odds ratio: 0.59, 95% CI: 0.40 to 0.86, $p=0.008$). Paper IV showed that most players think footballers are at moderate to high risk for groin injuries (87%) and that there is a need for preventive measures (96%). They also believe that a preventive programme with strength exercises targeting the hip adductors would reduce the risk of groin injury (91%). A majority of players reported using less than five minutes to complete the Adductor Strengthening Programme (73%), and only 11% wanted additional exercises. However, only 46% reported performing the programme as recommended, and a smaller proportion (31%) planned to continue using the programme as recommended the next season.

Conclusions

We found a high prevalence of groin problems among male football players during a period with match congestion. Elite male players had 3 times' higher risk of reporting groin problems than elite female players, but level of play did not influence the risk of reporting groin problems among males. We also found that the standard FIFA 11+ programme did not increase eccentric hip adduction strength, while including the Copenhagen Adduction exercise in the programme provided the missing strength effect. The Adductor Strengthening Programme substantially reduced the prevalence and risk of groin problems in male football players. Finally, we found that footballers believe that groin injury prevention measures are needed. Attitudes towards the implementation of the Adductor Strengthening Programme were positive, and the single-exercise approach was considered an important facilitator. However, in disseminating the programme, the players' reluctance to maintain the exercise protocol may be a potential barrier to implementation that should be addressed.

Sammendrag på norsk

Bakgrunn

Lyskeskader er et betydelig problem blant fotballspillere og står for 4% til 19% av alle fraværsskader blant mannlige spillere. Flere skadeforebyggende programmer har blitt introdusert, men inntil nå har ingen klart å vise effekt på skaderaten. Derimot har det siden programmene ble utviklet blitt publisert nye data på muskelaktivering og styrkeeffekten fra flere øvelser som fokuserer på hofteddusjon. Hovedformålet med dette doktorgradsprosjektet var å utvikle og teste effekten av et styrketreningsprogram for hoftedduttorene (Adductor Strengthening Programme), på prevalensen av lyskeproblemer blant mannlige fotballspillere. Vi ønsket også å teste en ny metode for registrering av lyskeproblemer blant fotballspillere av begge kjønn og på ulike nivå. Videre ønsket vi å undersøke styrkeeffekten av oppvarmingsprogrammet FIFA 11+. Avsluttende ville vi undersøke fotballspillernes erfaringer med implementeringen av Adductor Strengthening Programme og deres holdninger til forebygging av lyskeskader.

Metode

Doktorgradsavhandlingen er basert på fire ulike prosjekter. I det første prosjektet (Artikkel I) benyttet vi Oslo Sports Trauma Research Center Overuse Injury Questionnaire i en seks-ukers prospektiv registrering av lyskeproblemer blant 240 spillere i en periode med tett kampprogram. I det andre prosjektet (Artikkel II) undersøkte vi styrkeeffekten fra oppvarmingsprogrammet FIFA 11+, med og uten en spesifikk styrkeøvelse for hoftedduttorene (Copenhagen Adduction exercise), i en åtte-ukers randomisert kontrollert studie blant 45 mannlige U19 spillere. I det tredje prosjektet (Artikkel III) inkluderte vi 632 spillere i en 28-ukers randomisert kontrollert studie der vi undersøkte den skadeforebyggende effekten av Adductor Strengthening Programme. I det fjerde prosjektet (Artikkel IV) besvarte 501 av spillerne involvert i Artikkel III på en spørreundersøkelse angående deres erfaring med implementeringen av styrketreningsprogrammet og deres holdning til forebygging av lyskeproblemer.

Resultater

Artikkel I viste at gjennomsnittlig prevalens av alle lyskeproblemer og betydelige lyskeproblemer for alle mannlige fotballspillere var 29% (range, 23% til 32% på de ulike nivåene) og 10% (7% til 13%), respektivt. Kvinnelige elitespillere hadde en gjennomsnittlig prevalens av alle lyskeproblemer på 14%, mens prevalensen av betydelige lyskeproblemer var 4%. Mannlige elitespillere hadde en økt risiko for å få lyskeproblemer (odds ratio: 3.1, 95% CI: 1.5-6.4, $p=0.03$) sammenlignet med kvinnelige

elitespillere. Det var ingen forskjell i risiko for å få lyskeproblem mellom de ulike nivåene av herrefotball. I Artikkel II viste analyser av forskjell mellom gruppene en økning i eksentrisk hofteadduksjon på 0.29 Nm/kg (8.9%, $p=0.01$) i favør av gruppen som gjennomførte Copenhagen Adduction exercise. Analyser av forskjell innad i gruppene viste at gruppen som gjennomførte standard FIFA 11+ oppvarming ikke hadde endring i styrke (-0.02 Nm/kg [-0.7%], $p=0.69$). Artikkel III viste at den gjennomsnittlige prevalensen av alle lyskeproblemer var 13.5% (95% CI: 12.3% til 14.7%) for gruppen som gjennomførte Adductor Strengthening Programme og 21.3% (95% CI: 20.0% to 22.6%) for kontrollgruppen som gjennomførte ordinær trening. Risikoen for å rapportere lyskeproblemer var 41% lavere for gruppen som gjennomførte programmet (odds ratio: 0.59, 95% CI 0.40 til 0.86, $p=0.008$). Resultatene fra Artikkel IV viste at majoriteten av spillerne mente at fotballspillere har moderat til høy risiko for å få lyskeskader (87%) og at det er behov for å innføre forebyggende tiltak (96%). De trodde også at et skadeforebyggende program med styrkeøvelser fokusert på hofteadduksjon ville redusere risikoen for lyskeskader (91%). Majoriteten av spillerne rapporterte at de brukte mindre enn 5 minutter på å gjennomføre Adductor Strengthening Programme (73%) og kun 11% ønsket flere øvelser. Derimot rapporterte kun 46% at de hadde gjennomført programmet som anbefalt, og en enda lavere andel (31%) planla å benytte det med anbefalt treningsprotokoll neste sesong.

Konklusjon

Vi fant en høy prevalens av lyskeproblemer blant mannlige fotballspillere i en periode med tett kampprogram. Mannlige elitespillere hadde 3 ganger så høy risiko for å rapportere lyskeproblemer sammenlignet med kvinnelige spillere. Blant herrespillere utgjorde ikke nivået de spilte på noen forskjell i risiko for skade. Vi fant også at standard FIFA 11+ ikke ga noen styrkefremgang i hofteadduktorene, derimot kan inkludering av Copenhagen Adduction exercise bidra til økt styrkeeffekt. Det skadeforebyggende programmet Adductor Strengthening Programme reduserte prevalensen og risiko for lyskeproblemer blant mannlige spillere betydelig. Én-øvelses tilnærmingen viste seg å være en viktig faktor for vellykket implementering av programmet. Derimot kan den nølende holdningen til fortsatt gjennomføring av programmet representere en potensiell barriere.

Abbreviations

CA – Copenhagen Adduction exercise

CI – Confidence interval

DOMS – Delayed onset muscle soreness

FAI – Femoroacetabular impingement

GEE – General estimation equation

HAGOS – Copenhagen Hip and Groin Outcome Score

ICC – Intraclass correlation coefficient

ISRCTN – International Standard Randomised Controlled Trial Number registry

ITT – Intention to treat

MRI - Magnetic resonance imaging

MTJ - Musculotendinous junction

NH – Nordic hamstring exercise

NRS – Numeric rating scale

OSTRC – Oslo Sports Trauma Research Center

OSTRC-O – Oslo Sports Trauma Research Center Overuse Injury Questionnaire

PP – Per protocol

RCT – Randomised controlled trial

ROM – Range of motion

SEM – Standard error of measurement

Background

What is a groin injury?

The Medical Subject Headings (MeSH) defines the groin as 'the external junctural region between the lower part of the abdomen and the thigh'. However, the injured footballer can describe groin pain as pain deriving from different anatomical regions, such as the hip adductors, lower abdomen, hip flexors, hip joint or a combination of these different structures. The same inconsistency is present in both clinical practice and the literature. There is substantial variation in the terminology of diagnoses used to describe groin pain; the same term can even have multiple interpretations. This variation is highlighted in a systematic review on the management of groin pain in athletes (Sermer et al., 2015b). In the 72 studies identified, the authors found 33 different diagnoses used for groin pain in athletes (Sermer et al., 2015b). Although many of these represent different pathologies, different terms are used to describe similar symptoms. Examples of the unspecific diagnoses and terms used for groin pain are osteitis pubis, pubalgia and pubic bone stress, for which definitions often differ but can have considerable overlap (Sermer et al., 2015b). The lack of clear terminology and definitions may cause misunderstandings between clinicians as well as limit scientific advances.

In an attempt to agree on a standard terminology, the Doha agreement meeting on terminology and definitions in groin pain in athletes was held in 2014. Prior to the meeting, a group of 24 international experts from a variety of backgrounds were invited to participate in a Delphi procedure by providing their preferred terms to describe the diagnoses of two clinical cases (Weir et al., 2015a). In total, 18 different terms were used to describe the diagnosis for the first case, and 22 different terms were used for the second case. During the following agreement meeting, a single set of terms and definitions were agreed upon. This agreement enables similar classifications relating the athlete's groin pain to specific areas with defined clinical entities and based on reproducible clinical examination tests (Weir et al., 2015a). The classification system has three major subheadings for groin pain in athletes: (1) defined clinical entities for groin pain (figure 1), (2) hip-related groin pain and (3) other causes of groin pain in athletes.

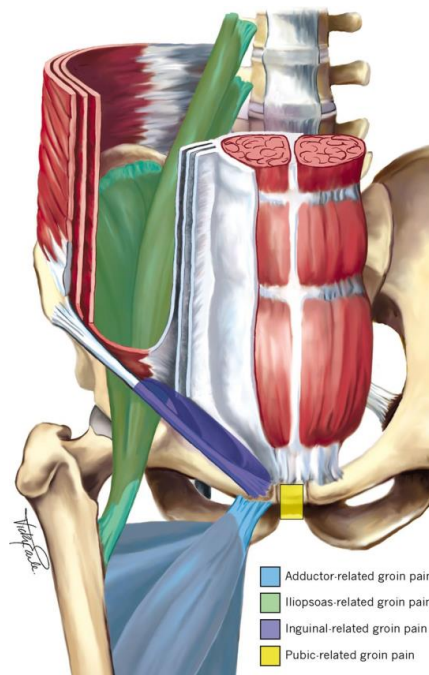


Figure 1 Location of the defined clinical entities for groin pain. Figure from Weir et al. (2015b) with permission.

Anatomical overview

Pelvis

The pelvis is formed from two innominate bones, each composed of three fused bones: the ilium, ischium and pubis. The pubic symphysis is a cartilaginous joint that sits between and joins the left and right superior rami of the pubic bones (Becker et al., 2010). Laterally within the pelvic ring, the ilium, ischium and pubis coalesce and are covered by hyaline cartilage to form the acetabulum, which articulates with the head of the femur. Posteriorly, the bones articulate with the sacrum.

Adductor muscles

The adductor muscle group is considered to include the adductor longus, adductor brevis, adductor magnus, pectineus, gracilis and obturator externus. The adductor longus originates from the anterior pubic body inferior to the pubic crest (Schilders et al., 2017). The proximal insertion has been shown to be fibrocartilaginous, and the muscle usually still consists of more than 90% tendon 3 mm from the origin (Davis et al., 2012). It expands to insert onto the linea aspera of the femur. The adductor brevis originates just inferior and posterior to the adductor longus. Some muscle fibres from the adductor brevis in males and some tendinous fibres in females are described as fusing with the gracilis, which originates from a small area on the external point of the ischiopubic ramus (Davis et

al., 2012). The adductor magnus has two proximal portions (Broski et al., 2016; Obey et al., 2016). The primary muscular origin extends posteriorly along the ischiopubic ramus into a tendinous insertion at the inferior ischial tuberosity (Broski et al., 2016; Obey et al., 2016). The origins of the pectineus on the superior pubic ramus as well as the obturator externus on the ischiopubic ramus have received less attention in relation to groin pain.

Abdominal muscles

The rectus abdominis, pyramidalis, transversus abdominis as well as internal and external obliques muscles are all understood to have relevance to groin pain due to their distal insertion on the pubic bone. Anterior capsular tissue of the pubic symphysis has been referred to as the pubic plate or pubic aponeurosis (Omar et al., 2008; Palisch et al., 2013). The lower abdominal wall is composed of several additional layers that form the rectus sheath anterior to the rectus abdominis. The pyramidalis muscles are paired and lie between the anterior surface of the rectus abdominis and the posterior surface of the rectus sheath (Lovering & Anderson, 2008; Schilders et al., 2017). The transversus abdominis is the deepest abdominal muscle and is described as fusing medially with the internal oblique to distally form a conjoint tendon. This forms the medial part of the inguinal ring, and attaches at the pubic crest and pectineal line. Anterior to the internal abdominal obliques is the external abdominal oblique, which extends diagonally from lateral proximal to medial distal, transitioning into an aponeurosis that distally forms the inguinal ligament (Fagan & Awad, 2004).

Hip flexors

The psoas major originates from the transverse processes of the lumbar vertebrae and courses caudally across the brim of the pelvis to lie anterior to the capsule of the hip. The iliacus tendon extends proximally into the belly of the iliacus muscle (Philippon et al., 2014), a triangular muscle that arises from the upper two thirds of the iliac fossa and the inner lip of the iliac crest. The fibres converge in the lateral side of the psoas major tendon. The distal iliopsoas muscle is described as having separate tendon insertions with distinct tendons originating from the psoas major and the iliacus muscles (Philippon et al., 2014; Tatu et al., 2001). The psoas major tendon is located medially, and the primary iliacus tendon is located slightly laterally. The proximal insertion of the rectus femoris includes two separate tendons from the anterior inferior iliac spine and above the rim of the acetabulum. The two tendons extend distally and unite to spread into an aponeurosis where the muscle fibres arise. The muscle inserts into the base of the patella (Gyftopoulos et al., 2008).

Which structures are injured?

Although the Doha classification system represents an important improvement in groin pain terminology, the exact pathologies remain unidentified. Within the different sub-headings of the

Doha classification system, there are several anatomical structures that can be injured. In the following section, an overview of most common anatomical structures thought to cause groin pain are presented.

Acute hip adductor and flexor injuries

In two different studies using magnetic resonance imaging (MRI), Serner et al. examined the characteristics of acute hip adductor injuries (2018a) and hip flexor injuries (2018b). In the study on acute adductor injuries, 71 male athletes (55% football players) were included and 121 injured sites were identified (Serner et al., 2018a). There were 46 isolated injuries, while 25 athletes had multiple adductor injured sites. An injury to the adductor longus was found in 87% of cases, followed by the adductor brevis (25%) and pectineus (24%). Three characteristic injury locations to the adductor longus muscle were seen (figure 2): (1) the proximal insertion (most injuries were complete avulsions), (2) the musculotendinous junction (MTJ) of the proximal tendon and (3) the MTJ of the distal tendon (Serner et al., 2018a).

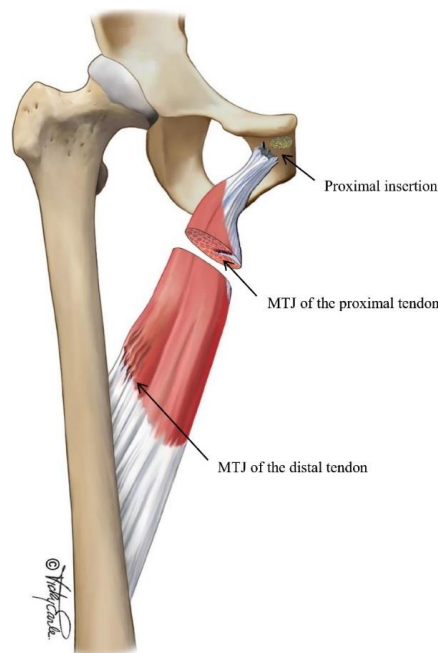


Figure 2 Anatomical illustration of the three most common acute adductor longus injury locations.
Figure from Serner et al. (2018a) with permission.

In the study on acute hip flexor injuries, 33 male athletes (67% footballers) were included and a total of 40 acute injuries were identified (Serner et al., 2018b). An injury to the rectus femoris was found in 48% of cases, and in 94% of those the proximal tendons (tendon insertions and MTJs of the direct and indirect tendons) were involved. The second-most injured muscle was the iliopsoas (33% of

cases), where three characteristic injury locations were seen: (1) proximal injury near the insertion of the posterior medial part of the iliacus, (2) the distal MTJ of the posteromedial part of the iliacus and (3) the distal MTJ of the psoas major (Serner et al., 2018b). Findings from the two studies have demonstrated the most frequently injured muscles and their most common locations in acute groin injuries. However, the limited number of athletes identified with injuries, especially with hip flexor injuries, may reduce the generalizability of the findings. Finally, the authors highlighted that the athletes attending the specialised hospital may have more severe injuries than other populations (Serner et al., 2018a).

Longstanding pubic- and adductor-related injuries

Symptoms in longstanding cases are often vague, and both injury location and onset can be challenging to determine. The use of differing diagnostic terminology was highlighted in a review reporting on the radiological findings in cases with prolonged groin pain in athletes (Branci et al., 2013). Although Branci et al. (2013) considered the current evidence to be based on relatively few heterogeneous studies of varying methodological quality, four main radiological findings appeared to be reported consistently: (1) degenerative changes at the pubic symphysis, (2) pathology in the adductor muscle insertions at the pubic bone, (3) pubic bone marrow oedema and (4) the secondary cleft sign (a high-signal intensity line extending laterally and inferiorly from the inferior part of the symphysis). The same group later developed a standardised MRI evaluation protocol for imaging patients with longstanding sports-related hip or groin pain (Branci et al., 2014a). In a cross-sectional study, MRI findings were compared between 28 symptomatic and 17 asymptomatic male football players (Branci et al., 2014b). Furthermore, findings from asymptomatic players were compared to findings from 20 asymptomatic athletes not playing football. The results showed that symptomatic players often had multiple findings. A protruding central fibrous symphysis disc was found in 74% of cases, adductor longus tendinopathy appeared in 72%, pubic bone marrow oedema appeared in 51%, fatty infiltration in bone marrow around the symphysis joint appeared in 49%, bony sclerosis along the symphysis joint appeared in 41% and subchondral cysts or joint surface irregularities in the symphysis joint appeared in 56% (Branci et al., 2014b). However, asymptomatic football players had similar findings, and groin pain in football players was only associated with central disc protrusion and severe grades of pubic bone marrow oedema. Furthermore, when comparing football players to non-football players, positive MRI findings were significantly more frequent in football players compared to non-players, irrespective of symptoms among the footballers. MRI findings may therefore only be associated with football play itself rather than groin pain in general (Branci et al., 2014b).

Background

A considerably larger prospective study including 382 athletes (14% footballers) with longstanding groin pain (median: 36 weeks) revealed a slightly different picture (Falvey et al., 2015). Pubic bone marrow oedema was found in 68% of cases, abnormal pubic aponeurosis was found in 53%, abnormal adductor imaging findings were found in 38% and abnormal hip imaging was found in 45%. Multiple findings were seen in 64% of cases (Falvey et al., 2015). Unfortunately, the results from these two studies highlights the different diagnostic terminology used in groin injury research. The confusing terminology results in difficulties with interpretation of the results. The two studies agree that multiple MRI changes are commonly seen in athletes with groin pain, but there are distinct differences in the proportion of positive findings, such as adductor longus injuries 72% (Branci et al., 2014b) vs. 38% (Falvey et al., 2015). There may be several reasons for this difference, including somewhat different populations, injury severity, MRI protocols and understandings of anatomy. These results show that we cannot rely on MRI findings alone to determine which structure is causing groin pain. An editorial from Weir et al. (2017) also underlines the need for combining anatomical, histological, clinical and radiological findings to improve our understanding of the underlying pathology for groin pain in athletes.

Inguinal-related groin pain

Inguinal-related groin pain is not well understood. There have been several attempts to describe its underlying pathology. A bulging of the posterior wall, bulging causing entrapment neuropathy, tendinopathy of the inguinal ligament, a tear in the external oblique aponeurosis and a tear in the conjoint tendon have all been proposed (Sheen et al., 2014). MRI imaging does not usually demonstrate any oedema or structural disruption in athletes with groin pain deriving from the inguinal region (Robinson et al., 2004). Asymmetry in the abdominal wall muscles is also not discriminatory, as atrophy can have several causes and is often asymptomatic (Robinson et al., 2004). However, several surgical techniques have been used to manage inguinal-related groin pain. Surgery often involves strengthening the abdominal wall using a mesh (Paajanen et al., 2015) or strengthening the transversalis fascia in combination with partial removal of the genitofemoral nerve (Muschaweck & Berger, 2010a, 2010b). Return to play rates are very high; however, as pointed out in a systematic review on groin pain management in athletes, an inverse correlation was seen between study quality and treatment success (Serner et al., 2015b). Thus, the pathology underlying inguinal-related groin pain remains unclear.

Hip-related groin pain

Hip-related groin pain is one of the three subheadings in the Doha agreement (Weir et al., 2015a). In recent years, the number of athletes being treated with arthroscopic surgery for femoroacetabular impingement (FAI) has risen sharply in many countries (Colvin et al., 2012; Griffin et al., 2016b). As a

result, the Warwick Agreement on FAI syndrome was developed to build a consensus on FAI diagnosis and management (Griffin et al., 2016a). FAI syndrome was defined as a triad of symptoms, clinical signs and image findings and represents symptomatic premature contact between the proximal femur and the acetabulum (Griffin et al., 2016a). Radiological findings of cam or pincer morphology on plain radiographs or MRIs are typical (Griffin et al., 2016a). Cam morphology refers to a flattening or convexity at the femoral head neck junction, whereas pincer morphology refers to a focal or global over-coverage of the femoral head by the acetabulum (Ganz et al., 2003). Often, FAI syndrome leads to damage within the joint, including the acetabular labrum and articular cartilage (Ganz et al., 2003). Athletes with long-standing groin pain have been reported to have a high prevalence of the bony hip morphology associated with FAI syndrome (Hölmich et al., 2014b; Weir et al., 2011). However, in several more recently studies, a high prevalence of bony hip morphology has been found in asymptomatic football players (Agricola et al., 2014; Mosler et al., 2016b; Tak et al., 2015). Thus, the relationship between bony hip morphology and groin pain in footballers remains unclear.

This overview demonstrates that which structure(s) actually cause groin pain among footballers is poorly understood. As already pointed out in the Doha agreement, differing terminology makes it hard to compare and summarise results. In addition, asymptomatic players showing positive findings may be one reason why imaging studies report multiple positive finding in players with groin pain. The lack of understanding of which structure cause groin pain may explain the sparse evidence for the treatment of groin pain and limits our ability to prevent these injuries.

Sequence of prevention

In order to successfully prevent groin injuries among football players, knowledge about why and how injuries occur is needed. Different models have been proposed to guide prevention research, the most fundamental of which is the four-step 'sequence of prevention' of sports injuries (figure 3) (van Mechelen et al., 1992). In the first step, the magnitude of the problem must be identified and described in terms of rate and severity of injuries. In the second step, risk factors and injury mechanisms that play a part in the occurrence of groin injuries must be identified. The third step is to develop and implement an injury prevention strategy based on the risk factors and injury mechanisms identified in step two. Finally, the effect of the measures must be evaluated by repeating step one (van Mechelen et al., 1992), preferably in the form of a randomised trial. In the following sections, this thesis synthesises and reviews the literature on the epidemiology and risk factors of groin injuries in football players. Subsequently, studies on groin injury prevention are identified and exercise selection, training effects and compliance are assessed.

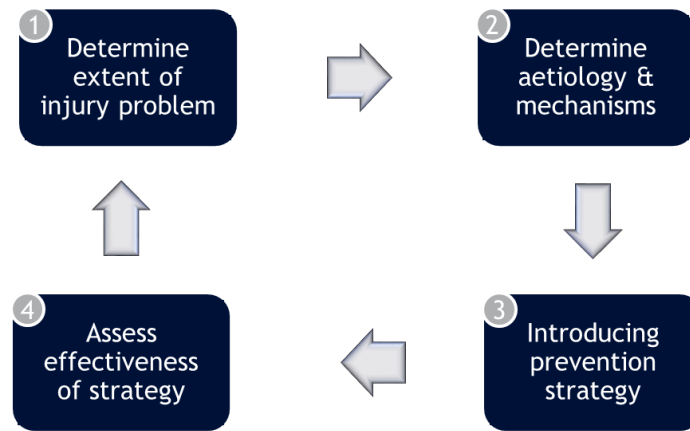


Figure 3 The sequence of prevention of sports injuries (adopted from van Mechelen et al. (1992)).

Groin injury epidemiology in football players

In 2015, Walden et al. published a systematic review on the epidemiology of groin injury in senior football players and compared injury occurrence between the sexes (Waldén et al., 2015). A total of 34 studies met the study criteria and were included. In April 2018, an updated literature search was performed. Studies were identified using the following search terms in the PubMed database: (football OR soccer) AND (groin inj* OR groin pain). Studies were included if they met the following criteria: (1) prospective design, (2) study period of at least one full season, (3) senior level and (4) full-text available in English. The following studies were excluded: (1) studies using the same cohort/study population, (2) studies with no available abstract, (3) studies in other football codes, (4) studies reporting only sub-types of groin injuries (e.g. only acute, overuse or adductor injuries), (5) studies on multiple sports where football-specific injury data could not be extracted and (6) studies on international tournaments or national teams.

A total of 253 studies were identified in the literature search. Of these, 207 were discarded after reviewing their titles and abstracts. The remaining 46 articles were assessed in detail, and 32 met the inclusion and exclusion criteria. The characteristics of the included studies are shown in tables 1 (males) and 2 (females).

Table 1 Groin injury frequency and rate of groin injury (injuries per 1000 h exposure) in male club football. Studies marked in *italic* are published after the Walden et al. (2015) review.

Study	Publication year	Country	Playing level	Seasons	Team seasons	Players	Injury definition	Groin injuries n (%)	Rate of groin injury (95% CI)
Ekstrand & Gillquist	1983	Sweden	IV	1	12	124	Time-loss	32 (13)	N/A
Engström et al.	1990	Sweden	I and II	1	3	64	Time-loss	10 (12)	N/A
Ekstrand & Hilding	1999	Sweden	IV	1	21	326	Time-loss	31 (8)	0.8 (0.6 to 1.1)
Hawkins & Fuller	1999	UK	Amateur ^b	3	12	108	Time-loss	62 (11)	N/A
Hawkins et al.	2001	UK	I to IV	2	182	2376	Time-loss	596 (10)	N/A
Arnason et al.	2004	Iceland	I and II	1	17	306	Time-loss	32 (13)	N/A
Walden et al.	2005	Sweden	I	1	14	310	Time-loss	114 (16)	N/A
Hägglund et al.	2006	Sweden	I	2	24	575	Time-loss	194 (16)	S1: 1.1 (0.9 to 1.4) S2: 1.3 (1.1 to 1.6)
Hägglund et al.	2007	Sweden	IV	1	10	241 ^a	Time-loss	12 (9)	N/A
Hägglund et al.	2009	Sweden	I	1	11	239	Time-loss	97 (18)	N/A
Engelbretsen et al.	2010	Norway	I to III	1	31	508	Time-loss	61 (12)	0.6 (0.4 to 0.7)
Sousa et al.	2013	Portugal	Amateur ^b	1	11	231	Time-loss	17 (8)	N/A
Bjørneboe et al.	2014	Norway	I	6	73	N/A	Time-loss	255 (11)	N/A
Hölmich et al.	2014	Denmark	V to VII	1	44	998	Combined ^c	58 (12)	0.4 (0.3 to 0.5)
Noya Scales et al.	2014	Spain	I	1	16	427	Time-loss	175 (14)	0.8 (0.7 to 0.9)
Noya Scales et al.	2014	Spain	II	1	11	301	Time-loss	144 (16)	0.6 (0.5 to 0.7)
Haxhiu et al.	2015	Kosovo	I	1	12	216	Time-loss	27 (17)	N/A
van Beijsterveldt et al.	2015	Netherlands	I	1	8	217	Time-loss	30 (11)	N/A
	2015	Netherlands	Amateur ^b	1	23	456	Time-loss	47 (11)	N/A
Gouttebarga et al.	2016	Australia	I	5	49	1127	Time-loss	88 (10)	N/A
Shalaj et al.	2016	Kosovo	I	1	11	143	Time-loss	22 (8)	N/A
Larruskain et al.	2018	Spain	I	5	5	50	Time-loss	63 (20)	1.6 (1.3 to 2.1)
Mosler et al.	2018	Qatar	I and II	2	N/A	606	Time-loss	206 (18)	1.0 (0.9 to 1.1)
Werner et al.	2018	Europe	I	15	268	7756	Time-loss	1812 (14)	1.0 (1.0 to 1.0)

^a Control group in a RCT. ^b The exact playing level was not defined. ^c The injury definition was a combination of medical attention and time-loss. S1 – season 1. S2 – season 2. CI – confidence interval. N/A – data were not available.

Table 2 Groin injury frequency and rate of groin injury (injuries per 1000 h exposure) in female's club football. The study marked in *italic* is published after the Walden et al. (2015) review.

Study	Publication year	Country	Playing level	Seasons	Team seasons	Players	Injury definition	Groin injuries n (%)	Rate of groin injury (95% CI)
Engström et al.	1991	Sweden	I and II	1	2	41	Time-loss	5 (6)	N/A
Österberg & Roos	2000	Sweden	I to V	1	8	123	Time-loss	5 (8)	N/A
Söderman et al.	2001	Sweden	II and III	1	13	146	Time-loss	4 (5) ^a	N/A
Faude et al.	2005	Germany	I	1	12	165	Time-loss	13 (5)	N/A
Jacobsen & Tegner	2006	Sweden	II	1	9	159	Time-loss	11 (5)	0.5 (0.3 to 0.8)
Jacobsen & Tegner	2007	Sweden	I	1	12	269	Time-loss	17 (7)	0.3 (0.2 to 0.5)
Tegnander et al.	2008	Norway	I	1	10	181	Time-loss	17 (9)	N/A
Häglund et al.	2009	Sweden	I	1	12	228	Time-loss	34 (11)	N/A
Gaulrapp et al.	2010	Germany	I	1	12	254	Time-loss	4 (2)	N/A
Nilstad et al.	2014	Norway	I	1	12	173	Time-loss	14 (8)	N/A
<i>Larruskain et al</i>	<i>2018</i>	<i>Spain</i>	<i>I</i>	<i>5</i>	<i>5</i>	<i>35</i>	<i>Time-loss</i>	<i>26 (16)</i>	<i>1.0 (0.7 to 1.5)</i>

^a Lower limb injuries only. CI – confidence interval. N/A – data were not available.

Male football

Of the studies identified in the literature, 23 reported groin injury data from senior elite male players. As shown in table 1, groin injuries account for 8% to 20% of all time-loss injuries in male football (Arnason et al., 2004; Bjørneboe et al., 2014; Ekstrand & Gillquist, 1983; Ekstrand & Hilding, 1999; Engebretsen et al., 2010; Engstrom et al., 1990; Gouttebauge et al., 2016; Hawkins & Fuller, 1999; Hawkins et al., 2001; Haxhiu et al., 2015; Hägglund et al., 2006, 2007, 2009a; Hölmich et al., 2014a; Larruskain et al., 2018; Mosler et al., 2018a; Noya Salces et al., 2014a; Noya Salces et al., 2014b; Shalaj et al., 2016; Sousa et al., 2013; van Beijsterveldt et al., 2015; Waldén et al., 2005; Werner et al., 2018). Only nine studies reported groin injury incidence, which varied between 0.4 and 1.6 per 1000 h of exposure (Ekstrand & Hilding, 1999; Engebretsen et al., 2010; Hägglund et al., 2006; Hölmich et al., 2014a; Larruskain et al., 2018; Mosler et al., 2018a; Noya Salces et al., 2014a; Noya Salces et al., 2014b; Werner et al., 2018). In the aforementioned systematic review, the authors reported aggregated analyses of groin injury incidence including previously unpublished data, which ranged from 0.2 to 2.1 groin injuries per 1000 h of exposure (Waldén et al., 2015). Finally, the match incidence rate ranged from 1.8 to 6.1 per 1000 h of exposure and was considerably greater than training incidence, which ranged from 0.3 to 1.3 (Engebretsen et al., 2010; Hägglund et al., 2006; Mosler et al., 2018a; Noya Salces et al., 2014a; Noya Salces et al., 2014b; Werner et al., 2018).

Few studies have reported specific diagnoses or clinical entities. One, categorizing injuries according to the Doha agreement, registered injuries among elite European clubs over a 15-season period (Werner et al., 2018). Adductor-related groin injuries accounted for almost two-thirds of all groin injuries, followed by iliopsoas-related injuries (Werner et al., 2018). Similar results have been reported in elite Qatari players. Most commonly, players were diagnosed with adductor-related groin pain (68%), followed by iliopsoas-related groin pain and pubic-related groin pain (Mosler et al., 2018a). Finally, at the Danish sub-elite level, adductor-related groin pain was considered the most frequent diagnosis, accounting for over half of reported groin injuries (Hölmich et al., 2014a).

Of the studies identified, eight categorised the injuries as acute or overuse (Arnason et al., 2004; Bjørneboe et al., 2014; Engebretsen et al., 2010; Engstrom et al., 1990; Hägglund et al., 2009a; Hölmich et al., 2014a; Mosler et al., 2018a; Werner et al., 2018). The findings are consistent with 60% to 73% of the injuries categorised as overuse injuries irrespective of level of play (Bjørneboe et al., 2014; Engebretsen et al., 2010; Engstrom et al., 1990; Hölmich et al., 2014a; Mosler et al., 2018a). However, the study among elite European players showed a somewhat lower proportion, with 51% classified as overuse injuries (Werner et al., 2018). In contrast, two studies have shown that acute injuries were more common, with only 21% and 31% of the injuries categorised as overuse injuries respectively (Arnason et al., 2004; Hägglund et al., 2009a).

Female football

Female players are considered to be at lower risk for groin injuries than males are; however, the reasons for these differences are unclear (Schache et al., 2017). Fewer studies have reported groin injury data in female footballers, and the majority are from the elite level. Only two studies used the comparable cohorts of males and females (Hägglund et al., 2009a; Larruskain et al., 2018). The results show that female players had lower injury rates compared to male players (Hägglund et al., 2009a; Larruskain et al., 2018). When including all studies reporting injury frequency in females, the proportion of groin injuries varied from 2% to 16% of all time-loss injuries (Engstrom et al., 1991; Faude et al., 2005; Gaulrapp et al., 2010; Hägglund et al., 2009a; Jacobson & Tegner, 2006, 2007; Larruskain et al., 2018; Nilstad et al., 2014; Söderman et al., 2001; Tegnander et al., 2008; Östenberg & Roos, 2000). Aggregated analyses from the aforementioned review describing the epidemiology of groin injury in senior football support this finding, identifying a more than two-fold higher rate in male footballers compared to female footballers (0.83 per 1000 h of exposure vs 0.35 per 1000 h of exposure, rate ratio: 2.4, 95% CI 2.0 to 2.9) (Waldén et al., 2015). However, a recently published study on 35 players over five seasons showed an incidence of 1.0 per 1000 h of exposure, indicating that injury rates may be higher than previously reported (Larruskain et al., 2018). Thus, in project 1, we wanted to compare the prevalence of groin problems among female players to male players at different competition levels.

Groin injuries - more than missing training or matches

As shown in tables 1 and 2, one study defined injury according to a combination of medical attention and time loss (Hölmich et al., 2014a). All other studies defined injuries according to various time-loss definitions; an injured player had to miss at least one upcoming training session or match, the next training session or match, miss the next day, miss the next 2 days or they did not specify their time loss definition (Arnason et al., 2004; Bjørneboe et al., 2014; Ekstrand & Gillquist, 1983; Ekstrand & Hilding, 1999; Engebretsen et al., 2010; Engstrom et al., 1990; Engstrom et al., 1991; Faude et al., 2005; Gaulrapp et al., 2010; Gouttebauge et al., 2016; Hawkins & Fuller, 1999; Hawkins et al., 2001; Haxhiu et al., 2015; Hägglund et al., 2006, 2007, 2009a; Jacobson & Tegner, 2006, 2007; Larruskain et al., 2018; Mosler et al., 2018a; Nilstad et al., 2014; Noya Salces et al., 2014a; Noya Salces et al., 2014b; Shalaj et al., 2016; Sousa et al., 2013; Söderman et al., 2001; Tegnander et al., 2008; van Beijsterveldt et al., 2015; Waldén et al., 2005; Werner et al., 2018; Östenberg & Roos, 2000).

However, a time-loss injury definition may be inappropriate for studying injuries with a large proportions of overuse injuries (Bahr, 2009). It is known that many players continue to participate with associated impairments or reduced performance, despite having groin-related complaints (Thorborg et al., 2014; Thorborg et al., 2015; Waldén et al., 2015). In a retrospective study on male

football players, almost 50% reported groin pain during the previous season (Thorborg et al., 2015). The data reported from injury surveillance studies may therefore only represent the ‘tip of the iceberg’, and the correct magnitude of groin injuries in football is still uncertain. To address this, the Oslo Sports Trauma Research Center (OSTRC) has developed a new method to improve the recording of sports injuries using an ‘all physical complaints’ approach in order to capture all cases leading to pain, decreased participation or decreased performance, not only those resulting in time loss (Clarsen et al., 2013). In project 1, we wanted to apply this method to assess the prevalence of groin problems in Norwegian footballers.

Risk factors for groin injury in football

An important step in van Mechelen et al.’s (1992) four-step sequence of injury prevention research is to establish the cause of the injury. This includes obtaining information on why a particular athlete may be at risk and how injuries happen. According to the risk factor model from Meeuwisse (1994), certain factors may influence the risk of sustaining an injury or predispose a player to injury. Risk factors for sports-related injuries are often categorised as intrinsic or extrinsic and modifiable or non-modifiable. The expanded version of the conceptual model (figure 4) illustrates the multifactorial nature of sports injuries, emphasising the relationship between intrinsic and extrinsic factors to the mechanisms of injury (Bahr & Krosshaug, 2005).

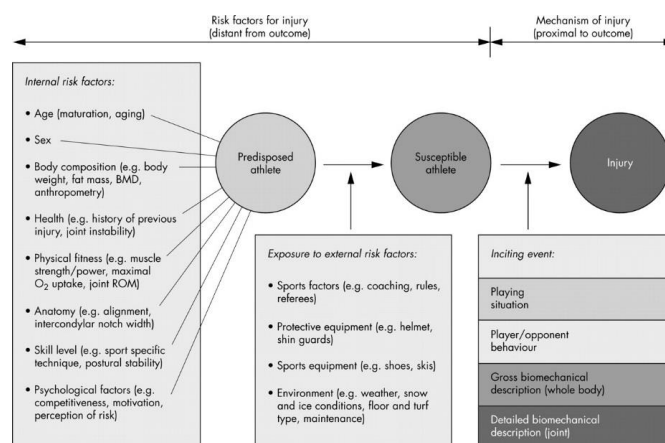


Figure 4 A comprehensive injury causation model based on Meeuwisse et al. (1994) and modified by Bahr and Krosshaug (2005). Reproduced with permission.

However, the models were made with acute injuries in mind, as the inciting event represents a single point in time. In contrast, overuse injuries are thought to be caused not by a single event but rather by a cumulative process over time. This is of particular interest in the case of groin injuries, as we know that the majority are overuse related (Bjørneboe et al., 2014; Engebretsen et al., 2010;

Engstrom et al., 1990; Hölmich et al., 2014a; Mosler et al., 2018a; Werner et al., 2018). Different models have been proposed to better describe the complex and multifactorial nature of sports injuries. Meeuwisse et al. (2007) suggested a modification to the model in the form of a dynamic, recursive injury model, acknowledging that previous linear models do not account for the dynamic and non-linear nature of injury risk.

In an attempt to describe the relationship of training workload to injury, Windt and Gabbett (2017) introduced 'the workload-injury aetiology model', which suggests that injuries will occur during training or competition workloads when players are exposed to external risk factors and potential inciting events. Bittencourt et al. (2016) have proposed an even more complex system (figure 5). This approach suggest to identify 'risk profiles' associated with injuries rather than individual risk factors alone. In this model, risk factors and potential interactions result in a 'web of determinants'. In each sporting context, one may use the model to determine patterns of relationships (interactions) between factors (regularities), what certain interactions produce (emerging patterns) as well as the regularities that may lead to injury (risk profile) (Bittencourt et al., 2016). Notably, multiple risk profiles may exist for the same outcome (i.e. injury) since individual risk factors within the web of determinants may have varying effects depending on other factors.

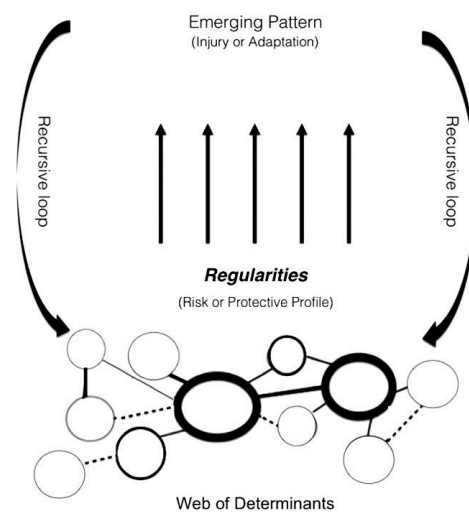


Figure 5 Complex model for sports injury. Factors associated with injuries form a web of determinants, and certain associations between these factors are regularities that contribute to an emerging pattern/outcome (in this case, injury). Figure from Bittencourt et al. (2016) with permission

In the following section, risk factors related to groin injuries in football are summarised. However, until now, studies have measured potential risk factors at a given point in time and have followed the players until injury, normally for one season. The effects of workloads and the complexity caused by changes in risk factors over time may therefore be missing from the picture.

Two recent systematic reviews have examined the potential risk factors for groin/hip injuries in field-based sports (Ryan et al., 2014) and among athletes in general (Whittaker et al., 2015). The most recent by Whittaker et al. (2015) updates a previous systematic review examining the risk factors for groin strain in sport (Maffey & Emery, 2007). A total of 30 unique studies are included in the two reviews, including the following sports: football (12 studies) (Arnason et al., 2004; Eirale et al., 2014; Ekstrand et al., 2011; Engebretsen et al., 2010; Häggglund et al., 2006, 2009a, 2013; Hölmich et al., 2010; Ibrahim et al., 2007; Le Gall et al., 2007; Steffen et al., 2008a; Witvrouw et al., 2003), Australian rules football (6) (Chalmers et al., 2013; Cowan et al., 2004; Crow et al., 2010; Gabbe et al., 2010; Orchard et al., 1998; Verrall et al., 2007), ice hockey (4) (Emery & Meeuwisse, 2001; Schick & Meeuwisse, 2003; Tyler et al., 2002; Tyler et al., 2001), multiple sports (4) (Jansen et al., 2010; Malliaras et al., 2009; Morrissey et al., 2012; Paajanen et al., 2011), swimming (1) (Grote et al., 2004), Gaelic football (1) (Nevin & Delahunt, 2014), rugby (1) (O'Connor, 2004) and cricket (1) (Orchard et al., 2010). An updated search identified only one study examining risk factors for groin injury in football players (Mosler et al., 2018b) published after the systematic reviews. In the following paragraphs, the risk factors for groin injury among football players, using data from 13 studies, are described.

Non-modifiable risk factors

Previous injury

Previous groin injury is the most consistently reported risk factor for groin injury in football (Arnason et al., 2004; Engebretsen et al., 2010; Häggglund et al., 2006, 2013; Hölmich et al., 2010; Mosler et al., 2018b; Steffen et al., 2008a). The suggested mechanisms underlying this risk factor are inadequate rehabilitation following initial injury, scar tissue formation or altered movement patterns after the injury (Ryan et al., 2014; Whittaker et al., 2015). Therefore, preventing the first groin injury and thorough, careful rehabilitation before returning to play are important.

Age

There is conflicting evidence in the literature regarding age as a risk factor for groin injury in football. In one large epidemiological study of professional European football players, an increased risk of injury was found in players aged 22 to 30 years (Ekstrand et al., 2011). In a study of Icelandic footballers, older players (>29 years of age) reported a higher risk of groin injury (Arnason et al., 2004). In contrast, several studies have shown that age is not a risk factor for groin injury (Engebretsen et al., 2010; Häggglund et al., 2006, 2013; Hölmich et al., 2010; Steffen et al., 2008a). Furthermore, one study shows that early maturing youth football players are prone to muscle strains in the groin (Le Gall et al., 2007). These players are chronologically the same age as their playing

Background

counterparts, but are biologically 'older' and therefore thought to be exposed to different intrinsic and extrinsic risk factors than their biologically 'younger' counterparts are (Le Gall et al., 2007).

Sex

The increased risk of groin injury for male players has already been discussed. The reasons for these gender differences are unclear but may include both intrinsic factors (anatomical differences or muscle strength) and extrinsic factors (training and match load or playing intensity) (Schache et al., 2017; Waldén et al., 2015).

Match-related risk factors

Match factors, like home/away games, match types, matches versus training and match results have shown to influence injury rates in football (Carling et al., 2010; Ekstrand et al., 2004; Hägglund et al., 2009b). In elite European football, it has been shown that adductor injuries are more likely to occur when playing matches, home games and domestic cup matches (Ekstrand et al., 2011; Hägglund et al., 2013). The reasons for these differences are unclear, but playing style or tactical approach may affect the risk of groin injury in games. For example, higher ball possession and time in attacking zones has been observed in home teams compared with away teams (Lago, 2009). Still, it is unclear whether this is linked to increased playing intensity or actions such as number of sprints or passes.

Level of play

Whether level of play increases the risk of groin injury is unclear. In a Danish study, players playing at a higher level almost tripled their risk of developing a groin injury (Hölmich et al., 2010), while in Norway, level of play did not affect the risk of injury (Engebretsen et al., 2010). Although the evidence is unclear, greater intensity in matches and training as well as more training hours may contribute to an increased risk of injury (Whittaker et al., 2015).

Playing position

There is conflicting evidence in the literature regarding playing position as a risk factor for groin injury in football. In a large prospective cohort study among elite male players in Europe, goalkeepers had a reduced risk of sustaining a groin injury compared to outfield players (Hägglund et al., 2013). However, studies from the Nordic countries have shown that playing position is not a risk factor (Engebretsen et al., 2010; Hölmich et al., 2010).

Modifiable risk factors

Hip adduction strength

Although reduced hip adduction strength is considered an important modifiable risk factor for groin injury in different team sports (Emery & Meeuwisse, 2001; Ryan et al., 2014; Whittaker et al., 2015),

only two studies have examined it in football players (Engebretsen et al., 2010; Mosler et al., 2018b). Engebretsen et al. (2010) examined isometric unilateral hip adduction strength using a hand-held dynamometer and classified adductor strength as weak or normal in a clinical examination using no equipment. Players assessed to have weak adductors in the clinical examination had a four-time higher injury risk compared to players with normal strength (Engebretsen et al., 2010). Results from a recently published study of elite male players also reported increased risk when examining eccentric hip adduction strength with a hand-held dynamometer (Mosler et al., 2018b). In contrast, Engebretsen et al. (2010) could not find adductor strength, as measured with a handheld dynamometer, to be significantly associated with risk of injury. The proposed reason for reduced muscle strength as a risk factor is that decreased levels of hip adductor strength may result in decreased muscle capacity and imbalances and increased risk of muscle injury during movements involving side-to-side cutting, striding, quick acceleration/deceleration and sudden directional changes (Whittaker et al., 2015).

However, Mosler et al. (2018b) highlighted an important problem when measuring adductor strength with a hand-held dynamometer. Measurement error when more than one tester performs the measurement is greater than the mean difference in strength between the injured and non-injured legs (Mosler et al., 2018b). Thus, Mosler et al. (2018b) conclude that the association is not strong enough to distinguish individual football players at risk, because the difference is potentially lower than the measurement error. Similarly, the isometric strength test, measured by several testers as in the Norwegian study, has shown large measurement error (Engebretsen et al., 2010; Kelln et al., 2008; Thorborg et al., 2010) and a potential systematic error when testers of different sexes and strengths perform the measurements (Thorborg et al., 2013). Another interesting finding from Qatar is that higher than normal eccentric hip adduction strength is associated with a greater risk of any hip/groin injury (Mosler et al., 2018b). Combined, Mosler et al.'s findings suggest that the mechanism of injury may be different for adductor-related groin injuries than for other categories of hip/groin injuries.

Hip range of motion

Results are conflicting on whether hip range of motion (ROM) is a risk factor for hip/groin injury. Both reduced hip adduction (Arnason et al., 2004) and reduced total hip ROM (internal rotation and external rotation combined) (Ibrahim et al., 2007) have shown to increase the risk of groin injury in football. However, in other studies performing the same measurements and other hip ROM tests, results have shown no difference in risk of injury (Arnason et al., 2004; Engebretsen et al., 2010; Witvrouw et al., 2003). In a recent systematic review examining hip ROM as a risk factor for athletes, total hip ROM was the factor most consistently related to groin pain (Tak et al., 2017). However, the

authors concluded that screening for hip ROM is unlikely to identify an athlete at risk of developing groin pain because of the small ROM differences found between injured and non-injured players as well as poor ROM measurement properties (Tak et al., 2017). Furthermore, recent investigations have found strong evidence that ROM is not a risk factor for groin injury (Mosler et al., 2018b).

Based on the current literature, reduced hip adduction strength may be considered the most important modifiable risk factor for groin injury, although there is some uncertainty in the measurement methods. Previous groin injury is the most consistently reported non-modifiable risk factor. Thus, preventive measures should be introduced early in youth football, aiming to prevent the first injury. Furthermore, strengthening the hip adductors should be specifically targeted through preventive training.

Muscle and tendon response to strength training

In the following section, responses to strength training are discussed, mainly concentrating on muscle and tendon effects.

Muscle-tendon unit hypertrophy

The characteristic increase in muscle size following strength training is extensively reported in the literature; increases in cross-sectional muscle area and volume are about 5% to 15% with 8 to 14 weeks training (Aagaard et al., 2001; Blazevich et al., 2007; Erskine et al., 2010; Narici et al., 1989; Wilkinson et al., 2006). Hence, muscle hypertrophy results primarily from a training-induced increase in muscle fibre's cross-sectional area. Commonly, hypertrophy occurs faster in type II fibres than type I (Aagaard et al., 2001; Andersen & Aagaard, 2000; Wilkinson et al., 2006).

An increased cross-sectional muscle area requires an expansion of the intramuscular collagen network. In coordination with muscle hypertrophy, strength training stimulates skeletal muscle collagen synthesis, and training-induced muscle hypertrophy is accompanied by a proportional increase in intramuscular connective tissue (Holm et al., 2010; Moore et al., 2005).

In addition to the increase in cross-sectional muscle fibre area, it has been shown that strength training induces an increase in myofibrillar cross-sectional area (MacDougall et al., 1980; MacDougall et al., 1979). Myofibrillar growth is considered to arise from the addition of contractile proteins to the periphery of a myofibril (Morkin, 1970). The increase in myofibrillar cross-sectional area contributes to the increase in muscle fibre area; however, the discrepancy between increases in cross-sectional muscle fibre area and myofibrillar area indicates that additional adaptations occur.

The evidence for tendon hypertrophy in response to strength training is unclear. Hypothetically, strength training could increase cross-sectional tendon size via increases in strength imposing

progressively greater mechanical loads to the tendons. This could initiate signalling cascades that stimulate cells located in the tissue to increase the production of extracellular matrix, ultimately leading to tendon hypertrophy (Svensson et al., 2016). Several studies have documented a modest increase in the cross-sectional area of either the Achilles or patellar tendon (Arampatzis et al., 2007; Bohm et al., 2014; Farup et al., 2014; Kongsgaard et al., 2007; Seynnes et al., 2009). Conversely, there are other studies showing no changes in either the Achilles or patellar tendon's cross-sectional area after periods of strength training (Arampatzis et al., 2010; Bloomquist et al., 2013; Kubo et al., 2012; Kubo et al., 2007; Kubo et al., 2006).

Tendon stiffness

Strength training has been demonstrated to increase tendon stiffness, and it seems that maximizing tendon strain may be necessary to optimize the adaptive response (Arampatzis et al., 2007; Malliaras et al., 2013). Tendon stiffness affects the time required to stretch the series elastic component and therefore affects both the electromechanical delay and the rate of force development, thus enhancing the rapid application of force (Folland & Williams, 2007).

Muscle architecture

Several studies have found a relationship between different muscle size indices and the angle of fibre pennation (Abe et al., 1998; Ichinose et al., 1998; Kawakami et al., 1993). This indicates that hypertrophy involves an increase in the angle of fibre pennation, which might reduce muscle contraction velocity (Folland & Williams, 2007). As the angle of fibre pennation increases, there is increased packing of muscle fibres within the same cross-sectional area, but less force from each fibre is transferred to the tendon due to their increasingly oblique angles of pull. Therefore, the effect of the fibres' pennation angles on strength may be a trade-off between these two factors (Folland & Williams, 2007).

Repeated eccentric contractions lead to exercise-induced muscle damage, which activates the repair process that leads to the addition of sarcomeres aligned in series, leading to increased fascicle length (Proske & Morgan, 2001). It has been proposed that this increase in serial sarcomeres accounts for a right shift in a muscle's force-length relationship curve (Bourne et al., 2017; Brockett et al., 2001). The shift in the force-length relationship curve indicates increased strength towards full stretch of the muscle, consequently reducing susceptibility to injury (Bourne et al., 2017; Brockett et al., 2001).

Satellite cells

Several studies have demonstrated an increase in satellite cell population after strength training (Kadi et al., 2004; Kadi & Thornell, 2000; Roth et al., 2001), and a recent study showed an increase in the number of satellite cells within four days of a single bout of eccentric high-load training (Crameri

et al., 2004). Satellite cells have the potential to provide additional myonuclei to their parent muscle fibres (Kadi et al., 2004). Upon activation, the cells can re-enter the cell cycle to proliferate and differentiate into myoblasts (Siegel et al., 2011).

Neural adaptation

The disproportionate increase in muscle strength rather than size, particularly in the early stages, indicates that initial adaptations to strength training may be neural in nature (Douglas et al., 2016). Previous studies have demonstrated significant changes in motor unit discharge rates (Patten et al., 2001), muscle fibre conduction velocity (Vila-Cha et al., 2012) and the rate of force development after strength training (Cadore et al., 2014; Patten et al., 2001). Collectively, these studies show that increased strength following strength training can be attributed to both supraspinal and spinal adaptations (Aagaard et al., 2002b). However, much of the evidence on neurological adaptation comes from indirect evidence that could be questioned both methodologically and neurophysiologically (Folland & Williams, 2007).

Prevention of groin injuries in football

In the third step of the injury prevention cycle, van Mechelen et al. (1992) suggest introducing measures to reduce the future risk of injury based on the risk factors and injury mechanisms identified in step two. In the following chapter, previous interventions aiming to reduce groin injuries are discussed. Of particular interest are the exercise selection and its relation to the important modifiable risk factor reduced hip adduction strength.

To identify studies examining the effect of groin injury prevention exercises in football, a systematic literature search was performed in April 2018. Studies were identified using the following search terms in the PubMed database: (football OR soccer) AND (prevent* OR train*) AND (groin OR injur*). Studies were included if they met the following criteria: (1) randomised or cluster-randomised controlled trial and (2) full text available in English. The following studies were excluded: (1) studies not reporting groin data, (2) studies not examining the effects of exercise or exercise programmes and (3) studies in other football codes.

A total of 156 studies were identified, of which 134 were discarded after reviewing the titles and abstracts. The remaining 22 articles were assessed in detail, and six met the inclusion and exclusion criteria. The characteristics of the included studies are shown in table 3.

Table 3 Overview of trials examining the effect of exercises programmes on the rate of groin injuries among football players.

Study	Population	Players (N)	Intervention	Compliance	Groin injuries (N)	Results
Engelbrechtsen et al. 2008	Male ^a	I: 62 C: 98	15 min program, 3 times a week. Combination of adductor and abdominal strength, jumping, and coordination exercises.	19.4% of the players completed 20 sessions or more (defined as compliant)	I: 11 C: 16	No significant difference in the number of groin injuries
Hölmich et al. 2010	Male amateur	I: 477 C: 430	13 min program, during regular training. Combination of adductor and abdominal strength, jumping, coordination exercises, and stretching.	Not reported	I: 23 ^b C: 30 ^b	A 31% non-significant reduction in risk of groin injury
Steffen et al. 2008	Female youth	I: 1073 C: 947	20 min 'The FIFA 11' every training for 15 sessions, thereafter once a week.	Teams performed 52% (67% player attendance) of the prescribed sessions;	I: 6 C: 14	No significant effect of the injury prevention program on the injury rate
van Beijsterveldt et al. 2012	Male amateur	I: 223 C: 233	20 min 'The FIFA 11' each training session.	Teams performed 73% (71% player attendance) of the prescribed sessions	I: 20 C: 23	No significant difference in the overall injury incidence or severity
Silvers-Granelli et al. 2015	Male collegiate	I: 675 C: 850	20 min 'The FIFA 11+' as warm-up three times per week throughout the season.	Teams performed 30.5±12.2 of the prescribed session (defined as moderate)	I: 48 C: 23	Significantly lower rate of groin injuries
Soligard et al. 2008	Female youth	I: 1055 C: 837	20 min 'The FIFA 11+' as warm-up for every training session and running exercises as part of warm-up prior to every match.	Teams performed 77% (60% player attendance) of the prescribed sessions	I: 10 ^c C: 9 ^c	No significant difference in incidence of hip and groin injuries

^a The exact playing level was not defined. ^b Groin injury data from Esteve et al (2015) ^c Hip and groin injuries. I – Intervention group and C – Control group.

Different strategies, but no clear effect on groin injury rates

As shown in table 3, different exercises to prevent groin injuries have been introduced. The identified studies can be divided into two categories: (1) structured exercise programmes (Silvers-Granelli et al., 2015; Soligard et al., 2008; Steffen et al., 2008b; van Beijsterveldt et al., 2012) and (2) groin-specific exercise programmes (Engebretsen et al., 2008; Hölmich et al., 2010).

The most promising results have been seen in the structured exercise programmes. The two studies examine the effect from the FIFA 11 did not show any reduction in groin injury rates (Steffen et al., 2008b; van Beijsterveldt et al., 2012). A recent systematic review and meta-analysis indicates that the revised version of the FIFA 11, FIFA 11+, may have a preventive effect on hip and groin injuries (Thorborg et al., 2017). However, this analysis was based on only two studies. A significant reduction in groin injury rates was observed in male collegiate players (Silvers-Granelli et al., 2015), while there was no difference in a study of young female players (Soligard et al., 2008).

Two studies have examined the effect of exercises similar to the ones used to successfully in management of longstanding adductor-related groin pain in athletes (Hölmich et al., 1999). Although a promising 31% reduction in the risk of groin injury rate was found among male Danish amateur players, none of the studies showed a significant effect on groin injury rates (Engebretsen et al., 2008; Hölmich et al., 2010).

Exercise selection

The FIFA 11 programme consisted of exercises focusing on core stability, balance, dynamic stabilisation and eccentric hamstring strength. The FIFA 11+ programme (figure 6) is a revised version of FIFA 11 and includes key exercises focused on enhancing the most important and modifiable injury risk factors as well as additional exercises to provide variation and progression. It also includes a new set of structured running exercises that make it better suited as a comprehensive warm-up programme for training and matches (Soligard et al., 2008). Several studies have explored the training effects of the programme on knee strength (Brito et al., 2010; Daneshjoo et al., 2013a; Impellizzeri et al., 2013; Reis et al., 2013), sprinting and jumping performance (Daneshjoo et al., 2013b; Impellizzeri et al., 2013; Kilding et al., 2008; Reis et al., 2013), lower extremity balance (Daneshjoo et al., 2012; Steffen et al., 2013), core stability (Impellizzeri et al., 2013) and knee proprioception (Daneshjoo et al., 2012). As mentioned above, reduced hip adduction strength has been shown to be an important modifiable risk factor for groin injuries. However, when looking at the exercises in the programme (figure 6), it seems that none specifically target hip adduction strength. Thus, in Paper II, we wanted to examine the hip adduction strength effect of FIFA 11+.

FIFA 11+

PART 1 RUNNING EXERCISES - 8 MINUTES

 <p>1 RUNNING STRAIGHT AHEAD</p> <p>The coach instructs 6 to 10 pairs of parallel cones, approx. 5 metres apart. Two players start at the same time from the 1st pair of cones, log together at the ends to the 2nd pair and so on. On the 6th pair, players measure your speed progressively as you reach up. 2 sets</p>	 <p>2 RUNNING HIP OUT</p> <p>Run on big body, stepping at each pair of cones to lift your knee and rotate your hip outwards. Alternate between left and right legs at successive cones. 2 sets</p>	 <p>3 RUNNING HIP IN</p> <p>On a pair of cones, stepping at each pair of cones to lift your knee and rotate your hip inwards. Alternate between left and right legs at successive cones. 2 sets</p>
 <p>4 RUNNING CIRCLING PARTNER</p> <p>Run forwards in pairs to the first pair of cones. Shuffle sideways by 90 degrees to meet the middle. Shuffle as you circle around one another and then shuffle back to the cones. Repeat backwards on partners. There are 6 pairs of cones. Run and keep your arms or hands on your hips and knees. 2 sets</p>	 <p>5 RUNNING SHOULDER CONTACT</p> <p>Run forwards in pairs to the first pair of cones. Shuffle backwards by 90 degrees to meet in the middle. Jump sideways towards each other to make shoulder-to-shoulder contact. Touch forearms, you and your partner with your hands behind your back. Do not let your knees lift upwards. Shuffle a 1.8 metre and repeat the drill on the next pair of cones. 2 sets</p>	 <p>6 RUNNING QUICK FORWARDS & BACKWARDS</p> <p>On a pair of cones, quickly to the second pair of cones then run backwards quickly to the first pair of cones keeping your legs and knees slightly bent. Only repeat the drill once. Shuffle as you circle around one another and then shuffle back to the cones. Repeat backwards on partners. There are 6 pairs of cones. Run and keep your arms or hands on your hips and knees. 2 sets</p>

PART 2 STRENGTH - PLYOMETRICS - BALANCE - 10 MINUTES

<p>LEVEL 1</p>  <p>7 THE BENCH STATIC</p> <p>Starting position: Lie on your front, supporting yourself on your forearms and feet. Your elbow should be directly under your shoulder. Exercise: Lift your feet and hold the position for 30-35 sec. Your body should be in a straight line. Try not to wiggle or wobble. 3 sets</p>	<p>LEVEL 2</p>  <p>8 SIDEWAYS BENCH RAISE & LOWER HIP</p> <p>Starting position: Lie on your front, supporting yourself on your forearms and feet. Your elbow should be directly under your shoulder. Exercise: Lift your feet and hold the position for 30-35 sec. Your body should be in a straight line. Try not to wiggle or wobble. 3 sets</p>	<p>LEVEL 3</p>  <p>9 HAMSTRINGS ADVANCED</p> <p>Starting position: Lie on your front, supporting yourself on your forearms and feet. Your elbow should be directly under your shoulder. Exercise: Lift your feet and hold the position for 30-35 sec. Your body should be in a straight line. Try not to wiggle or wobble. 3 sets</p>
 <p>10 SINGLE-LEG STANCE HOLD THE BALL</p> <p>Starting position: Stand on one leg. Exercise: Hold the ball with both hands. Keep your body straight and your feet together. 3 sets</p>	 <p>11 SQUATS WALKING LUNGES</p> <p>Starting position: Stand with your feet hip-width apart. Exercise: Perform a lunge, then a squat, then a lunge, then a squat. 3 sets</p>	 <p>12 JUMPING BOX JUMPS</p> <p>Starting position: Stand on one leg. Exercise: Jump up and land on the box. 3 sets</p>
 <p>13 RUNNING ACROSS THE PITCH</p> <p>Run across the pitch, from one side to the other, at 75-80% maximum pace. 2 sets</p>	 <p>14 RUNNING BOUNDING</p> <p>Run with high bounding steps with a high knee. Feet land gently on the ball of your foot. 2 sets</p>	 <p>15 RUNNING PLANT & CUT</p> <p>On a pair of cones, quickly to the second pair of cones then run backwards quickly to the first pair of cones keeping your legs and knees slightly bent. 2 sets</p>

PART 3 RUNNING EXERCISES - 2 MINUTES

 <p>13 RUNNING ACROSS THE PITCH</p> <p>Run across the pitch, from one side to the other, at 75-80% maximum pace. 2 sets</p>	 <p>14 RUNNING BOUNDING</p> <p>Run with high bounding steps with a high knee. Feet land gently on the ball of your foot. 2 sets</p>	 <p>15 RUNNING PLANT & CUT</p> <p>On a pair of cones, quickly to the second pair of cones then run backwards quickly to the first pair of cones keeping your legs and knees slightly bent. 2 sets</p>
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Figure 6 Overview of the different exercises included in the FIFA 11+ warm-up programme.

Background

The two groin-specific injury prevention programmes included a combination of adductor and abdominal strength, jumping, coordination exercises and stretching. Exercises included in the programmes are shown in table 4 and figure 7.

Table 4 Exercises included in the groin-specific programme from Engebretsen et al. (2008).

Warm-up	Keeping a ball between extended legs, pushing the legs together for 15 s while lying on the ground. Repeated 10 times.
	Similar exercise. The only difference is having the knees flexed and placing the ball between the knees.
Transverse abdominal muscles	Lie facing the ground resting on the forearms and toes in a straight position while contracting the abdominal muscles by 'forcing the umbilicus inwards'. Performed for 20 s and repeated 5 times.
Sideways jumping	Knee-over-toe position while jumping sideways with arms resting on the hips.
Sliding	Wearing only socks, alternately slide one leg away and towards the other, which is bearing the weight. The exercise can be performed both sideways and diagonally for 30–60 s before switching legs.
Diagonal walking	One-leg exercise of flexing and extending knee and swinging the arms (crosscountry skiing) rhythmically; 5x15 times for each leg.

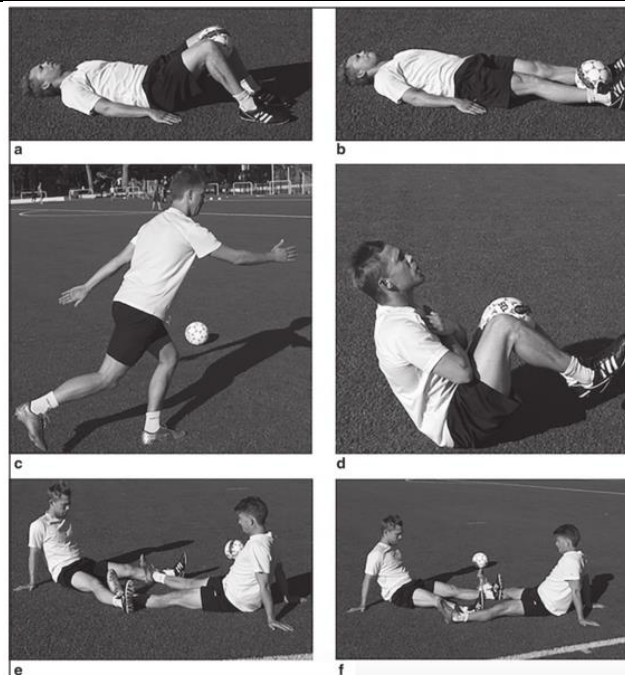


Figure 7 The six exercises included in Hölmich et al.'s (2010) prevention programme. a: isometric adduction against a football placed between the knees; b: isometric adduction against a football placed between the ankles; c: crosscountry skiing on one leg; d: folding knife; e: adduction partner, performed by the partner to the left; f: abduction partner, performed by the player to the left. Figure from Krommes et al. (2017) with permission.

Suggested explanations for the lack of effect on groin injury rates are insufficient exercise intensity or specificity. Results from studies on muscle activation patterns (Delmore et al., 2014; Krommes et al., 2017; Serner et al., 2014) indicate sufficient activation of the adductor longus from the exercises included in the two groin-specific programmes. However, there is no data on hip adduction strength effects. As described, most groin injuries in football affect the adductors (Hölmich et al., 2014a; Mosler et al., 2018a; Werner et al., 2018), specifically the adductor longus muscle or tendon insertion into the pubic bone (Branci et al., 2014b; Branci et al., 2013; Hölmich, 2007; Hölmich et al., 2014a; Serner et al., 2018a). Thus, specific exercises, targeting the adductor longus and the important modifiable risk factor of reduced hip adduction strength may be an alternative approach to reducing groin injury rates.

After the two groin-specific programmes were designed, more data on hip adduction exercises have been published. Different studies have examined adductor longus activation in different hip adduction specific exercises. Delmore et al. (2014) found that the side-lying hip adduction exercise, adductor squeeze (45°) and side lunges generated the highest activation levels, while standing hip adduction on a Swiss ball, rotational squats and sumo squats ranked lower. Examining six traditional and two new exercises, Serner et al. (2014) found that the adductor squeeze (45°), the Copenhagen Adduction exercise (CA) and hip adduction with an elastic band generated the highest activation. Finally, Krommes et al. (2017) examined the activation from the six exercises included in the Hölmich prevention programme. Results showed that the adductor squeeze (45°), adduction partner exercise and adductor squeeze (0°) had the highest activation levels. There is not much data on strength effects from hip adduction exercises, but the Danish group have performed two trials examining the effects from the CA (Ishøi et al., 2015) and hip adduction with an elastic band (Jensen et al., 2014). Both exercises are, in contrast to the adductor squeezes (0° and 45°), full-range exercises. Following intensive eight-week protocols, the CA led to a 36% increase in eccentric hip adduction strength (Ishøi et al., 2015), while hip adduction using an elastic band led to a 30% increase in strength (Jensen et al., 2014). Both exercises require no or minimal equipment, which make them easy to implement during training. Thus, they seem promising for the prevention of adductor-related injuries. In Paper III, we therefore wanted to examine the effect of a new Adductor Strengthening Programme, based on the CA, on the prevalence of groin problems.

Compliance with the exercise programmes

It is well known that player compliance with injury prevention programmes represents a challenge (Bahr et al., 2015; McCall et al., 2016; van Beijsterveldt et al., 2013). The effect of several injury prevention programmes is well known, and poor compliance may be a gap between science and best practice. Compliance with sport injury prevention interventions in randomised controlled trials

(RCTs) is registered and reported using different methods (van Reijen et al., 2016). Individual compliance registers to what degree each player follows the prescribed intervention, while team compliance registers to what degree the team follows the prescribed intervention. Among the six studies examining the preventive effect on groin injury rates (table 3), five reported compliance (Engebretsen et al., 2008; Silvers-Granelli et al., 2015; Soligard et al., 2008; Steffen et al., 2008b; van Beijsterveldt et al., 2012). However, the interpretation and comparison of the reported data is difficult. One study reported individual compliance (Engebretsen et al., 2008), one reported team compliance (Silvers-Granelli et al., 2015) and three reported both (Soligard et al., 2008; Steffen et al., 2008b; van Beijsterveldt et al., 2012). Furthermore, two of the studies did not report the total number of prescribed sessions, and the authors' interpretation of compliance is only registered as low, moderate or high (Engebretsen et al., 2008; Silvers-Granelli et al., 2015). In summary, the reported compliance was insufficient in both studies examining the effect of groin-specific exercise programmes; while three (Soligard et al., 2008; Steffen et al., 2008b; van Beijsterveldt et al., 2012) of the four (Silvers-Granelli et al., 2015; Soligard et al., 2008; Steffen et al., 2008b; van Beijsterveldt et al., 2012) studies examining the effect of FIFA 11/11+ provided sufficient data. An overview of the reported compliance in the different trials can be found in table 3.

The RE-AIM framework has been developed to describe five key components of successful implementation: Reach, Efficacy, Adoption, Implementation and Maintenance (Glasgow et al., 1999). The framework is a useful tool that allows decision-makers to assess how interventions are implemented in practice and their impact at the individual and organisational levels. Furthermore, it can help determine which interventions are feasible in real-world settings (Glasgow et al., 1999; O'Brien & Finch, 2014a, 2014b). A systematic review concludes that information on the RE-AIM components in published trials on injury prevention exercise programmes is insufficient, especially regarding adoption and maintenance (O'Brien & Finch, 2014b). At the elite European level, it has been shown that players' compliance with prevention programmes is low, despite coaches being positive (McCall et al., 2016). By using the RE-AIM framework to evaluate the players' experiences with the implementation of the Adductor Strengthening Programme, we may reveal factors that are important for successful dissemination. Thus, in Paper IV, we wanted to examine the players' experiences with the implementation of the Adductor Strengthening Programme used in Paper III.

Aims of the thesis

1. Apply the OSTRC Overuse Injury Questionnaire to assess the prevalence of groin problems in Norwegian footballers of both sexes and across different levels of play (Paper I).
2. Investigate the effect on eccentric hip adduction strength of the FIFA 11+ warm-up program with or without the Copenhagen Adduction exercise (Paper II).
3. Test the effect of a single-exercise approach, based on the Copenhagen Adduction exercise, on the prevalence of groin problems in male football players (Paper III).
4. Use the RE-AIM framework to examine the players' experiences with the implementation of the Adductor Strengthening Programme among male sub-elite football players. Furthermore, we investigated player attitudes towards groin injury prevention (Paper IV).

Methods

The four papers included in this dissertation result from four separate research projects. In all projects, players were identified as potential participants based on their membership to a team. There were no exclusion criteria except for players in Paper III who were injured or ill and did not expect to return to normal training within six to eight weeks from the time of inclusion.

Design, participants and interventions

Groin problems among Norwegian football players (Paper I)

The first paper was the result of a six-week prospective cohort study among players from both sexes and different levels of Norwegian football. We used the OSTRC Overuse Injury Questionnaire (OSTRC-O) to examine the extent of groin problems.

A total 240 players from 15 teams at four different levels of play were recruited in order to examine the prevalence of groin problems across three elite female teams (45 players), three elite male teams (49 players), three sub-elite male teams (57 players), three amateur male teams (45 players) and three U19 elite male teams (44 players). This was a convenience sample with teams recruited through our personal network.

Strength and sprint effects of the FIFA 11+ (Paper II)

In Paper II, we examined the effect of the FIFA 11+ warm-up programme on strength and sprint time among 45 players from two U19 elite male football teams in an eight-week RCT.

Intervention procedure

Players were individually randomised into two groups; one group carried out the standard FIFA 11+ programme (NH group), while the other carried out the FIFA 11+ but replaced the Nordic Hamstring exercise (NH) with the CA (CA group). The exercise prescription for the CA was the same as that for the NH in the FIFA 11+ programme, but performed separately on each side (table 5) (Soligard et al., 2008). Both groups performed the intervention three times weekly for eight weeks.

Table 5 Exercise prescription for the Nordic hamstring and Copenhagen Adduction exercises.

Level	Weekly sessions	Number of sets	Number of repetitions
Beginner			3-5
Intermediate	3	1	7-10
Advanced			12-15

Prevention of groin problems among male football players (Paper III)

In Paper III, we invited male teams playing on the second and third levels of Norwegian football to participate in a 28-week cluster RCT. Of the 47 teams invited, 35 agreed to participate, comprising 652 players. Teams were cluster-randomised into an intervention group performing the Adductor Strengthening Programme (18 teams, 339 players) and a control group continuing normal training (17 teams, 313 players).

Intervention procedure

The Adductor Strengthening Programme consisted of a single exercise with multiple levels of difficulty. The programme was based on the CA. As the exercise might be painful or difficult for symptomatic players, we created two easier levels that players could choose from—Level 1 (easiest): side-lying hip adduction, Level 2 (moderate): the CA as previously described (Sermer et al., 2014) but with a shorter lever arm and Level 3 (hardest): the CA as previously described (Sermer et al., 2014) (Figure 8).

Exercise prescription

Players were asked to start at Level 3. However, if they experienced groin pain during the exercise greater than 3 on an 11-point numeric rating scale (NRS) (0–10, where 0 = no pain and 10 = maximal pain) (Hawker et al., 2011), they were instructed to perform at Level 2. Similarly, if Level 2 provoked pain > 3, the player was instructed to perform at Level 1. The exercise was performed on both sides.

Table 6 Training protocol for the Adductor Strengthening Programme.

Week	Weekly sessions	Sets per side	Repetitions per side
Pre-season			
- Week 1	2	1	3-5
- Week 2	3	1	3-5
- Week 3-4	3	1	7-10
- Week 5-6	3	1	12-15
- Week 7-8	2	1	12-15
In season	1	1	12-15

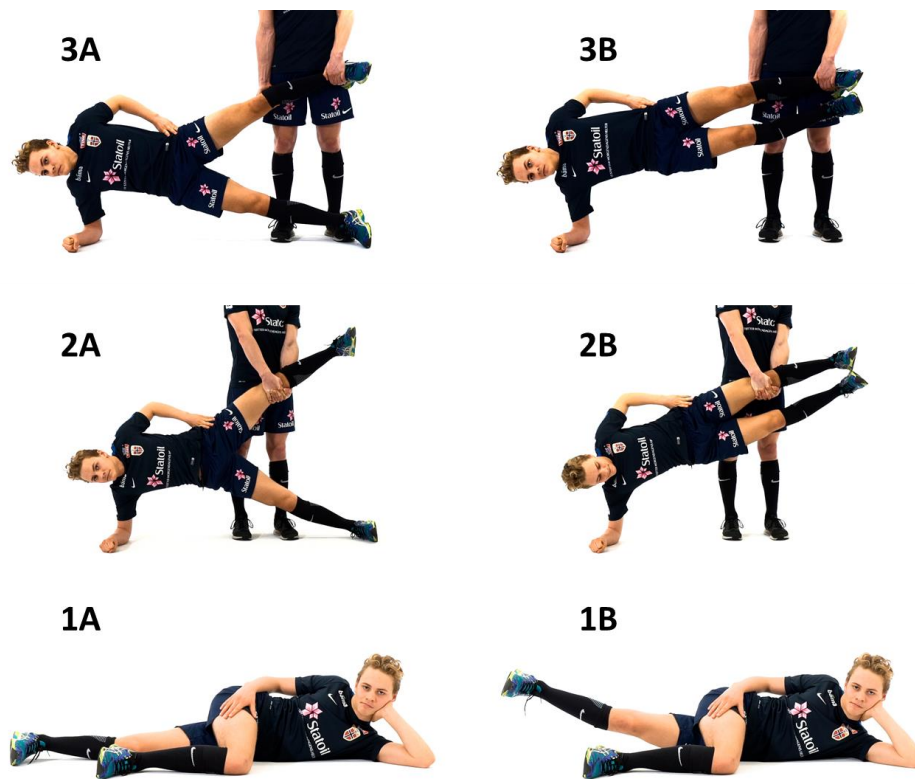


Figure 8 A) Starting/ending positions and B) mid positions for the different levels of the Adductor Strengthening Programme.

Teams in the intervention group were asked to perform the programme as a part of their regular warm-up two to three times a week during a six to eight week period of the pre-season and maintain the programme once per week throughout the regular season (table 6).

Attitudes and beliefs about groin injuries (Paper IV)

Paper IV was the result of an observational study examining the implementation of the Adductor Strengthening Programme and investigated players' attitudes towards groin injury prevention. A total of 501 of the 652 players who enrolled in Paper III agreed to participate.

Data collection methods

OSTRC-O (Papers I and III)

In Papers I and III, we used the OSTRC-O to register groin symptoms. In the first paper, we modified the original questionnaire from Clarsen et al. (Clarsen et al., 2013) and asked four questions regarding the consequences of groin problems on football participation, training volume, performance and pain. We also included a question about the onset of the reported groin problem

(acute or gradual) and asked which leg was affected. Finally, we asked three questions about football training and match exposure. The complete questionnaire is available in Appendix IX. We used the same modified version of the questionnaire in Paper III.

Questionnaire administration

The questionnaire was distributed using a smartphone application (Spartanova; Spartanova NV, Ghent, Belgium). Each player received a notification through the smartphone application to complete the questionnaire every Sunday evening and received an SMS notification every Monday. Non-responders received an SMS reminder the following Thursday. As an additional strategy to increase response rates in Paper I, we asked non-responders to complete the questionnaire on paper during a training session in the subsequent week. In Paper III, players who failed to respond through the smartphone application were contacted by telephone and asked to complete the questionnaire verbally. Furthermore, during the last four weeks of the data collection period, we visited each team and asked players to retrospectively respond to the questionnaire for weeks with missing responses from the start of the regular season to the beginning of September.

Categorising reported groin problems

Players were categorised as having a groin problem if they recorded any hip or groin symptoms in the questionnaire, including 'pain, ache, stiffness, clicking/catching or other complaints related to the groin', or if they reported reduced training participation, volume or performance due to groin problems. Players were categorised as having a substantial groin problem if they reported moderate or severe reductions in training volume or football performance or a complete inability to participate due to groin problems.

Outcome measures

The primary outcome measure was the weekly prevalence of all groin problems registered during a six-week period with match congestion (Paper I) and during the 28 weeks of the regular season (Paper III). The secondary outcome measure was the weekly prevalence of substantial groin problems registered during the same periods.

Each week, we calculated the prevalence of all groin problems and substantial groin problems by dividing the number of reported problems by the number of questionnaire respondents. At the end of the registration period, the average prevalence of all problems and substantial problems was calculated with the corresponding 95% confidence interval (CI). Finally, we calculated the cumulative incidence for all groin problems and substantial groin problems as the number of new cases for each during the study period divided by the number of players included in the analysis.

Methods

Strength and sprint testing (Paper II)

All tests were performed four days prior to the first training session in the intervention period (January 2016) and within the four days after completing the last training session (March 2016). The players performed eccentric strength tests and a 20 m sprint test. All players performed a warm-up of 15 min of light running (11 km/h) on a treadmill (PRO, Woodway, Waukesha, Wisconsin, USA). Strength and performance tests were administered in the same order, pre- and post-intervention, starting with the eccentric hip adduction strength test, the 20 m sprint test and finishing with the eccentric knee flexor strength test.

A physiotherapist assigned to each team registered weekly compliance with the warm-up programme for each player, football training and match exposure as well as weekly maximal delayed-onset muscle soreness (DOMS) in the adductor and hamstring muscles using an 11-point NRS (0–10) (Hawker et al., 2011).

Eccentric hip adduction strength

The test setup included a portable hand-held dynamometer (Hoggan microFET2; Hoggan Scientific, Salt Lake City, Utah, USA) and an examination table. The dominant and non-dominant legs were tested on all players. Eccentric hip adduction strength was measured in a break test with the player in a side-lying position with the tested leg in a straight position, as described by Thorborg et al. (2011a). The player was asked to complete one practice trial before performing three maximal tests, and the best result of the three was retained.

Leg length was measured in the supine position from the most prominent point of the anterior superior iliac spine to 5 cm proximal to the most prominent point of the medial malleolus. Leg length was used to calculate torque and was adjusted to body mass (Nm/kg).

Eccentric knee flexor strength

Eccentric knee flexor strength was measured using a NordBord (VALD Performance; Brisbane, Australia), as described by Opar et al. (2013a). The players were asked to perform one practice trial before performing one set of three maximal repetitions. All force values were body-mass adjusted (N/kg). The best of the three maximal trials was retained.

20 m sprint time

The 20 m sprint tests were performed on an indoor 8-mm Mondotrack FTS surface (Mondo, Conshohocken, Pennsylvania, USA) using a Newtest Powertimer portable system (Ele-Products Oy, Tyrnävä, Finland) using infrared photocells (Model 300s) mounted on the track and connected to a computer that measured to the nearest 0.001 s. Players performed two sub-maximal 20 m sprints before maximal sprint testing. Maximum running speed (s) was tested by sprinting 3 x 20 m with 4-6

min of recovery between trials. Time was measured for every 5 m, and the best results (0-5 m, 0-10 m, 0-15 m and 0-20 m) were retained for analyses.

Outcome measures

The primary outcome in Paper II was eccentric hip adduction strength (Nm/kg). Secondary outcomes were eccentric knee flexor strength (N/kg) and 0-5 m, 0-10 m, 0-15 m and 0-20 m sprint times (s).

Questionnaire on attitudes and beliefs (Paper IV)

The survey was based on the different dimensions of the RE-AIM framework (Glasgow et al., 1999), and was developed based on a similar survey used to examine the implementation of the OSTRC Shoulder Injury Prevention Programme in handball players (Andersson et al., 2016). We included a separate section with questions about the implementation of the Adductor Strengthening Programme for players in the intervention group and questions regarding knowledge about the programme for players in the control group. In addition, we included questions about attitudes towards groin injuries and groin injury prevention for both groups. The complete questionnaire is available in Appendix X.

Questionnaire administration

During the last weeks of the 2016 season, teams that agreed to participate received a personal visit, where players were asked to complete a written version of the questionnaire. Players who did not attend training were contacted through mail or phone and asked to complete an online version of the questionnaire using Questback (Questback V. 9692, Questback AS, Oslo, Norway).

Baseline characteristics and demographic data (All papers)

In Papers I, II and III, players completed a form with personal and demographic information at the time of inclusion. During pre-testing in Paper II, all players were weighed. Furthermore, players in Paper III registered hip and groin symptoms using the OSTRC-O (Clarsen et al., 2013) and the Copenhagen Hip and Groin Outcome Score (HAGOS) (Thorborg et al., 2011b) at the time of inclusion. These baseline characteristics and hip and groin symptom scores were used in Papers III and IV.

Statistical analyses

The analyses were performed using SPSS Statistics for Windows, version 24.0 (SPSS Inc.; Chicago, Illinois, USA) or Stata Release 14 (Stata-Corp LP; Texas, USA). In all papers, an α level of ≤ 0.05 was considered significant.

Sample size calculations

We performed sample size calculations for the two RCTs (Papers II and III). In Paper II, the sample size calculation was based on a previous study examining the eccentric hip adduction strength effects of

the CA (Ishøi et al., 2015). For a 10% increase in eccentric hip adductor strength, the expected between group difference was set at 0.28 Nm/kg with a standard deviation (SD) of 0.32 Nm/kg. For a power of 80% and a significance level (α) of 0.05, we needed 20 players in each group.

In Paper III, the sample size calculation was based on the average prevalence of all groin problems reported among male Norwegian football players (29%, Paper I). Based on an ANOVA of within-subject and within-team prevalence, an inflation factor of 1.65, a cluster size of 20 players, a power of 80% and a 5% significance level (α), we estimated the ability to detect a 40% reduction in prevalence with 380 players (19 teams) in each group.

Differences in prevalence measures (Papers I and III)

To assess differences in the prevalence of all groin problems and substantial groin problems between the different groups over time, we performed generalized estimating equations (GEEs) using an exchangeable covariance matrix and an α of 0.05 for all analyses. All anthropometric and demographic variables were treated as potential effect modifiers and were included as candidate variables in a final multivariable GEE model built using a forward selection procedure. In Paper I, we assessed the difference between the elite male and elite female groups and between the senior male groups. In Paper III, we compared the intervention group performing the Adductor Strengthening Programme with the control group continuing normal training to assess the effect of the programme. The primary analyses were performed using an intention to treat (ITT) principle. We also performed secondary per-protocol (PP) analyses from which we excluded players who performed less than 67% of the programme during the pre-season or less than 50% during the regular season.

Missing data on groin problems were imputed using multivariate imputation by a chained equation algorithm in combination with a predictive mean matching approach, which led to the pooled results of five multiple imputed data sets (van Buuren, 2012). In order to perform imputation with sufficient data in Paper III, we chose to remove players with a response rate below 75% (equivalent to less than 21 weekly reports). The cut-off was based on an assessment of the distribution of total responses, which showed a distinct cut-off at 21 reports.

Differences in strength and sprint measures (Paper II)

All outcome variables were analysed according to the PP principle, conducted with a minimum compliance limit set at 16 training sessions (67%). ITT analyses were not performed, since we were interested in the potential efficacy of the exercise and, therefore, only in participants who complied with the specific intervention as planned (Hollis & Campbell, 1999). Between-group differences in strength and performance tests were assessed with repeated-measures analysis of covariance using the pre-intervention test as a covariate (Vickers & Altman, 2001). Within-group differences from pre-

to post-intervention testing were assessed with paired t-tests. We included both legs in these analyses to obtain robust variance estimations, but incorporated player as a cluster variable in the models. Effect sizes were calculated by use of Cohen's d and were interpreted as either small (d = 0.2), moderate (d = 0.5) or large (d = 0.8) (Cohen, 1992).

Differences in baseline characteristics (Paper II and III)

In Papers II and III, we assessed between-group differences in baseline characteristics and exposure using an independent t-test, a Mann-Whitney U-test, a Fisher exact test or a Chi-square test as appropriate. In Paper III, we also assessed differences in baseline characteristics between players included in the ITT analysis and those excluded due to an insufficient response rate (<75%).

Research ethics

All projects were approved by the South-Eastern Norway Regional Committee for Research Ethics and the Norwegian Data Inspectorate (Appendix I to IV). Projects 2 and 3 were registered with the International Standard Randomised Controlled Trial Number registry prior to the recruitment of teams (ISRCTN13731446 and ISRCTN98514933). In all projects, all teams who agreed to participate were visited to inform and invite players to participate. The players received verbal and written information about the study's purpose and procedures and provided written consent to participate (Appendix V to VIII).

Results

Groin problems among Norwegian football players (Paper I)

The overall response rate among the 240 participants to the six weekly questionnaires was 97% in elite male teams, 94% in sub-elite male teams, 98% in elite female teams, 96% in amateur male teams and 95% in U19 male teams. During of the study, 74% of the players responded to all six questionnaires.

During the six weeks, 112 male players (59%) and 20 female players (45%) reported at least one episode of a groin problem, while 47 male players (25%) and 4 female players (9%) reported at least one episode of a substantial groin problem. As shown in figure 9, 34% of the groin problems among male players and 20% among the female players led to time loss. Of the registered problems among male players, 67% had a gradual onset. All the problems reported by female players had a gradual onset.

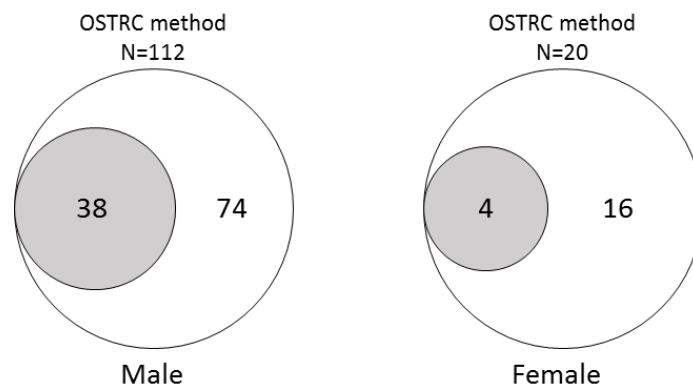


Figure 9 Venn diagram displaying the number of groin problems identified by standard injury registration (grey circle) and the new OSTRC method.

The average weekly prevalence of all groin problems and substantial groin problems for all male players was 29% (range 23-32% across different levels) and 7% (range 9-11% across different levels), respectively. Elite male players had an increased risk of experiencing groin problems (odds ratio: 3.1 95% CI: 1.5-6.4, $p=0.03$) compared to elite female players. There was no difference in the risk of experiencing groin problems between elite, sub-elite or amateur male players. For substantial problems, there was no difference between elite male and elite female players or between any levels of play for senior male players. Table 7 shows the average prevalence of all groin problems and of substantial groin problems for each level and both sexes.

The incidence rate of acute time-loss groin problems for male players was 4.0/1000 h (95% CI: 2.6-5.4/1000h). Female players reported no acute groin problems.

Table 7 Average weekly prevalence of all groin problems and substantial groin problems, % [95% confidence interval].

Group	All groin problems (%)	Substantial groin problems ^a (%)
Female		
Elite	14 [10-18]	4 [4-4]
Male		
Elite	32 [27-37]	13 [12-14]
Sub-elite	31 [22-40]	7 [5-9]
Amateur	29 [22-36]	12 [10-14]
U19 Elite	23 [14-32]	7 [3-11]

^a Substantial groin problems: Causing moderate or severe reduction in training volume or football performance, or completely inability to participate in training or competition.

Strength and sprint effects of the FIFA 11+ (Paper II)

Of the 45 eligible players invited and tested at baseline, 33 players completed at least 67% of the prescribed training protocol and were included in the PP analyses.

Primary outcome - Eccentric hip adduction strength

Eccentric hip adduction strength increased in the group performing the CA exercise and between-group analyses revealed that there was a significant group effect (table 8). The between group effect size calculation suggested a moderate to large ($d=0.60$) strength effect. Within-group analyses showed that there was an increase in eccentric hip adduction strength in the CA group.

Secondary outcomes - Eccentric knee flexor strength and running speed

While within-group analyses showed that there was an increase in eccentric knee flexion strength in the NH group, we did not detect any significant between-group difference (table 8). We did not observe any within- or between-group differences in running speed (table 8).

Compliance to the exercise programme

Of the 24 training sessions planned, the average compliance was 21.5 ± 1.9 sessions (90% of planned sessions) in the CA group and 21.0 ± 1.6 (88% of planned sessions) in the NH group.

Table 8 Test results. Baseline results and change from test 1 to test 2 within the CA and NH group, as well as between-group differences in the change from test 1 to test 2. Positive values denote increased strength and slower sprint time from test 1 to test 2 and in the CA group vs the NH group. Values are reported as the mean with SD or 95% CI, as shown.

	CA group (n=17)				NH group (n=16)				Between group difference				
	Test 1	Test 2	Test 2-Test 1	%	P	Test 1	Test 2	Test 2-Test 1	%	P	CA-NH (95% CI)	%	P
Adduction (Nm/kg)													
Non-dominant	3.25 (0.62)	3.51 (0.63)	0.26 (0.33)	8.0%	<0.001	3.24 (0.50)	3.22 (0.46)	-0.02 (0.35)	-0.7%	0.69	0.29 (0.09,0.49)	8.9%	0.01
Dominant	3.22 (0.68)	3.49 (0.69)	0.28 (0.26)	8.5%	<0.001	3.19 (0.46)	3.13 (0.45)	-0.06 (0.36)	-1.8%	0.52	0.34 (0.12,0.55)	10.6%	<0.001
Hamstrings (N/kg)													
Non-dominant	3.29 (0.57)	3.53 (0.58)	0.24 (0.40)	7.4%	0.02	3.29 (0.54)	3.30 (0.46)	0.00 (0.34)	0.0%	0.91	0.23 (-0.01,0.48)	7.0%	0.06
Dominant	4.97 (0.75)	5.12 (0.72)	0.15 (0.45)	3.0%	0.07	5.07 (0.70)	5.46 (0.73)	0.39 (0.55)	7.7%	<0.001	-0.27 (-0.59,0.06)	-5.4%	0.11
Sprint (s)*													
Non-dominant	4.84 (0.75)	4.99 (0.54)	0.14 (0.42)	2.9%	0.18	4.93 (0.52)	5.32 (0.61)	0.39 (0.48)	7.9%	0.01	-0.28 (-0.57,0.01)	-5.7%	0.06
Dominant	5.11 (0.75)	5.26 (0.86)	0.15 (0.49)	3.0%	0.22	5.22 (0.84)	5.61 (0.83)	0.39 (0.63)	7.5%	0.03	-0.26 (-0.67,0.16)	-5.0%	0.22
0-5 m	0.82 (0.03)	0.82 (0.03)	0.00 (0.02)	-0.4%	0.60	0.82 (0.05)	0.83 (0.02)	0.00 (0.04)	0.2%	0.26	-0.02 (-0.03,0.00)	-1.9%	0.06
0-10 m	1.53 (0.05)	1.55 (0.04)	0.00 (0.03)	-0.1%	0.88	1.56 (0.06)	1.57 (0.04)	0.01 (0.04)	0.5%	0.47	-0.01 (-0.03,0.01)	-0.6%	0.34
0-15 m	2.21 (0.06)	2.21 (0.06)	0.00 (0.04)	-0.1%	0.81	2.21 (0.07)	2.22 (0.05)	0.01 (0.04)	0.4%	0.48	-0.01 (-0.04,0.02)	-0.5%	0.43
0-20 m	2.83 (0.08)	2.83 (0.08)	0.00 (0.05)	-0.2%	0.71	2.83 (0.09)	2.83 (0.08)	0.00 (0.04)	0.2%	0.68	-0.01 (-0.04,0.02)	-0.3%	0.58

*n=14 in NH group and n=16 in CA group. CA – Copenhagen Adduction. NH – Nordic hamstring.

Prevention of groin problems among male football players (Paper III)

Of the 35 teams randomised, one (20 players) withdrew directly after being randomised to the control group. Seventy-seven percent of players included at baseline (intervention group; 247 players and control group; 242) responded to at least 75% of the weekly questionnaires, and were included in the ITT-analyses. Forty-nine percent (122 players) of the players in the intervention group met the criteria to be included in the PP-analyses.

Response rate to the weekly questionnaire

A total of 13628 weekly reports were registered, of which 17% were registered retrospectively. The average weekly response rate was 74% (range 47-93%) in the intervention group and 80% (52-96%) in the control group. The average weekly response rate for players included in the ITT-analyses was 90% (weekly range 62-100%) in the intervention group and 90% (61-100%) in the control group. Furthermore, 21% retrospective data is included in the ITT-analyses and 10% missing data were imputed.

Primary outcome – all groin problems

The average weekly prevalence of all groin problems during the competitive season was 13.5% (95% CI 12.3% to 14.7%) in the intervention group and 21.3% (95% CI 20.0% to 22.6%) in the control group. The 28 in-season prevalence measures in both groups are illustrated in figure 10. GEE analyses revealed a 41% lower risk of reporting groin problems in the intervention group compared to the control group (Table 9).

Secondary outcome – substantial groin problems

The average weekly prevalence of substantial groin problems during the competitive season was 5.7% (95% CI 5.1% to 6.3%) in the intervention group and 8.0% (95% CI 7.5% to 8.5%) in the control group. The 28 in-season prevalence measures in both groups are illustrated in figure 10. An 18% lower risk of reporting substantial groin problems was detected; however, this was not significant (Table 9).

Results

Table 9 Generalised estimating equation (GEE) model for both intention-to-treat and per protocol analyses

	Mean difference in prevalence	Odds Ratio ^a	95% CI	P value
All problems				
<i>Intention-to-treat</i>	7.8 %	0.59	0.40 to 0.86	0.008
<i>Per protocol</i>	9.6 %	0.53	0.36 to 0.78	0.001
Substantial problems				
<i>Intention-to-treat</i> ^b	2.3 %	0.82	0.51 to 1.33	0.42
<i>Per protocol</i> ^c	3.4 %	0.70	0.40 to 1.23	0.22

^a All analyses performed using intervention group as reference value. ^b Age, years as senior, height and weight were included as covariates in the GEE model. ^c Height was included as a covariate in the GEE model.

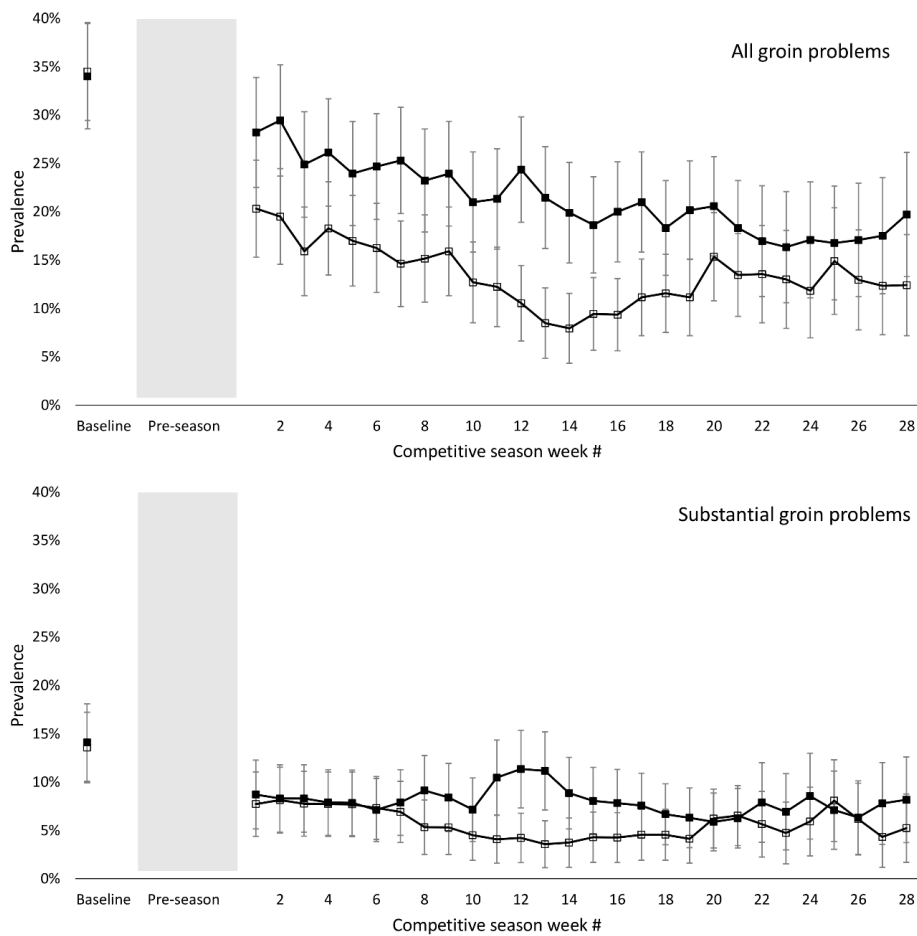


Figure 10 Prevalence of all groin problems (upper panel) and substantial groin problems (lower panel) in the intervention group (open squares) and control group (filled squares) with 95% CI, measured at baseline and 28 times during competitive season for players included in the intention-to-treat analyses. The shaded area represents the 6 to 8 week period where the pre-season protocol of the Adductor Strengthening Programme was performed.

Per protocol analyses – all and substantial groin problems

When we removed the players not meeting the PP criteria ($\geq 67\%$ of the programme during the pre-season and $\geq 50\%$ during the competitive season), the average weekly prevalence of groin problems in the intervention group was 11.7% (95% CI 10.9% to 12.5%) while that of substantial groin problems was 4.5% (95% CI 4.1% to 5.1%). Results from GEE analysis are shown in table 9.

Characteristics of the reported groin problems

Groin problems were reported in 2458 of the 13628 questionnaire responses. The cumulative incidence of all groin problems for players included in the ITT-analysis was 55% in the intervention group and 67% in the control group. A substantial groin problem was reported by 28% of the players in the intervention group, and 37% in the control group. Characteristics of the reported problems are shown in table 10.

Table 10 Characteristics of the groin problems reported during the 28 weeks of the competitive season for players included in the intention-to-treat analysis.

	Intervention group (n=844 groin problems)	Control group (n=1321 groin problems)
Time loss (%)	41	33
Gradual onset (%)	78	79
Acute onset (%)	22	21
Dominant leg (%)	45	44
Non-dominant leg (%)	35	34
Both legs (%)	20	22

Compliance with the exercise programme

Players in the intervention group included in the ITT-analysis completed on average 73% of the recommended pre-season protocol. During the competitive season, the Adductor Strengthening Programme was completed on average 0.7 times per week (range 0.6-0.9), equivalent to 70% of the recommended exercise prescription. Forty-two percent of the players had an average in-season weekly compliance higher than our recommendations, 2 players (1%) did not complete any of the recommended pre-season training sessions, and 7 players (3%) did not complete any of the recommended in-season training sessions. Players included in the PP analyses completed 93% of the recommended pre-season training sessions and on average completed the programme 0.9 times per week (range 0.7-1.0) in-season.

Implementation of the Adductor Strengthening Programme (Paper IV)

Three of the 34 teams in Paper III declined to participate. In total 501 (79%) of the players enrolled at baseline being included, 255 from the intervention group (75%) and 246 from the control group

Results

(84%). Of the 501, 408 (81%) responded to the questionnaire during our team visit, while 93 responded to the online-version of the questionnaire within two weeks.

Player attitudes towards groin injuries and groin injury prevention

Of the players, 87.3% considered footballers to be exposed to groin problems to a moderate or high extent. The players perceived low muscle strength (23.0%), reduced mobility (21.1%) and playing on artificial turf (18.4%) as the most important causes of groin injuries. Furthermore, prevention of groin injuries was considered at least moderately important by 95.5% of the players. However, when asked about their squad's attitude towards preventive measures, their impression was that only 50.1% of the players were positive.

Player experience with the Adductor Strengthening Programme

Strengthening of the adductor muscles was considered important in reducing groin problems by 90.6% of the players in the intervention group. Of the players in the intervention group, 72.5% reported that they spent less than five minutes to complete the programme. Two-thirds (66.7%) of the players reported that they appreciated that the programme consisted of a single exercise and believed motivation for doing the programme would decrease if it were more time-consuming. Only 11.4% of the players wanted additional exercises. Sixty-six percent of the players reported that the programme was performed in connection with organized football training. The players reported that coaches (52.0%) and players (36.8%) were responsible for initiating the Adductor Strengthening Programme during training. Coaches (40.7%) and players (46.8%) were also responsible for the players performing the exercises with the same quality as instructed. The exercise protocol was conducted as recommended or more frequently than recommended by 45.9% of the players. When players were asked whether they thought they would perform the programme the next season, 64.7% of the players confirmed this, however 33.7% reported that they would do the programme less often.

Groin injury prevention done by players in the control group

Of the players in the control group, 30.5% reported having knowledge about the content of the Adductor Strengthening Programme and 53.3% reported that they had performed the programme or other exercises to prevent groin injuries during the season the study took place.

Discussion

The overall aim of this thesis was to develop and examine the effect of an Adductor Strengthening Programme on the prevalence of groin problems among male football players. Furthermore, we wanted to test a new method for registering groin problems among football players of both sexes and at different levels of play. In addition, we wanted to examine the strength and sprint effects of the FIFA 11+ warm-up programme with and without the CA. Finally, we examined players' attitudes towards groin injury prevention and their experiences with the implementation of the Adductor Strengthening Programme.

Weekly prevalence of groin problems

Papers I and III show that the prevalence in male footballers across various levels of play was greater than previously reported. Furthermore, Paper I shows that elite male players had 3 times higher risk of reporting groin problems than elite female players, but level of play did not influence the risk of reporting groin problems.

This is the first studies showing the weekly prevalence of groin problems in football players. From the sub-elite level in Denmark, a seasonal prevalence close to 50% among male players has been reported (Thorborg et al., 2015). Our data support this finding and suggest an even higher seasonal prevalence with 67% of players (control group Paper III) reporting at least one episode with groin problems during the regular season. The data also indicate that the prevalence of groin problems varies throughout the season. The average prevalence was 21%, while the lowest weekly prevalence was 16% in match-week 23 and the highest was 29% in match-week 2. Results from match-week 2 correspond to the results from Paper I, where the average prevalence among male players in a period with match congestion was 29%. Our results support previous findings in elite Qatari players that groin injury incidence was greatest earlier in the season (Mosler et al., 2018a), possibly due to the increase in match workload that occurs during this phase (Blanch & Gabbett, 2016; Gabbett et al., 2016). Fixture congestion has also been associated with increased rates of muscle injury among male players at the elite European level (Bengtsson et al., 2013). In addition to the peak in prevalence of groin problems in the beginning of the season and during match congestion periods, an increase was found during the weeks prior to the summer break. These results highlight the need for player surveillance throughout the season to detect groin problems early, using the OSTRC-O (Clarsen et al., 2013) or by monitoring hip and groin strength (Wollin et al., 2018a; Wollin et al., 2018b). However, further exploration of these peaks in prevalence is needed.

Most studies reporting on the onset of groin injury in football have shown that 60% to 73% of injuries are overuse injuries (Bjørneboe et al., 2014; Engebretsen et al., 2010; Engstrom et al., 1990; Hölmich

et al., 2014a; Mosler et al., 2018a). However, in a recent study investigating hip and groin injury rates over 15 consecutive seasons in elite European football, the results reveal a somewhat lower rate of overuse injuries at 51% (Werner et al., 2018). Our results from the match-congested period are in the upper scale of the previously reported data (Paper I), and the full season data show an even greater proportion, with 78% of the injuries categorised as overuse injuries (Paper III). The explanation for the high proportion of overuse problems reported in our studies may be the injury registration method, which registers the player's own perception of groin problems with regard to participation, training volume, performance and pain. This method could be overly sensitive, registering cases based on minor symptoms like muscle soreness, which the players may categorise as overuse symptoms. However, irrespective of methodological differences in injury registration, our data seem to be consistent with previous studies showing overuse injuries as the most frequent cause of groin problems.

What is a groin problem, and what are we preventing?

Our definition of a groin problem encompasses all physical symptoms and may have multiple causes, such as adductor-, inguinal-, iliopsoas- and pubic-related causes and even others such as hip joint or lower back pain. The lack of detailed diagnostic information in each case should be considered a limitation of the injury registration method, and the effect of the Adductor Strengthening Programme may differ between specific diagnoses. Reliable medical follow-up was not feasible given the scale of these projects.

In previous injury surveillance studies, few report specific diagnoses or classify injuries according to the Doha agreement on terminology and definitions. However, Mosler et al. (2018a) registered groin injuries among elite Qatari players according to the Doha agreement, and more than two-thirds of the problems were adductor-related. Similar results have been reported in elite European players, where about two-thirds of injuries are registered as adductor-related (Werner et al., 2018) and about half of the injuries in Danish sub-elite players were adductor-related (Hölmich et al., 2010). Furthermore, among a group of athletes (60% football players) attending a clinical examination at a multidisciplinary sports groin pain clinic in Doha, about 60% were classified having adductor-related groin pain (Taylor et al., 2017). Even when examining acute injuries only, the same pattern exists with two thirds of athletes (57% of the cohort were football players) having adductor-related injuries (Serner et al., 2015a). From the studies describing specific injury characteristics of the adductors, the results show that the adductor longus is most often affected (Hölmich, 2007; Hölmich et al., 2014a; Serner et al., 2018a). Although the method used for injury registration in Papers I and III differs from these studies, it would be surprising if groin problems identified using the OSTRC-O deviate substantially from the consistent finding that adductor-related/adductor longus injuries are the most

common groin injuries in footballers. However, in future studies, self-reported groin problems should be examined, classified and reported according to the Doha agreement on terminology and definitions (Weir et al., 2015a) or specific diagnoses that are more detailed. This will increase the understanding of what a groin problem is and what types of problems we are aiming to prevent.

Why does the Adductor Strengthening Programme reduce the risk of groin problems?

The Adductor Strengthening Programme reduced the prevalence of groin problems among male football players; the risk of reporting groin problems during the competitive season was 41% lower in favour of the intervention group in the ITT analysis and 47% lower in the PP analysis.

Our Adductor Strengthening Programme is the first groin-specific exercise-based programme to demonstrate a reduction in the risk of groin injury in male footballers. The hip adductors were specifically targeted in this programme, while previous studies have had a combined focus on the hip adductors, flexors and abdominals (Engebretsen et al., 2008; Hölmich et al., 2010). Furthermore, the intensive protocol implemented during the pre-season is considered vital to document an effect of the programme prior to counting injuries during the regular season. This is in contrast to previous studies, which implemented the prevention programme and injury registration at the same time (Engebretsen et al., 2008; Hölmich et al., 2010).

Compliance with the protocol

Another reason why we may have found an effect is that the compliance reported in the present study was much higher (Engebretsen et al., 2008; Esteve et al., 2015; Hölmich et al., 2010). On average, the players completed approximately 70% of the prescribed protocol during both the pre-season and competitive season. Actually, 42% of the players included in the ITT analysis had a higher average in-season weekly compliance than our recommendations. However, compliance was self-reported and we do not know if they performed the exercise as often as reported. In fact, in the survey at the end of the season, only 46% of players reported having performed the exercise protocol as prescribed or more frequently (Paper IV). The compliance reported in other studies examining the preventive effect of exercise programmes on groin injury rate varies. Engebretsen et al. (2008) reported that players had a 19% compliance rate with a programme including static and dynamic hip adduction strength and abdominal exercises, while studies examining the effect of the FIFA 11 report between 52% and 73% compliance (Steffen et al., 2008b; van Beijsterveldt et al., 2012). Silvers-Granelli et al. reported a mean utilization of the FIFA 11+ of 30 sessions per season, which they interpreted as moderate (Silvers-Granelli et al., 2015). The other study of the FIFA 11+ reported 77% team compliance and 59% individual compliance (Soligard et al., 2008). Hölmich et al. did not report any data on compliance with their programme, which included static and dynamic hip

adduction strength, abdominal exercises and stretching (Hölmich et al., 2010). Compliance is believed to be a key factor. In two large RCTs on the FIFA 11+ programme, the risk of sustaining an injury was lower for the high compliance group compared to players with intermediate or low compliance (Silvers-Granelli et al., 2015; Soligard et al., 2008). This is also indicated in our analysis; the PP analysis showed an even lower risk of groin problems than the ITT analysis.

A single-exercise approach

The single-exercise approach used in the Adductor Strengthening Programme was considered an important facilitator. In Paper IV, only a small number of the players wanted to perform more exercises. They also believed that a programme with several exercises, taking more time to perform, would decrease their motivation. The in-season Adductor Strengthening Programme protocol consisted of one weekly session, which most players reported taking less than 5 minutes to complete. In other studies reporting on the uptake of injury prevention exercise programmes in football, the length of the programme has been emphasised as an important barrier to implementation (Engebretsen et al., 2008; Soligard et al., 2010).

However, the single-exercise approach may also be considered a limitation, as we only specifically target one of four defined clinical entities for groin pain (Weir et al., 2015a). We would argue that targeting the adductors addresses the main problem, as adductor-related groin pain accounts for about two-thirds of all hip and groin injuries in football, as discussed above (Hölmich et al., 2014a; Mosler et al., 2018a; Werner et al., 2018). In a recently published study on elite male Qatari players, the authors suggest that the mechanism of injury may vary for adductor-related groin injuries in comparison to other categories of hip/groin injuries (Mosler et al., 2016a). It is unknown which entities the Adductor Strengthening Programme affected specifically; however, we feel we have addressed an important modifiable risk factor for adductor-related groin injuries, reduced hip adduction strength. In the following section, the training response and mechanism behind the preventive effect of the programme is discussed.

Training response to the Adductor Strengthening Programme

The CA is a dynamic, high-intensity, partner exercise including a concentric and eccentric phase (Serner et al., 2014). Based on results from previous studies and the present thesis, we know that the exercise promotes high activation of the adductor longus (Serner et al., 2014), increases hip adduction strength (Ishøi et al., 2015) and that the Adductor Strengthening Programme using the CA as the main exercise reduces the risk of groin problems. However, the underlying mechanisms as to why strength training may protect against groin injuries are currently unknown.

Although debated, strength training may increase the cross-sectional area of the tendon (Arampatzis et al., 2007; Bohm et al., 2014; Farup et al., 2014; Kongsgaard et al., 2007; Seynnes et al., 2009). Heavy, slow resistance training consisting of a substantial eccentric component has been shown to increase the cross-sectional area and density of the patellar tendon (Kongsgaard et al., 2010; Kongsgaard et al., 2007). An increase in cross-sectional area may contribute to decreased tendon stress. Furthermore, heavy, slow resistance training is effective in treating tendinopathy, and it seems to have a healing effect on the tendon by adding more fibrils (Beyer et al., 2015; Kongsgaard et al., 2009; Kongsgaard et al., 2010). It is unlikely that the exercise protocol for the Adductor Strengthening Programme provides the same mechanical load as the protocols used in treating Achilles and patellar tendinopathy, and we do not know if the same effect will occur in the adductor longus tendon. However, decreased tendon stress may be beneficial, as the majority of groin injuries in football are adductor related (Hölmich et al., 2014a; Mosler et al., 2018a; Werner et al., 2018), have a gradual onset (Bjørneboe et al., 2014; Engebretsen et al., 2010; Engstrom et al., 1990; Hölmich et al., 2014a; Mosler et al., 2018a; Werner et al., 2018), are often longstanding and affect the insertion of the tendon to the pubic bone (Branci et al., 2014b; Falvey et al., 2015; Hölmich, 2007).

From hamstring injury research, another theory for the protective effect of strength training has been proposed via increased muscle fascicle length in the long head of the biceps femoris. It has also been proposed that athletes with shorter fascicles are more prone to hamstring injury (Timmins et al., 2016). Repeated eccentric contractions lead to exercise-induced muscle damage, which activates the repair process that leads to the addition of sarcomeres aligned in series (Proske & Morgan, 2001). It has been proposed that this increase in serial sarcomeres accounts for a shift in a muscle's force-length relationship, consequently reducing the muscle's susceptibility to injury (Bourne et al., 2017; Brockett et al., 2001). The shift in the force-length relationship curve indicates increased hamstring strength towards full extension of the knee. This shift seems advantageous, as the mechanism for hamstring injury is in the latter part of the swing phase during sprinting, where the hamstring muscle is sub-maximally stretched (Chumanov et al., 2007, 2011). Some similarities can be seen in acute hamstring injuries and acute adductor injuries. The most frequent cause of an acute adductor injury is kicking (Mosler et al., 2018a; Serner et al., 2015a). Similar to the mechanism of an acute hamstring injury, the adductor longus is at highest risk of acute injury when the muscle reaches its highest muscle activity and maximal rate of stretch in the swing phase of the kicking leg (Charnock et al., 2009). Again, a direct comparison of hamstring injury to groin injury research cannot be done. However, the CA, which is included as the highest level of the Adductor Strengthening

Programme, has an eccentric phase similar to the NH, and a potentially increased fascicle length from performing the programme may be protective against acute injuries to the adductor longus.

Another theory from hamstring injury research is an increase in early onset of muscle activity (i.e. the rate of force development), a combination of recruitment and firing rate (Aagaard et al., 2002a; Grabiner & Owings, 2002). The rate of force development is obtained from the slope of the force-time curve and is important in fast and forceful muscle contractions (Aagaard et al., 2002a). For the prevention of hamstring injuries, it has been suggested that the ability to activate the hamstring muscle quickly and efficiently is important to reduce the risk of suffering an injury (Delahunt et al., 2016; Opar et al., 2013b). An increase in the rate of force development leads to a steeper slope of the force-time curve, indicating a faster achievement of maximal force (Aagaard et al., 2002a; Delahunt et al., 2016). The faster development of muscle activation can consequently be an important factor to reducing the risk of over-stretching the adductor muscles in the swing phase of a kick. However, results from a recently published study could not find an association between rate of force development and onset of muscle activity and risk of future hamstring injury (van Dyk et al., 2018). Thus, the role of the rate of force development in reducing the risk of injury is uncertain. Finally, as for the other proposed theories from hamstring research, we do not know if the same effect can derive from performing the Adductor Strengthening Programme.

Summarised, the CA or the Adductor Strengthening Programme seem to specifically increase hip adduction strength, and the exercises seem to target the adductor longus muscles. From hamstring injury research, there are interesting theories, and because of the similarity between the NH and CA, the same effects may be seen in the prevention of acute adductor injuries as well. However, there is a need for future studies to examine the effect of the Adductor Strengthening Programme on the adductors muscles and the tendon insertion.

Optimal exercise prescription

The effect of the Adductor Strengthening Programme on hip adduction strength is unknown. In Paper II, we found an 8.9% increase in eccentric hip adduction strength effect in favour of the players performing the CA. The increase in strength is considerably lower compared to a Danish study that showed a 35.7% increase in eccentric hip adduction strength using the same exercise and testing procedure (Ishøi et al., 2015). However, one crucial factor may explain this discrepancy. In our study, we prescribed three weekly training sessions consisting of one set on each side and a variation from 3-5 to 12-15 repetitions, resulting in a total of 72 (beginner) to 360 (advanced) repetitions on each side during the eight weeks. The protocol Ishøi et al. (2015) used consisted of two weekly training sessions, with two or three sets on each side and a progression from 6 to 15 repetitions, resulting in a

total of 480 repetitions on each side at maximum. This suggests that there could be a dose-response relationship between training load and outcome, explaining the substantially greater strength effect in the Danish study (Ishøi et al., 2015). The pre-season protocol used in the Adductor Strengthening Programme with only one set per side per session is likely to induce a strength increase in the lower range of these results. Additionally, we did not register the level of the protocol performed by each player. As the data indicate a dose-response relationship on eccentric adduction strength, it can be speculated that a more intense protocol would result in an even lower risk of groin problems. On the other hand, we do not know the effect of increasing intensity or volume on players' motivation to perform the programme. Paper IV, however, indicates that simplicity was considered an important facilitator and that adding more exercises would decrease player motivation. Hence, the optimal exercise prescription to maximize the effects on injury risk requires further exploration.

Methodological considerations

Injury registration method

The OSTRC-O has now been used in studies on several different body parts and seems to be a better alternative to recording overuse injuries, identifying more cases leading to pain, decreased participation or performance without necessarily leading to time loss (Andersson et al., 2016; Clarsen et al., 2014; Clarsen et al., 2013; Pluim et al., 2015). In the same way, Paper I shows that as many as two-thirds of reported injuries did not lead to time loss from training or match play. We would argue that the results presented for one full season (Paper III) and a period with match congestion (Paper I) show a better estimate of the magnitude of groin injuries in football in comparison to previous injury surveillance studies using a time-loss injury definition (Arnason et al., 2004; Bjørneboe et al., 2014; Ekstrand & Gillquist, 1983; Ekstrand & Hilding, 1999; Engebretsen et al., 2008; Engstrom et al., 1990; Engstrom et al., 1991; Faude et al., 2005; Gaulrapp et al., 2010; Gouttebauge et al., 2016; Hawkins & Fuller, 1999; Hawkins et al., 2001; Haxhiu et al., 2015; Häggglund et al., 2006, 2007, 2009a; Jacobson & Tegner, 2006, 2007; Larruskain et al., 2018; Mosler et al., 2018a; Nilstad et al., 2014; Noya Salces et al., 2014a; Noya Salces et al., 2014b; Shalaj et al., 2016; Sousa et al., 2013; Söderman et al., 2001; Tegnander et al., 2008; van Beijsterveldt et al., 2015; Waldén et al., 2005; Werner et al., 2018; Östenberg & Roos, 2000). Thus, the injury registration method used in Papers I and III appears to be a better alternative with which to record groin problems. We suggest that the new method be used in future injury surveillance studies examining groin problems in order to capture the full extent of the problem.

Missing data

One of the main limitations of our injury registration method was the reliance on a good response from the players. In the two studies using the OSTRC-O, our response rates were 96% (Paper I) and 77% (Paper III) respectively.

The amount of missing data affects which statistical methods can be used. Ideally, longitudinal methods, such as GEE, should be used to analyse repeated measurements, as these account for changes over time (Twisk, 2006). However, one limitation of these analyses is that all subjects with any data missing are excluded. This is likely to lead to exclusion of a large proportion of subjects in studies with many reported measurements, thus reducing statistical power and increasing the likelihood of biased results. To deal with missing data in our papers, we used multiple imputation to estimate the missing values. However, multiple imputation can only be utilized if data are missing at random and if sufficient data exist (Sterne et al., 2009). There are no definitive criteria for the amount of data necessary, but in previous studies at OSTRC, at least 70% of the dataset and at least 50% of the subjects having complete data have been used as criteria (Andersson et al., 2016; Clarsen et al., 2014; Clarsen et al., 2013).

In Paper I, the response rate was very high; consequently, only 4% of the missing data were imputed. However, in Paper III the weekly response rate took a substantial drop during the summer break and gradually declined towards the end of the season. Thus, we chose to include a retrospective data collection, asking players to fill-in missing responses. Of the 13628 weekly reports registered, 17% were registered retrospectively, and in the analyses (including players having response rate >75%) 21% of the data are retrospectively registered. We believe that the substantial drop in response during the summer break (weeks 13 to 17) was due to a combination of insufficient information for the players to continue responding and an unwillingness from the players to respond during their holidays. As the retrospective data collection increased the response rate, the missing data imputed in Paper III was 10%, which is in line with guidelines used at OSTRC.

The retrospective registration during the last month of the study may induce a recollection bias and represents a limitation of the injury registration. The decision to register retrospectively was done to ensure sufficient data for the analyses. Aiming to reduce recall bias when completing the retrospective registration, players had access to a document summarising their previous questionnaire responses and their match fixtures. Still, there is a potential for recall bias; however, it seems highly unlikely that this would affect players in the intervention and control groups differently. To examine the retrospective data's influence on the analyses, we repeated the ITT analyses in Paper III without including the retrospectively registered data. In the new model, 31.5% (21.3%

retrospective data and 10.2% missing data) of the data were imputed. Results from the new analyses showed a somewhat lower odds ratio for both all and substantial groin problems. However, when performing imputation and analyses repeatedly, each calculation led to slightly different results. This discrepancy, we believe, must be the result of the large amount of imputed data.

We believe that the retrospective data ensures a more robust dataset, compared to the alternative of omitting the retrospective data. A larger share of missing data seems to introduce more variation to the analyses. The results from these new analyses highlight the need for strategies to ensure a high response rate in large-scale studies using the OSTRC-O and similar analytical approaches. We believe that a mixed-methods approach (as used in Paper I) with both a smartphone application and written administration can ensure higher participation and reduce the risk of recall bias in future surveillance studies.

Deviation from the registered protocol

The project protocols for both RCTs (Papers II and III) were registered with the ISRCTN registry prior to the start of the trials. Project 2 was conducted as planned; however, in project 3 we made two deviations from the registered protocol: the retrospective registration, discussed previously, and the exclusion of players having a response rate that was too low. Deviations from the registered protocol should be considered a limitation in any trial. The decision to remove players with low response rates (<75%) was done to ensure sufficient data to perform imputation. The majority (77%) of the enrolled players were included in the GEE analyses. Although the post-randomised change of criteria for the analyses may introduce bias (Nuesch et al., 2009), the decision to diverge from the protocol was taken prior to the analyses and was based on the response rates, irrespective of whether they had actually performed the Adductor Strengthening Programme. In addition, a difference in sub-scale scores of the HAGOS at baseline between the players removed from the analysis compared with the ones included indicates that players with lower response rates had slightly more severe symptoms. However, we do not consider these small differences to be clinically relevant. Furthermore, there were no differences in any of the sub-scales when comparing players removed from the intervention group with the ones removed from the control group.

Future implementation of the Adductor Strengthening Programme

The reported preventive effect of the Adductor Strengthening Programme suggests that dissemination and widespread use in the football community would be beneficial. The results from Paper IV indicate that players agree that footballers are at risk for groin injuries and that preventive measure are needed. Hence, the footballers seem to be primed for the adoption and implementation of the Adductor Strengthening Programme, which is an important premise to success in injury

prevention measures (Janz & Becker, 1984). Players also reported a high compliance with the programme, indicating that adoption of the programme was good (Paper III). However, based on our data, maintenance of the programme seems to be the biggest challenge. Results from Paper IV show that 65% of the players planned to continue using the programme the next season; however, only 31% planned to perform it as recommended. This should be considered a potential barrier to successful implementation in the real-world setting. Furthermore, we examined the effect of the programme at the sub-elite Norwegian footballers. Players reported that the coaching staff and players initiated and were responsible for the quality of the programme, while medical staff members were not as involved (Paper IV). This not only indicates that coaches and players were the most important facilitators for implementation and compliance but also that at the sub-elite (and most likely also at lower levels) players and coaches should be specifically targeted when introducing the programme.

The results from the present study suggest that the Adductor Strengthening Programme should be included in football training, at least among senior male football players. The three progression levels of the programme are also suggested to be included in the FIFA 11+ programme to specifically target adductor muscles. Whether the preventive effects of the programme can be generalised to female or youth players, as well as players at the highest professional level is not known. Athletes from other sports may also benefit from the programme, as reduced hip adduction strength is also considered a risk factor associated with groin problems in sports with similar movement patterns, such as ice hockey, rugby and Australian rules football (Crow et al., 2010; Emery & Meeuwisse, 2001; O'Connor, 2004; Tyler et al., 2001).

Conclusions

- I. We found a high prevalence of groin problems among male football players during a period with match congestion. Elite male players had 3 times' higher risk of reporting groin problems compared to elite female players, while playing level did not influence the risk of reporting a groin problem among males.
- II. Including the Copenhagen Adduction exercise in the FIFA 11+ program increased eccentric hip adduction strength, while the standard FIFA 11+ program did not.
- III. The Adductor Strengthening Programme substantially reduced the prevalence and risk of groin problems in male football players.
- IV. Football players feel they are at high risk of sustaining groin injuries and believe that the Adductor Strengthening Programme will be effective in reducing that risk, suggesting that there is fertile ground for implementation. The single-exercise approach was an important facilitator for successful implementation. However, the players' reluctance to maintain the exercise protocol may be considered a potential barrier to implementation that should be addressed.

References

- Aagaard, P., Andersen, J. L., Dyhre-Poulsen, P., Leffers, A. M., Wagner, A., Magnusson, S. P., Halkjaer-Kristensen, J., & Simonsen, E. B. (2001). A mechanism for increased contractile strength of human pennate muscle in response to strength training: changes in muscle architecture. *J Physiol*, *534*(Pt. 2), 613-623.
- Aagaard, P., Simonsen, E. B., Andersen, J. L., Magnusson, P., & Dyhre-Poulsen, P. (2002a). Increased rate of force development and neural drive of human skeletal muscle following resistance training. *J Appl Physiol* (1985), *93*(4), 1318-1326. doi:10.1152/jappphysiol.00283.2002
- Aagaard, P., Simonsen, E. B., Andersen, J. L., Magnusson, P., & Dyhre-Poulsen, P. (2002b). Neural adaptation to resistance training: changes in evoked V-wave and H-reflex responses. *J Appl Physiol* (1985), *92*(6), 2309-2318. doi:10.1152/jappphysiol.01185.2001
- Abe, T., Brechue, W. F., Fujita, S., & Brown, J. B. (1998). Gender differences in FFM accumulation and architectural characteristics of muscle. *Med Sci Sports Exerc*, *30*(7), 1066-1070.
- Agricola, R., Heijboer, M. P., Ginai, A. Z., Roels, P., Zadpoor, A. A., Verhaar, J. A., Weinans, H., & Waarsing, J. H. (2014). A cam deformity is gradually acquired during skeletal maturation in adolescent and young male soccer players: a prospective study with minimum 2-year follow-up. *Am J Sports Med*, *42*(4), 798-806. doi:10.1177/0363546514524364
- Andersen, J. L., & Aagaard, P. (2000). Myosin heavy chain IIX overshoot in human skeletal muscle. *Muscle Nerve*, *23*(7), 1095-1104.
- Andersson, S. H., Bahr, R., Clarsen, B., & Myklebust, G. (2016). Preventing overuse shoulder injuries among throwing athletes: a cluster-randomised controlled trial in 660 elite handball players. *Br J Sports Med*. doi:10.1136/bjsports-2016-096226
- Arampatzis, A., Karamanidis, K., Morey-Klapsing, G., De Monte, G., & Stafilidis, S. (2007). Mechanical properties of the triceps surae tendon and aponeurosis in relation to intensity of sport activity. *J Biomech*, *40*(9), 1946-1952. doi:10.1016/j.jbiomech.2006.09.005
- Arampatzis, A., Peper, A., Bierbaum, S., & Albracht, K. (2010). Plasticity of human Achilles tendon mechanical and morphological properties in response to cyclic strain. *J Biomech*, *43*(16), 3073-3079. doi:10.1016/j.jbiomech.2010.08.014
- Arnason, A., Sigurdsson, S. B., Gudmundsson, A., Holme, I., Engebretsen, L., & Bahr, R. (2004). Risk factors for injuries in football. *Am J Sports Med*, *32*(1 Suppl), 5S-16S. doi:10.1177/0363546503258912
- Bahr, R. (2009). No injuries, but plenty of pain? On the methodology for recording overuse symptoms in sports. *Br J Sports Med*, *43*(13), 966-972. doi:10.1136/bjism.2009.066936
- Bahr, R., & Krosshaug, T. (2005). Understanding injury mechanisms: a key component of preventing injuries in sport. *Br J Sports Med*, *39*(6), 324-329. doi:10.1136/bjism.2005.018341
- Bahr, R., Thorborg, K., & Ekstrand, J. (2015). Evidence-based hamstring injury prevention is not adopted by the majority of Champions League or Norwegian Premier League football teams: the Nordic Hamstring survey. *Br J Sports Med*, *49*(22), 1466-1471. doi:10.1136/bjsports-2015-094826
- Becker, I., Woodley, S. J., & Stringer, M. D. (2010). The adult human pubic symphysis: a systematic review. *J Anat*, *217*(5), 475-487. doi:10.1111/j.1469-7580.2010.01300.x
- Bengtsson, H., Ekstrand, J., & Hägglund, M. (2013). Muscle injury rates in professional football increase with fixture congestion: an 11-year follow-up of the UEFA Champions League injury study. *Br J Sports Med*, *47*(12), 743-747. doi:10.1136/bjsports-2013-092383
- Beyer, R., Kongsgaard, M., Hougs Kjaer, B., Ohlenschlaeger, T., Kjaer, M., & Magnusson, S. P. (2015). Heavy Slow Resistance Versus Eccentric Training as Treatment for Achilles Tendinopathy: A Randomized Controlled Trial. *Am J Sports Med*, *43*(7), 1704-1711. doi:10.1177/0363546515584760
- Bittencourt, N. F., Meeuwisse, W. H., Mendonca, L. D., Nettel-Aguirre, A., Ocarino, J. M., & Fonseca, S. T. (2016). Complex systems approach for sports injuries: moving from risk factor

- identification to injury pattern recognition-narrative review and new concept. *Br J Sports Med*. doi:10.1136/bjsports-2015-095850
- Bjørneboe, J., Bahr, R., & Andersen, T. E. (2014). Gradual increase in the risk of match injury in Norwegian male professional football: a 6-year prospective study. *Scand J Med Sci Sports*, 24(1), 189-196. doi:10.1111/j.1600-0838.2012.01476.x
- Blanch, P., & Gabbett, T. J. (2016). Has the athlete trained enough to return to play safely? The acute:chronic workload ratio permits clinicians to quantify a player's risk of subsequent injury. *Br J Sports Med*, 50(8), 471-475. doi:10.1136/bjsports-2015-095445
- Blazevich, A. J., Cannavan, D., Coleman, D. R., & Horne, S. (2007). Influence of concentric and eccentric resistance training on architectural adaptation in human quadriceps muscles. *J Appl Physiol (1985)*, 103(5), 1565-1575. doi:10.1152/jappphysiol.00578.2007
- Bloomquist, K., Langberg, H., Karlsen, S., Madsgaard, S., Boesen, M., & Raastad, T. (2013). Effect of range of motion in heavy load squatting on muscle and tendon adaptations. *Eur J Appl Physiol*, 113(8), 2133-2142. doi:10.1007/s00421-013-2642-7
- Bohm, S., Mersmann, F., Tettke, M., Kraft, M., & Arampatzis, A. (2014). Human Achilles tendon plasticity in response to cyclic strain: effect of rate and duration. *J Exp Biol*, 217(Pt 22), 4010-4017. doi:10.1242/jeb.112268
- Bourne, M. N., Duhig, S. J., Timmins, R. G., Williams, M. D., Opar, D. A., Al Najjar, A., Kerr, G. K., & Shield, A. J. (2017). Impact of the Nordic hamstring and hip extension exercises on hamstring architecture and morphology: implications for injury prevention. *Br J Sports Med*, 51(5), 469-477. doi:10.1136/bjsports-2016-096130
- Branci, S., Thorborg, K., Bech, B. H., Boesen, M., Magnussen, E., Court-Payen, M., Nielsen, M. B., & Hölmich, P. (2014a). The Copenhagen Standardised MRI protocol to assess the pubic symphysis and adductor regions of athletes: outline and intratester and intertester reliability. *Br J Sports Med*. doi:10.1136/bjsports-2014-094239
- Branci, S., Thorborg, K., Bech, B. H., Boesen, M., Nielsen, M. B., & Hölmich, P. (2014b). MRI findings in soccer players with long-standing adductor-related groin pain and asymptomatic controls. *Br J Sports Med*. doi:10.1136/bjsports-2014-093710
- Branci, S., Thorborg, K., Nielsen, M. B., & Hölmich, P. (2013). Radiological findings in symphyseal and adductor-related groin pain in athletes: a critical review of the literature. *Br J Sports Med*, 47(10), 611-619. doi:10.1136/bjsports-2012-091905
- Brito, J., Figueiredo, P., Fernandes, L., Seabra, A., Soares, J. M., Krstrup, P., & Rebelo, A. (2010). Isokinetic strength effects of FIFA's "The 11+" injury prevention training programme. *Isokinetics & Exercise Science*, 18(4), 211-215.
- Brockett, C. L., Morgan, D. L., & Proske, U. (2001). Human hamstring muscles adapt to eccentric exercise by changing optimum length. *Med Sci Sports Exerc*, 33(5), 783-790.
- Broski, S. M., Murthy, N. S., Krych, A. J., Obey, M. R., & Collins, M. S. (2016). The adductor magnus "mini-hamstring": MRI appearance and potential pitfalls. *Skeletal Radiol*, 45(2), 213-219. doi:10.1007/s00256-015-2291-5
- Cadore, E. L., Gonzalez-Izal, M., Pallares, J. G., Rodriguez-Falces, J., Hakkinen, K., Kraemer, W. J., Pinto, R. S., & Izquierdo, M. (2014). Muscle conduction velocity, strength, neural activity, and morphological changes after eccentric and concentric training. *Scand J Med Sci Sports*, 24(5), e343-352. doi:10.1111/sms.12186
- Carling, C., Orhant, E., & LeGall, F. (2010). Match injuries in professional soccer: inter-seasonal variation and effects of competition type, match congestion and positional role. *Int J Sports Med*, 31(4), 271-276. doi:10.1055/s-0029-1243646
- Chalmers, S., Magarey, M. E., Esterman, A., Speechley, M., Scase, E., & Heynen, M. (2013). The relationship between pre-season fitness testing and injury in elite junior Australian football players. *J Sci Med Sport*, 16(4), 307-311. doi:10.1016/j.jsams.2012.09.005
- Charnock, B. L., Lewis, C. L., Garrett, W. E., Jr., & Queen, R. M. (2009). Adductor longus mechanics during the maximal effort soccer kick. *Sports Biomech*, 8(3), 223-234. doi:10.1080/14763140903229500

References

- Chumanov, E. S., Heiderscheit, B. C., & Thelen, D. G. (2007). The effect of speed and influence of individual muscles on hamstring mechanics during the swing phase of sprinting. *J Biomech*, *40*(16), 3555-3562. doi:10.1016/j.jbiomech.2007.05.026
- Chumanov, E. S., Heiderscheit, B. C., & Thelen, D. G. (2011). Hamstring musculotendon dynamics during stance and swing phases of high-speed running. *Med Sci Sports Exerc*, *43*(3), 525-532. doi:10.1249/MSS.0b013e3181f23fe8
- Clarsen, B., Bahr, R., Heymans, M. W., Engedahl, M., Midsundstad, G., Rosenlund, L., Thorsen, G., & Myklebust, G. (2014). The prevalence and impact of overuse injuries in five Norwegian sports: Application of a new surveillance method. *Scand J Med Sci Sports*. doi:10.1111/sms.12223
- Clarsen, B., Myklebust, G., & Bahr, R. (2013). Development and validation of a new method for the registration of overuse injuries in sports injury epidemiology: the Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire. *Br J Sports Med*, *47*(8), 495-502. doi:10.1136/bjsports-2012-091524
- Cohen, J. (1992). A power primer. *Psychol Bull*, *112*(1), 155-159.
- Colvin, A. C., Harrast, J., & Harner, C. (2012). Trends in hip arthroscopy. *J Bone Joint Surg Am*, *94*(4), e23. doi:10.2106/jbjs.j.01886
- Cowan, S. M., Schache, A. G., Brukner, P., Bennell, K. L., Hodges, P. W., Coburn, P., & Crossley, K. M. (2004). Delayed onset of transversus abdominus in long-standing groin pain. *Med Sci Sports Exerc*, *36*(12), 2040-2045.
- Cramer, R. M., Langberg, H., Magnusson, P., Jensen, C. H., Schroder, H. D., Olesen, J. L., Suetta, C., Teisner, B., & Kjaer, M. (2004). Changes in satellite cells in human skeletal muscle after a single bout of high intensity exercise. *J Physiol*, *558*(Pt 1), 333-340. doi:10.1113/jphysiol.2004.061846
- Crow, J. F., Pearce, A. J., Veale, J. P., VanderWesthuizen, D., Coburn, P. T., & Pizzari, T. (2010). Hip adductor muscle strength is reduced preceding and during the onset of groin pain in elite junior Australian football players. *J Sci Med Sport*, *13*(2), 202-204. doi:10.1016/j.jsams.2009.03.007
- Daneshjoo, A., Mokhtar, A., Rahnama, N., & Yusof, A. (2013a). The effects of injury prevention warm-up programmes on knee strength in male soccer players. *Biol Sport*, *30*(4), 281-288. doi:10.5604/20831862.1077554
- Daneshjoo, A., Mokhtar, A. H., Rahnama, N., & Yusof, A. (2012). The effects of comprehensive warm-up programs on proprioception, static and dynamic balance on male soccer players. *PLoS One*, *7*(12), e51568. doi:10.1371/journal.pone.0051568
- Daneshjoo, A., Mokhtar, A. H., Rahnama, N., & Yusof, A. (2013b). Effects of the 11+ and Harmoknee Warm-up Programs on Physical Performance Measures in Professional Soccer Players. *J Sports Sci Med*, *12*(3), 489-496.
- Davis, J. A., Stringer, M. D., & Woodley, S. J. (2012). New insights into the proximal tendons of adductor longus, adductor brevis and gracilis. *Br J Sports Med*, *46*(12), 871-876. doi:10.1136/bjsports-2011-090044
- Delahunt, E., McGroarty, M., De Vito, G., & Ditroilo, M. (2016). Nordic hamstring exercise training alters knee joint kinematics and hamstring activation patterns in young men. *Eur J Appl Physiol*, *116*(4), 663-672. doi:10.1007/s00421-015-3325-3
- Delmore, R. J., Laudner, K. G., & Torry, M. R. (2014). Adductor longus activation during common hip exercises. *J Sport Rehabil*, *23*(2), 79-87. doi:10.1123/jsr.2012-0046
- Douglas, J., Pearson, S., Ross, A., & McGuigan, M. (2016). Chronic Adaptations to Eccentric Training: A Systematic Review. *Sports Med*. doi:10.1007/s40279-016-0628-4
- Eirale, C., Tol, J. L., Whiteley, R., Chalabi, H., & Hölmich, P. (2014). Different injury pattern in goalkeepers compared to field players: a three-year epidemiological study of professional football. *J Sci Med Sport*, *17*(1), 34-38. doi:10.1016/j.jsams.2013.05.004
- Ekstrand, J., & Gillquist, J. (1983). Soccer injuries and their mechanisms: a prospective study. *Med Sci Sports Exerc*, *15*(3), 267-270.

- Ekstrand, J., & Hilding, J. (1999). The incidence and differential diagnosis of acute groin injuries in male soccer players. *Scand J Med Sci Sports*, 9(2), 98-103.
- Ekstrand, J., Häggglund, M., & Waldén, M. (2011). Epidemiology of muscle injuries in professional football (soccer). *Am J Sports Med*, 39(6), 1226-1232. doi:10.1177/0363546510395879
- Ekstrand, J., Waldén, M., & Häggglund, M. (2004). Risk for injury when playing in a national football team. *Scand J Med Sci Sports*, 14(1), 34-38.
- Emery, C. A., & Meeuwisse, W. H. (2001). Risk factors for groin injuries in hockey. *Med Sci Sports Exerc*, 33(9), 1423-1433.
- Engebretsen, A. H., Myklebust, G., Holme, I., Engebretsen, L., & Bahr, R. (2008). Prevention of injuries among male soccer players: a prospective, randomized intervention study targeting players with previous injuries or reduced function. *Am J Sports Med*, 36(6), 1052-1060. doi:10.1177/0363546508314432
- Engebretsen, A. H., Myklebust, G., Holme, I., Engebretsen, L., & Bahr, R. (2010). Intrinsic risk factors for groin injuries among male soccer players: a prospective cohort study. *Am J Sports Med*, 38(10), 2051-2057. doi:10.1177/0363546510375544
- Engstrom, B., Forssblad, M., Johansson, C., & Tornkvist, H. (1990). Does a major knee injury definitely sideline an elite soccer player? *Am J Sports Med*, 18(1), 101-105. doi:10.1177/036354659001800118
- Engstrom, B., Johansson, C., & Tornkvist, H. (1991). Soccer injuries among elite female players. *Am J Sports Med*, 19(4), 372-375. doi:10.1177/036354659101900408
- Erschine, R. M., Jones, D. A., Williams, A. G., Stewart, C. E., & Degens, H. (2010). Inter-individual variability in the adaptation of human muscle specific tension to progressive resistance training. *Eur J Appl Physiol*, 110(6), 1117-1125. doi:10.1007/s00421-010-1601-9
- Esteve, E., Rathleff, M. S., Bagur-Calafat, C., Urrutia, G., & Thorborg, K. (2015). Prevention of groin injuries in sports: a systematic review with meta-analysis of randomised controlled trials. *Br J Sports Med*. doi:10.1136/bjsports-2014-094162
- Fagan, S. P., & Awad, S. S. (2004). Abdominal wall anatomy: the key to a successful inguinal hernia repair. *Am J Surg*, 188(6A Suppl), 3s-8s. doi:10.1016/j.amjsurg.2004.09.004
- Falvey, E. C., King, E., Kinsella, S., & Franklyn-Miller, A. (2015). Athletic groin pain (part 1): a prospective anatomical diagnosis of 382 patients-clinical findings, MRI findings and patient-reported outcome measures at baseline. *Br J Sports Med*. doi:10.1136/bjsports-2015-094912
- Farup, J., Rahbek, S. K., Vendelbo, M. H., Matzon, A., Hindhede, J., Bejder, A., Ringgard, S., & Vissing, K. (2014). Whey protein hydrolysate augments tendon and muscle hypertrophy independent of resistance exercise contraction mode. *Scand J Med Sci Sports*, 24(5), 788-798. doi:10.1111/sms.12083
- Faude, O., Junge, A., Kindermann, W., & Dvorak, J. (2005). Injuries in female soccer players: a prospective study in the German national league. *Am J Sports Med*, 33(11), 1694-1700. doi:10.1177/0363546505275011
- Folland, J. P., & Williams, A. G. (2007). The adaptations to strength training : morphological and neurological contributions to increased strength. *Sports Med*, 37(2), 145-168.
- Gabbe, B. J., Bailey, M., Cook, J. L., Makdissi, M., Scase, E., Ames, N., Wood, T., McNeil, J. J., & Orchard, J. W. (2010). The association between hip and groin injuries in the elite junior football years and injuries sustained during elite senior competition. *Br J Sports Med*, 44(11), 799-802. doi:10.1136/bjism.2009.062554
- Gabbett, T. J., Hulin, B. T., Blanch, P., & Whiteley, R. (2016). High training workloads alone do not cause sports injuries: how you get there is the real issue. *Br J Sports Med*, 50(8), 444-445. doi:10.1136/bjsports-2015-095567
- Ganz, R., Parvizi, J., Beck, M., Leunig, M., Notzli, H., & Siebenrock, K. A. (2003). Femoroacetabular impingement: a cause for osteoarthritis of the hip. *Clin Orthop Relat Res*(417), 112-120. doi:10.1097/01.blo.0000096804.78689.c2

References

- Gaulrapp, H., Becker, A., Walther, M., & Hess, H. (2010). Injuries in women's soccer: a 1-year all players prospective field study of the women's Bundesliga (German premier league). *Clin J Sport Med*, 20(4), 264-271. doi:10.1097/JSM.0b013e3181e78e33
- Glasgow, R. E., Vogt, T. M., & Boles, S. M. (1999). Evaluating the public health impact of health promotion interventions: the RE-AIM framework. *Am J Public Health*, 89(9), 1322-1327.
- Gouttebauge, V., Hughes Schwab, B. A., Vivian, A., & G, M. M. J. K. (2016). Injuries, Matches Missed and the Influence of Minimum Medical Standards in the A-League Professional Football: A 5-Year Prospective Study. *Asian J Sports Med*, 7(1), e31385. doi:10.5812/asjasm.31385
- Grabiner, M. D., & Owings, T. M. (2002). EMG differences between concentric and eccentric maximum voluntary contractions are evident prior to movement onset. *Exp Brain Res*, 145(4), 505-511. doi:10.1007/s00221-002-1129-2
- Griffin, D., Dickenson, E. J., O'Donnell, J., Agricola, R., Awan, T., Beck, M., Clohisy, J. C., Dijkstra, H. P., Falvey, E., Gimpel, M., Hinman, R. S., Hölmich, P., Kassarjian, A., Martin, H. D., Martin, R., Mather, R. C., Philippon, M. J., Reiman, M. P., Takla, A., Thorborg, K., Walker, S., Weir, A., & Bennell, K. L. (2016a). The Warwick Agreement on femoroacetabular impingement syndrome (FAI syndrome): an international consensus statement. *Br J Sports Med*, 50(19), 1169-1176. doi:10.1136/bjsports-2016-096743
- Griffin, D., Wall, P., Realpe, A., Adams, A., Parsons, N., Hobson, R., Achten, J., Fry, J., Costa, M., Petrou, S., Foster, N., & Donovan, J. (2016b). UK FASHIoN: feasibility study of a randomised controlled trial of arthroscopic surgery for hip impingement compared with best conservative care. *Health Technol Assess*, 20(32), 1-172. doi:10.3310/hta20320
- Grote, K., Lincoln, T. L., & Gamble, J. G. (2004). Hip adductor injury in competitive swimmers. *Am J Sports Med*, 32(1), 104-108. doi:10.1177/0363546503258905
- Gyftopoulos, S., Rosenberg, Z. S., Schweitzer, M. E., & Bordalo-Rodrigues, M. (2008). Normal anatomy and strains of the deep musculotendinous junction of the proximal rectus femoris: MRI features. *AJR Am J Roentgenol*, 190(3), W182-186. doi:10.2214/ajr.07.2947
- Hawker, G. A., Mian, S., Kendzerska, T., & French, M. (2011). Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). *Arthritis Care Res (Hoboken)*, 63 Suppl 11, S240-252. doi:10.1002/acr.20543
- Hawkins, R. D., & Fuller, C. W. (1999). A prospective epidemiological study of injuries in four English professional football clubs. *Br J Sports Med*, 33(3), 196-203.
- Hawkins, R. D., Hulse, M. A., Wilkinson, C., Hodson, A., & Gibson, M. (2001). The association football medical research programme: an audit of injuries in professional football. *Br J Sports Med*, 35(1), 43-47.
- Haxhiu, B., Murtezani, A., Zahiti, B., Shalaj, I., & Sllamniku, S. (2015). Risk Factors for Injuries in Professional Football Players. *Folia Med (Plovdiv)*, 57(2), 138-143. doi:10.1515/folmed-2015-0033
- Hollis, S., & Campbell, F. (1999). What is meant by intention to treat analysis? Survey of published randomised controlled trials. *BMJ*, 319(7211), 670-674.
- Holm, L., van Hall, G., Rose, A. J., Miller, B. F., Doessing, S., Richter, E. A., & Kjaer, M. (2010). Contraction intensity and feeding affect collagen and myofibrillar protein synthesis rates differently in human skeletal muscle. *Am J Physiol Endocrinol Metab*, 298(2), E257-269. doi:10.1152/ajpendo.00609.2009
- Hägglund, M., Waldén, M., & Ekstrand, J. (2006). Previous injury as a risk factor for injury in elite football: a prospective study over two consecutive seasons. *Br J Sports Med*, 40(9), 767-772. doi:10.1136/bjism.2006.026609
- Hägglund, M., Waldén, M., & Ekstrand, J. (2007). Lower reinjury rate with a coach-controlled rehabilitation program in amateur male soccer: a randomized controlled trial. *Am J Sports Med*, 35(9), 1433-1442. doi:10.1177/0363546507300063

- Häggglund, M., Waldén, M., & Ekstrand, J. (2009a). Injuries among male and female elite football players. *Scand J Med Sci Sports*, 19(6), 819-827. doi:10.1111/j.1600-0838.2008.00861.x
- Häggglund, M., Waldén, M., & Ekstrand, J. (2009b). UEFA injury study--an injury audit of European Championships 2006 to 2008. *Br J Sports Med*, 43(7), 483-489. doi:10.1136/bjsm.2008.056937
- Häggglund, M., Waldén, M., & Ekstrand, J. (2013). Risk factors for lower extremity muscle injury in professional soccer: the UEFA Injury Study. *Am J Sports Med*, 41(2), 327-335. doi:10.1177/0363546512470634
- Hölmich, P. (2007). Long-standing groin pain in sportspeople falls into three primary patterns, a "clinical entity" approach: a prospective study of 207 patients. *Br J Sports Med*, 41(4), 247-252; discussion 252. doi:10.1136/bjsm.2006.033373
- Hölmich, P., Larsen, K., Krogsgaard, K., & Gluud, C. (2010). Exercise program for prevention of groin pain in football players: a cluster-randomized trial. *Scand J Med Sci Sports*, 20(6), 814-821. doi:10.1111/j.1600-0838.2009.00998.x
- Hölmich, P., Thorborg, K., Dehlendorff, C., Krogsgaard, K., & Gluud, C. (2014a). Incidence and clinical presentation of groin injuries in sub-elite male soccer. *Br J Sports Med*, 48(16), 1245-1250. doi:10.1136/bjsports-2013-092627
- Hölmich, P., Thorborg, K., Nyvold, P., Klit, J., Nielsen, M. B., & Troelsen, A. (2014b). Does bony hip morphology affect the outcome of treatment for patients with adductor-related groin pain? Outcome 10 years after baseline assessment. *Br J Sports Med*, 48(16), 1240-1244. doi:10.1136/bjsports-2013-092478
- Hölmich, P., Uhrskou, P., Ulnits, L., Kanstrup, I. L., Nielsen, M. B., Bjerg, A. M., & Krogsgaard, K. (1999). Effectiveness of active physical training as treatment for long-standing adductor-related groin pain in athletes: randomised trial. *Lancet*, 353(9151), 439-443. doi:10.1016/s0140-6736(98)03340-6
- Ibrahim, A., Murrell, G. A., & Knapman, P. (2007). Adductor strain and hip range of movement in male professional soccer players. *J Orthop Surg (Hong Kong)*, 15(1), 46-49. doi:10.1177/230949900701500111
- Ichinose, Y., Kanehisa, H., Ito, M., Kawakami, Y., & Fukunaga, T. (1998). Relationship between muscle fiber pennation and force generation capability in Olympic athletes. *Int J Sports Med*, 19(8), 541-546. doi:10.1055/s-2007-971957
- Impellizzeri, F. M., Bizzini, M., Dvorak, J., Pellegrini, B., Schena, F., & Junge, A. (2013). Physiological and performance responses to the FIFA 11+ (part 2): a randomised controlled trial on the training effects. *J Sports Sci*, 31(13), 1491-1502. doi:10.1080/02640414.2013.802926
- Ishøi, L., Sorensen, C. N., Kaae, N. M., Jorgensen, L. B., Hölmich, P., & Serner, A. (2015). Large eccentric strength increase using the Copenhagen Adduction exercise in football: A randomized controlled trial. *Scand J Med Sci Sports*. doi:10.1111/sms.12585
- Jacobson, I., & Tegner, Y. (2006). Injuries among female football players – With special emphasis on regional differences. *Advances in Physiotherapy*, 8(2), 66-74. doi:10.1080/14038190600621706
- Jacobson, I., & Tegner, Y. (2007). Injuries among Swedish female elite football players: a prospective population study. *Scand J Med Sci Sports*, 17(1), 84-91. doi:10.1111/j.1600-0838.2006.00524.x
- Jansen, J., Weir, A., Denis, R., Mens, J., Backx, F., & Stam, H. (2010). Resting thickness of transversus abdominis is decreased in athletes with longstanding adduction-related groin pain. *Man Ther*, 15(2), 200-205. doi:10.1016/j.math.2009.11.001
- Janz, N. K., & Becker, M. H. (1984). The Health Belief Model: a decade later. *Health Educ Q*, 11(1), 1-47. doi:10.1177/109019818401100101
- Jensen, J., Hölmich, P., Bandholm, T., Zebis, M. K., Andersen, L. L., & Thorborg, K. (2014). Eccentric strengthening effect of hip-adductor training with elastic bands in soccer players: a randomised controlled trial. *Br J Sports Med*, 48(4), 332-338. doi:10.1136/bjsports-2012-091095

References

- Kadi, F., Schjerling, P., Andersen, L. L., Charifi, N., Madsen, J. L., Christensen, L. R., & Andersen, J. L. (2004). The effects of heavy resistance training and detraining on satellite cells in human skeletal muscles. *J Physiol*, *558*(Pt 3), 1005-1012. doi:10.1113/jphysiol.2004.065904
- Kadi, F., & Thornell, L. E. (2000). Concomitant increases in myonuclear and satellite cell content in female trapezius muscle following strength training. *Histochem Cell Biol*, *113*(2), 99-103.
- Kawakami, Y., Abe, T., & Fukunaga, T. (1993). Muscle-fiber pennation angles are greater in hypertrophied than in normal muscles. *J Appl Physiol* (1985), *74*(6), 2740-2744. doi:10.1152/jappl.1993.74.6.2740
- Kelln, B. M., McKeon, P. O., Gontkof, L. M., & Hertel, J. (2008). Hand-held dynamometry: reliability of lower extremity muscle testing in healthy, physically active, young adults. *J Sport Rehabil*, *17*(2), 160-170.
- Kilding, A. E., Tunstall, H., & Kuzmic, D. (2008). Suitability of FIFA's "The 11" Training Programme for Young Football Players – Impact on Physical Performance. *J Sports Sci Med*, *7*(3), 320-326.
- Kongsgaard, M., Kovanen, V., Aagaard, P., Doessing, S., Hansen, P., Laursen, A. H., Kaldau, N. C., Kjaer, M., & Magnusson, S. P. (2009). Corticosteroid injections, eccentric decline squat training and heavy slow resistance training in patellar tendinopathy. *Scand J Med Sci Sports*, *19*(6), 790-802. doi:10.1111/j.1600-0838.2009.00949.x
- Kongsgaard, M., Qvortrup, K., Larsen, J., Aagaard, P., Doessing, S., Hansen, P., Kjaer, M., & Magnusson, S. P. (2010). Fibril morphology and tendon mechanical properties in patellar tendinopathy: effects of heavy slow resistance training. *Am J Sports Med*, *38*(4), 749-756. doi:10.1177/0363546509350915
- Kongsgaard, M., Reitelseder, S., Pedersen, T. G., Holm, L., Aagaard, P., Kjaer, M., & Magnusson, S. P. (2007). Region specific patellar tendon hypertrophy in humans following resistance training. *Acta Physiol (Oxf)*, *191*(2), 111-121. doi:10.1111/j.1748-1716.2007.01714.x
- Krommes, K., Bandholm, T., Jakobsen, M. D., Andersen, L. L., Serner, A., Hölmich, P., & Thorborg, K. (2017). DYNAMIC HIP ADDUCTION, ABDUCTION AND ABDOMINAL EXERCISES FROM THE HOLMICH GROIN-INJURY PREVENTION PROGRAM ARE INTENSE ENOUGH TO BE CONSIDERED STRENGTHENING EXERCISES - A CROSS-SECTIONAL STUDY. *Int J Sports Phys Ther*, *12*(3), 371-380.
- Kubo, K., Ikebukuro, T., Maki, A., Yata, H., & Tsunoda, N. (2012). Time course of changes in the human Achilles tendon properties and metabolism during training and detraining in vivo. *Eur J Appl Physiol*, *112*(7), 2679-2691. doi:10.1007/s00421-011-2248-x
- Kubo, K., Morimoto, M., Komuro, T., Yata, H., Tsunoda, N., Kanehisa, H., & Fukunaga, T. (2007). Effects of plyometric and weight training on muscle-tendon complex and jump performance. *Med Sci Sports Exerc*, *39*(10), 1801-1810. doi:10.1249/mss.0b013e31813e630a
- Kubo, K., Ohgo, K., Takeishi, R., Yoshinaga, K., Tsunoda, N., Kanehisa, H., & Fukunaga, T. (2006). Effects of isometric training at different knee angles on the muscle-tendon complex in vivo. *Scand J Med Sci Sports*, *16*(3), 159-167. doi:10.1111/j.1600-0838.2005.00450.x
- Lago, C. (2009). The influence of match location, quality of opposition, and match status on possession strategies in professional association football. *J Sports Sci*, *27*(13), 1463-1469. doi:10.1080/02640410903131681
- Larruskain, J., Lekue, J. A., Diaz, N., Odriozola, A., & Gil, S. M. (2018). A comparison of injuries in elite male and female football players: A five-season prospective study. *Scand J Med Sci Sports*, *28*(1), 237-245. doi:10.1111/sms.12860
- Le Gall, F., Carling, C., & Reilly, T. (2007). Biological maturity and injury in elite youth football. *Scand J Med Sci Sports*, *17*(5), 564-572. doi:10.1111/j.1600-0838.2006.00594.x
- Lovering, R. M., & Anderson, L. D. (2008). Architecture and fiber type of the pyramidalis muscle. *Anat Sci Int*, *83*(4), 294-297. doi:10.1111/j.1447-073X.2007.00226.x
- MacDougall, J. D., Elder, G. C., Sale, D. G., Moroz, J. R., & Sutton, J. R. (1980). Effects of strength training and immobilization on human muscle fibres. *Eur J Appl Physiol Occup Physiol*, *43*(1), 25-34.

- MacDougall, J. D., Sale, D. G., Moroz, J. R., Elder, G. C., Sutton, J. R., & Howald, H. (1979). Mitochondrial volume density in human skeletal muscle following heavy resistance training. *Med Sci Sports, 11*(2), 164-166.
- Maffey, L., & Emery, C. (2007). What are the risk factors for groin strain injury in sport? A systematic review of the literature. *Sports Med, 37*(10), 881-894.
- Malliaras, P., Hogan, A., Nawrocki, A., Crossley, K., & Schache, A. (2009). Hip flexibility and strength measures: reliability and association with athletic groin pain. *Br J Sports Med, 43*(10), 739-744. doi:10.1136/bjism.2008.055749
- Malliaras, P., Kamal, B., Nowell, A., Farley, T., Dhamu, H., Simpson, V., Morrissey, D., Langberg, H., Maffulli, N., & Reeves, N. D. (2013). Patellar tendon adaptation in relation to load-intensity and contraction type. *J Biomech, 46*(11), 1893-1899. doi:10.1016/j.jbiomech.2013.04.022
- McCall, A., Dupont, G., & Ekstrand, J. (2016). Injury prevention strategies, coach compliance and player adherence of 33 of the UEFA Elite Club Injury Study teams: a survey of teams' head medical officers. *Br J Sports Med, 50*(12), 725-730. doi:10.1136/bjsports-2015-095259
- Meeuwisse, W. H. (1994). Assessing Causation in Sport Injury: A Multifactorial Model. *Clinical Journal of Sport Medicine, 4*(3), 166-170.
- Meeuwisse, W. H., Tyreman, H., Hagel, B., & Emery, C. (2007). A dynamic model of etiology in sport injury: the recursive nature of risk and causation. *Clin J Sport Med, 17*(3), 215-219. doi:10.1097/JSM.0b013e3180592a48
- Moore, D. R., Phillips, S. M., Babraj, J. A., Smith, K., & Rennie, M. J. (2005). Myofibrillar and collagen protein synthesis in human skeletal muscle in young men after maximal shortening and lengthening contractions. *Am J Physiol Endocrinol Metab, 288*(6), E1153-1159. doi:10.1152/ajpendo.00387.2004
- Morkin, E. (1970). Postnatal muscle fiber assembly: localization of newly synthesized myofibrillar proteins. *Science, 167*(3924), 1499-1501.
- Morrissey, D., Graham, J., Screen, H., Sinha, A., Small, C., Twycross-Lewis, R., & Woledge, R. (2012). Coronal plane hip muscle activation in football code athletes with chronic adductor groin strain injury during standing hip flexion. *Man Ther, 17*(2), 145-149. doi:10.1016/j.math.2011.12.003
- Mosler, A. B., Crossley, K. M., Thorborg, K., Whiteley, R. J., Weir, A., Serner, A., & Hölmich, P. (2016a). Hip strength and range of motion: Normal values from a professional football league. *Journal of Science and Medicine in Sport. doi:10.1016/j.jsams.2016.05.010*
- Mosler, A. B., Crossley, K. M., Waarsing, J. H., Jomaah, N., Weir, A., Hölmich, P., & Agricola, R. (2016b). Ethnic Differences in Bony Hip Morphology in a Cohort of 445 Professional Male Soccer Players. *Am J Sports Med, 44*(11), 2967-2974. doi:10.1177/0363546516656163
- Mosler, A. B., Weir, A., Eirale, C., Farooq, A., Thorborg, K., Whiteley, R. J., Hlmich, P., & Crossley, K. M. (2018a). Epidemiology of time loss groin injuries in a men's professional football league: a 2-year prospective study of 17 clubs and 606 players. *Br J Sports Med, 52*(5), 292-297. doi:10.1136/bjsports-2016-097277
- Mosler, A. B., Weir, A., Serner, A., Agricola, R., Eirale, C., Farooq, A., Bakken, A., Thorborg, K., Whiteley, R. J., Hölmich, P., Bahr, R., & Crossley, K. M. (2018b). Musculoskeletal Screening Tests and Bony Hip Morphology Cannot Identify Male Professional Soccer Players at Risk of Groin Injuries: A 2-Year Prospective Cohort Study. *Am J Sports Med, 36*3546518763373. doi:10.1177/0363546518763373
- Muschaweck, U., & Berger, L. (2010a). Minimal Repair technique of sportsmen's groin: an innovative open-suture repair to treat chronic inguinal pain. *Hernia, 14*(1), 27-33. doi:10.1007/s10029-009-0614-y
- Muschaweck, U., & Berger, L. (2010b). Sportsmen's Groin-Diagnostic Approach and Treatment With the Minimal Repair Technique: A Single-Center Uncontrolled Clinical Review. *Sports Health, 2*(3), 216-221. doi:10.1177/1941738110367623

References

- Narici, M. V., Roi, G. S., Landoni, L., Minetti, A. E., & Cerretelli, P. (1989). Changes in force, cross-sectional area and neural activation during strength training and detraining of the human quadriceps. *Eur J Appl Physiol Occup Physiol*, *59*(4), 310-319.
- Nevin, F., & Delahunt, E. (2014). Adductor squeeze test values and hip joint range of motion in Gaelic football athletes with longstanding groin pain. *J Sci Med Sport*, *17*(2), 155-159. doi:10.1016/j.jsams.2013.04.008
- Nilstad, A., Andersen, T. E., Bahr, R., Holme, I., & Steffen, K. (2014). Risk factors for lower extremity injuries in elite female soccer players. *Am J Sports Med*, *42*(4), 940-948. doi:10.1177/0363546513518741
- Noya Salces, J., Gomez-Carmona, P. M., Gracia-Marco, L., Moliner-Urdiales, D., & Sillero-Quintana, M. (2014a). Epidemiology of injuries in First Division Spanish football. *J Sports Sci*, *32*(13), 1263-1270. doi:10.1080/02640414.2014.884720
- Noya Salces, J., Gomez-Carmona, P. M., Moliner-Urdiales, D., Gracia-Marco, L., & Sillero-Quintana, M. (2014b). An examination of injuries in Spanish Professional Soccer League. *J Sports Med Phys Fitness*, *54*(6), 765-771.
- Nuesch, E., Trelle, S., Reichenbach, S., Rutjes, A. W., Burgi, E., Scherer, M., Altman, D. G., & Juni, P. (2009). The effects of excluding patients from the analysis in randomised controlled trials: meta-epidemiological study. *BMJ*, *339*, b3244. doi:10.1136/bmj.b3244
- O'Brien, J., & Finch, C. F. (2014a). The implementation of musculoskeletal injury-prevention exercise programmes in team ball sports: a systematic review employing the RE-AIM framework. *Sports Med*, *44*(9), 1305-1318. doi:10.1007/s40279-014-0208-4
- O'Brien, J., & Finch, C. F. (2014b). A systematic review of core implementation components in team ball sport injury prevention trials. *Inj Prev*, *20*(5), 357-362. doi:10.1136/injuryprev-2013-041087
- O'Connor, D. (2004). Groin injuries in professional rugby league players: a prospective study. *J Sports Sci*, *22*(7), 629-636. doi:10.1080/02640410310001655804
- Obey, M. R., Broski, S. M., Spinner, R. J., Collins, M. S., & Krych, A. J. (2016). Anatomy of the Adductor Magnus Origin: Implications for Proximal Hamstring Injuries. *Orthop J Sports Med*, *4*(1), 2325967115625055. doi:10.1177/2325967115625055
- Omar, I. M., Zoga, A. C., Kavanagh, E. C., Koulouris, G., Bergin, D., Gopez, A. G., Morrison, W. B., & Meyers, W. C. (2008). Athletic pubalgia and "sports hernia": optimal MR imaging technique and findings. *Radiographics*, *28*(5), 1415-1438. doi:10.1148/rg.285075217
- Opar, D. A., Piatkowski, T., Williams, M. D., & Shield, A. J. (2013a). A novel device using the Nordic hamstring exercise to assess eccentric knee flexor strength: a reliability and retrospective injury study. *J Orthop Sports Phys Ther*, *43*(9), 636-640. doi:10.2519/jospt.2013.4837
- Opar, D. A., Williams, M. D., Timmins, R. G., Dear, N. M., & Shield, A. J. (2013b). Knee flexor strength and bicep femoris electromyographical activity is lower in previously strained hamstrings. *J Electromyogr Kinesiol*, *23*(3), 696-703. doi:10.1016/j.jelekin.2012.11.004
- Orchard, J., Farhart, P., Kountouris, A., James, T., & Portus, M. (2010). Pace bowlers in cricket with history of lumbar stress fracture have increased risk of lower limb muscle strains, particularly calf strains. *Open Access J Sports Med*, *1*, 177-182. doi:10.2147/oajsm.s10623
- Orchard, J., Wood, T., Seward, H., & Broad, A. (1998). Comparison of injuries in elite senior and junior Australian football. *J Sci Med Sport*, *1*(2), 83-88.
- Paajanen, H., Montgomery, A., Simon, T., & Sheen, A. J. (2015). Systematic review: laparoscopic treatment of long-standing groin pain in athletes. *Br J Sports Med*, *49*(12), 814-818. doi:10.1136/bjsports-2014-094544
- Paajanen, H., Ristolainen, L., Turunen, H., & Kujala, U. M. (2011). Prevalence and etiological factors of sport-related groin injuries in top-level soccer compared to non-contact sports. *Arch Orthop Trauma Surg*, *131*(2), 261-266. doi:10.1007/s00402-010-1169-1
- Palisch, A., Zoga, A. C., & Meyers, W. C. (2013). Imaging of athletic pubalgia and core muscle injuries: clinical and therapeutic correlations. *Clin Sports Med*, *32*(3), 427-447. doi:10.1016/j.csm.2013.03.002

- Patten, C., Kamen, G., & Rowland, D. M. (2001). Adaptations in maximal motor unit discharge rate to strength training in young and older adults. *Muscle Nerve*, *24*(4), 542-550.
- Philippon, M. J., Devitt, B. M., Campbell, K. J., Michalski, M. P., Espinoza, C., Wijdicks, C. A., & Laprade, R. F. (2014). Anatomic variance of the iliopsoas tendon. *Am J Sports Med*, *42*(4), 807-811. doi:10.1177/0363546513518414
- Pluim, B. M., Loeffen, F. G., Clarsen, B., Bahr, R., & Verhagen, E. A. (2015). A one-season prospective study of injuries and illness in elite junior tennis. *Scand J Med Sci Sports*. doi:10.1111/sms.12471
- Proske, U., & Morgan, D. L. (2001). Muscle damage from eccentric exercise: mechanism, mechanical signs, adaptation and clinical applications. *J Physiol*, *537*(Pt 2), 333-345.
- Reis, I., Rebelo, A., Krustup, P., & Brito, J. (2013). Performance enhancement effects of Federation Internationale de Football Association's "The 11+" injury prevention training program in youth futsal players. *Clin J Sport Med*, *23*(4), 318-320. doi:10.1097/JSM.0b013e318285630e
- Robinson, P., Barron, D. A., Parsons, W., Grainger, A. J., Schilders, E. M., & O'Connor, P. J. (2004). Adductor-related groin pain in athletes: correlation of MR imaging with clinical findings. *Skeletal Radiol*, *33*(8), 451-457. doi:10.1007/s00256-004-0753-2
- Roth, S. M., Martel, G. F., Ivey, F. M., Lemmer, J. T., Tracy, B. L., Metter, E. J., Hurley, B. F., & Rogers, M. A. (2001). Skeletal muscle satellite cell characteristics in young and older men and women after heavy resistance strength training. *J Gerontol A Biol Sci Med Sci*, *56*(6), B240-247.
- Ryan, J., DeBurca, N., & Mc Creesh, K. (2014). Risk factors for groin/hip injuries in field-based sports: a systematic review. *Br J Sports Med*, *48*(14), 1089-1096. doi:10.1136/bjsports-2013-092263
- Schache, A. G., Woodley, S. J., Schilders, E., Orchard, J. W., & Crossley, K. M. (2017). Anatomical and morphological characteristics may explain why groin pain is more common in male than female athletes. *Br J Sports Med*, *51*(7), 554-555. doi:10.1136/bjsports-2016-096945
- Schick, D. M., & Meeuwisse, W. H. (2003). Injury rates and profiles in female ice hockey players. *Am J Sports Med*, *31*(1), 47-52. doi:10.1177/03635465030310011901
- Schilders, E., Bharam, S., Golan, E., Dimitrakopoulou, A., Mitchell, A., Spaepen, M., Beggs, C., Cooke, C., & Hölmich, P. (2017). The pyramidalis-anterior pubic ligament-adductor longus complex (PLAC) and its role with adductor injuries: a new anatomical concept. *Knee Surg Sports Traumatol Arthrosc*, *25*(12), 3969-3977. doi:10.1007/s00167-017-4688-2
- Serner, A., Jakobsen, M. D., Andersen, L. L., Hölmich, P., Sundstrup, E., & Thorborg, K. (2014). EMG evaluation of hip adduction exercises for soccer players: implications for exercise selection in prevention and treatment of groin injuries. *Br J Sports Med*, *48*(14), 1108-1114. doi:10.1136/bjsports-2012-091746
- Serner, A., Tol, J. L., Jomaah, N., Weir, A., Whiteley, R., Thorborg, K., Robinson, M., & Hölmich, P. (2015a). Diagnosis of Acute Groin Injuries: A Prospective Study of 110 Athletes. *Am J Sports Med*, *43*(8), 1857-1864. doi:10.1177/0363546515585123
- Serner, A., van Eijck, C. H., Beumer, B. R., Hölmich, P., Weir, A., & de Vos, R. J. (2015b). Study quality on groin injury management remains low: a systematic review on treatment of groin pain in athletes. *Br J Sports Med*, *49*(12), 813. doi:10.1136/bjsports-2014-094256
- Serner, A., Weir, A., Tol, J. L., Thorborg, K., Roemer, F., Guermazi, A., Yamashiro, E., & Hölmich, P. (2018a). Characteristics of acute groin injuries in the adductor muscles: A detailed MRI study in athletes. *Scand J Med Sci Sports*, *28*(2), 667-676. doi:10.1111/sms.12936
- Serner, A., Weir, A., Tol, J. L., Thorborg, K., Roemer, F., Guermazi, A., Yamashiro, E., & Hölmich, P. (2018b). Characteristics of acute groin injuries in the hip flexor muscles - a detailed MRI study in athletes. *Scand J Med Sci Sports*, *28*(2), 677-685. doi:10.1111/sms.12939
- Seynnes, O. R., Erskine, R. M., Maganaris, C. N., Longo, S., Simoneau, E. M., Grosset, J. F., & Narici, M. V. (2009). Training-induced changes in structural and mechanical properties of the patellar tendon are related to muscle hypertrophy but not to strength gains. *J Appl Physiol* (1985), *107*(2), 523-530. doi:10.1152/jappphysiol.00213.2009

References

- Shalaj, I., Tishukaj, F., Bachl, N., Tschan, H., Wessner, B., & Csapo, R. (2016). Injuries in professional male football players in Kosovo: a descriptive epidemiological study. *BMC Musculoskeletal Disord*, *17*, 338. doi:10.1186/s12891-016-1202-9
- Sheen, A. J., Stephenson, B. M., Lloyd, D. M., Robinson, P., Fevre, D., Paajanen, H., de Beaux, A., Kingsnorth, A., Gilmore, O. J., Bennett, D., Maclennan, I., O'Dwyer, P., Sanders, D., & Kurzer, M. (2014). 'Treatment of the Sportsman's groin': British Hernia Society's 2014 position statement based on the Manchester Consensus Conference. *Br J Sports Med*, *48*, 1079-1087.
- Siegel, A. L., Kuhlmann, P. K., & Cornelison, D. D. (2011). Muscle satellite cell proliferation and association: new insights from myofiber time-lapse imaging. *Skelet Muscle*, *1*(1), 7. doi:10.1186/2044-5040-1-7
- Silvers-Granelli, H., Mandelbaum, B., Adeniji, O., Insler, S., Bizzini, M., Pohlig, R., Junge, A., Snyder-Mackler, L., & Dvorak, J. (2015). Efficacy of the FIFA 11+ Injury Prevention Program in the Collegiate Male Soccer Player. *Am J Sports Med*, *43*(11), 2628-2637. doi:10.1177/0363546515602009
- Soligard, T., Myklebust, G., Steffen, K., Holme, I., Silvers, H., Bizzini, M., Junge, A., Dvorak, J., Bahr, R., & Andersen, T. E. (2008). Comprehensive warm-up programme to prevent injuries in young female footballers: cluster randomised controlled trial. *BMJ*, *337*, a2469. doi:10.1136/bmj.a2469
- Soligard, T., Nilstad, A., Steffen, K., Myklebust, G., Holme, I., Dvorak, J., Bahr, R., & Andersen, T. E. (2010). Compliance with a comprehensive warm-up programme to prevent injuries in youth football. *Br J Sports Med*, *44*(11), 787-793. doi:10.1136/bjism.2009.070672
- Sousa, P., Rebelo, A., & Brito, J. (2013). Injuries in amateur soccer players on artificial turf: a one-season prospective study. *Phys Ther Sport*, *14*(3), 146-151. doi:10.1016/j.ptsp.2012.05.003
- Steffen, K., Emery, C. A., Romiti, M., Kang, J., Bizzini, M., Dvorak, J., Finch, C. F., & Meeuwisse, W. H. (2013). High adherence to a neuromuscular injury prevention programme (FIFA 11+) improves functional balance and reduces injury risk in Canadian youth female football players: a cluster randomised trial. *Br J Sports Med*, *47*(12), 794-802. doi:10.1136/bjsports-2012-091886
- Steffen, K., Myklebust, G., Andersen, T. E., Holme, I., & Bahr, R. (2008a). Self-reported injury history and lower limb function as risk factors for injuries in female youth soccer. *Am J Sports Med*, *36*(4), 700-708. doi:10.1177/0363546507311598
- Steffen, K., Myklebust, G., Olsen, O. E., Holme, I., & Bahr, R. (2008b). Preventing injuries in female youth football—a cluster-randomized controlled trial. *Scand J Med Sci Sports*, *18*(5), 605-614. doi:10.1111/j.1600-0838.2007.00703.x
- Sterne, J. A., White, I. R., Carlin, J. B., Spratt, M., Royston, P., Kenward, M. G., Wood, A. M., & Carpenter, J. R. (2009). Multiple imputation for missing data in epidemiological and clinical research: potential and pitfalls. *BMJ*, *338*, b2393. doi:10.1136/bmj.b2393
- Svensson, R. B., Heinemeier, K. M., Couppe, C., Kjaer, M., & Magnusson, S. P. (2016). Effect of aging and exercise on the tendon. *J Appl Physiol (1985)*, *121*(6), 1237-1246. doi:10.1152/jappphysiol.00328.2016
- Söderman, K., Alfredson, H., Pietila, T., & Werner, S. (2001). Risk factors for leg injuries in female soccer players: a prospective investigation during one out-door season. *Knee Surg Sports Traumatol Arthrosc*, *9*(5), 313-321. doi:10.1007/s001670100228
- Tak, I., Engelaar, L., Gouttebauge, V., Barendrecht, M., Van den Heuvel, S., Kerkhoffs, G., Langhout, R., Stubbe, J., & Weir, A. (2017). Is lower hip range of motion a risk factor for groin pain in athletes? A systematic review with clinical applications. *Br J Sports Med*. doi:10.1136/bjsports-2016-096619
- Tak, I., Weir, A., Langhout, R., Waarsing, J. H., Stubbe, J., Kerkhoffs, G., & Agricola, R. (2015). The relationship between the frequency of football practice during skeletal growth and the presence of a cam deformity in adult elite football players. *Br J Sports Med*, *49*(9), 630-634. doi:10.1136/bjsports-2014-094130

- Tatu, L., Parratte, B., Vuillier, F., Diop, M., & Monnier, G. (2001). Descriptive anatomy of the femoral portion of the iliopsoas muscle. Anatomical basis of anterior snapping of the hip. *Surg Radiol Anat*, 23(6), 371-374.
- Taylor, R., Vuckovic, Z., Mosler, A., Agricola, R., Otten, R., Jacobsen, P., Hölmich, P., & Weir, A. (2017). Multidisciplinary Assessment of 100 Athletes With Groin Pain Using the Doha Agreement: High Prevalence of Adductor-Related Groin Pain in Conjunction With Multiple Causes. *Clin J Sport Med*. doi:10.1097/jsm.0000000000000469
- Tegnander, A., Olsen, O. E., Moholdt, T. T., Engebretsen, L., & Bahr, R. (2008). Injuries in Norwegian female elite soccer: a prospective one-season cohort study. *Knee Surg Sports Traumatol Arthrosc*, 16(2), 194-198. doi:10.1007/s00167-007-0403-z
- Thorborg, K., Bandholm, T., Schick, M., Jensen, J., & Hölmich, P. (2013). Hip strength assessment using handheld dynamometry is subject to intertester bias when testers are of different sex and strength. *Scand J Med Sci Sports*, 23(4), 487-493. doi:10.1111/j.1600-0838.2011.01405.x
- Thorborg, K., Branci, S., Stensbirk, F., Jensen, J., & Hölmich, P. (2014). Copenhagen hip and groin outcome score (HAGOS) in male soccer: reference values for hip and groin injury-free players. *Br J Sports Med*, 48(7), 557-559. doi:10.1136/bjsports-2013-092607
- Thorborg, K., Coupe, C., Petersen, J., Magnusson, S. P., & Hölmich, P. (2011a). Eccentric hip adduction and abduction strength in elite soccer players and matched controls: a cross-sectional study. *Br J Sports Med*, 45(1), 10-13. doi:10.1136/bjism.2009.061762
- Thorborg, K., Hölmich, P., Christensen, R., Petersen, J., & Roos, E. M. (2011b). The Copenhagen Hip and Groin Outcome Score (HAGOS): development and validation according to the COSMIN checklist. *Br J Sports Med*, 45(6), 478-491. doi:10.1136/bjism.2010.080937
- Thorborg, K., Krommes, K. K., Esteve, E., Clausen, M. B., Bartels, E. M., & Rathleff, M. S. (2017). Effect of specific exercise-based football injury prevention programmes on the overall injury rate in football: a systematic review and meta-analysis of the FIFA 11 and 11+ programmes. *Br J Sports Med*, 51(7), 562-571. doi:10.1136/bjsports-2016-097066
- Thorborg, K., Petersen, J., Magnusson, S. P., & Hölmich, P. (2010). Clinical assessment of hip strength using a hand-held dynamometer is reliable. *Scand J Med Sci Sports*, 20(3), 493-501. doi:10.1111/j.1600-0838.2009.00958.x
- Thorborg, K., Rathleff, M. S., Petersen, P., Branci, S., & Hölmich, P. (2015). Prevalence and severity of hip and groin pain in sub-elite male football: a cross-sectional cohort study of 695 players. *Scand J Med Sci Sports*. doi:10.1111/sms.12623
- Timmins, R. G., Bourne, M. N., Shield, A. J., Williams, M. D., Lorenzen, C., & Opar, D. A. (2016). Short biceps femoris fascicles and eccentric knee flexor weakness increase the risk of hamstring injury in elite football (soccer): a prospective cohort study. *Br J Sports Med*, 50(24), 1524-1535. doi:10.1136/bjsports-2015-095362
- Twisk, J. W. R. (2006). *Applied Multilevel Analysis: A Practical Guide for Medical Researchers*. Cambridge: Cambridge University Press.
- Tyler, T. F., Nicholas, S. J., Campbell, R. J., Donellan, S., & McHugh, M. P. (2002). The effectiveness of a preseason exercise program to prevent adductor muscle strains in professional ice hockey players. *Am J Sports Med*, 30(5), 680-683. doi:10.1177/03635465020300050801
- Tyler, T. F., Nicholas, S. J., Campbell, R. J., & McHugh, M. P. (2001). The association of hip strength and flexibility with the incidence of adductor muscle strains in professional ice hockey players. *Am J Sports Med*, 29(2), 124-128.
- van Beijsterveldt, A. M., Stubbe, J. H., Schmikli, S. L., van de Port, I. G., & Backx, F. J. (2015). Differences in injury risk and characteristics between Dutch amateur and professional soccer players. *J Sci Med Sport*, 18(2), 145-149. doi:10.1016/j.jsams.2014.02.004
- van Beijsterveldt, A. M., van de Port, I. G., Krist, M. R., Schmikli, S. L., Stubbe, J. H., Frederiks, J. E., & Backx, F. J. (2012). Effectiveness of an injury prevention programme for adult male amateur soccer players: a cluster-randomised controlled trial. *Br J Sports Med*, 46(16), 1114-1118. doi:10.1136/bjsports-2012-091277

References

- van Beijsterveldt, A. M., van der Horst, N., van de Port, I. G., & Backx, F. J. (2013). How effective are exercise-based injury prevention programmes for soccer players? : A systematic review. *Sports Med*, 43(4), 257-265. doi:10.1007/s40279-013-0026-0
- van Buuren, S. (2012). *Flexible Imputation of Missing Data*. Hoboken: Taylor and Francis.
- van Dyk, N., Bahr, R., Burnett, A. F., Verhagen, E., von Tiggelen, D., & Witvrouw, E. (2018). No association between rate of torque development and onset of muscle activity with increased risk of hamstring injury in elite football. *Scand J Med Sci Sports*. doi:10.1111/sms.13224
- van Mechelen, W., Hlobil, H., & Kemper, H. C. (1992). Incidence, severity, aetiology and prevention of sports injuries. A review of concepts. *Sports Med*, 14(2), 82-99.
- van Reijen, M., Vriend, I., van Mechelen, W., Finch, C. F., & Verhagen, E. A. (2016). Compliance with Sport Injury Prevention Interventions in Randomised Controlled Trials: A Systematic Review. *Sports Med*, 46(8), 1125-1139. doi:10.1007/s40279-016-0470-8
- Verrall, G. M., Slavotinek, J. P., Barnes, P. G., Esterman, A., Oakeshott, R. D., & Spriggins, A. J. (2007). Hip joint range of motion restriction precedes athletic chronic groin injury. *J Sci Med Sport*, 10(6), 463-466. doi:10.1016/j.jsams.2006.11.006
- Vickers, A. J., & Altman, D. G. (2001). Statistics notes: Analysing controlled trials with baseline and follow up measurements. *BMJ*, 323(7321), 1123-1124.
- Vila-Cha, C., Falla, D., Correia, M. V., & Farina, D. (2012). Adjustments in motor unit properties during fatiguing contractions after training. *Med Sci Sports Exerc*, 44(4), 616-624. doi:10.1249/MSS.0b013e318235d81d
- Waldén, M., Häggglund, M., & Ekstrand, J. (2005). Injuries in Swedish elite football--a prospective study on injury definitions, risk for injury and injury pattern during 2001. *Scand J Med Sci Sports*, 15(2), 118-125. doi:10.1111/j.1600-0838.2004.00393.x
- Waldén, M., Häggglund, M., & Ekstrand, J. (2015). The epidemiology of groin injury in senior football: a systematic review of prospective studies. *Br J Sports Med*, 49(12), 792-797. doi:10.1136/bjsports-2015-094705
- Weir, A., Brukner, P., Delahunt, E., Ekstrand, J., Griffin, D., Khan, K. M., Lovell, G., Meyers, W. C., Muschaweck, U., Orchard, J., Paajanen, H., Philippon, M., Reboul, G., Robinson, P., Schache, A. G., Schilders, E., Serner, A., Silvers, H., Thorborg, K., Tyler, T., Verrall, G., de Vos, R. J., Vuckovic, Z., & Hölmich, P. (2015a). Doha agreement meeting on terminology and definitions in groin pain in athletes. *Br J Sports Med*, 49(12), 768-774. doi:10.1136/bjsports-2015-094869
- Weir, A., de Vos, R. J., Moen, M., Hölmich, P., & Tol, J. L. (2011). Prevalence of radiological signs of femoroacetabular impingement in patients presenting with long-standing adductor-related groin pain. *Br J Sports Med*, 45(1), 6-9. doi:10.1136/bjism.2009.060434
- Weir, A., Hölmich, P., Schache, A. G., Delahunt, E., & de Vos, R. J. (2015b). Terminology and definitions on groin pain in athletes: building agreement using a short Delphi method. *Br J Sports Med*, 49(12), 825-827. doi:10.1136/bjsports-2015-094807
- Weir, A., Robinson, P., Hogan, B., & Franklyn-Miller, A. (2017). MRI investigation for groin pain in athletes: is radiological terminology clarifying or confusing? *Br J Sports Med*, 51(16), 1185-1186. doi:10.1136/bjsports-2016-096973
- Werner, J., Häggglund, M., Ekstrand, J., & Waldén, M. (2018). Hip and groin time-loss injuries decreased slightly but injury burden remained constant in men's professional football: the 15-year prospective UEFA Elite Club Injury Study. *Br J Sports Med*. doi:10.1136/bjsports-2017-097796
- Whittaker, J. L., Small, C., Maffey, L., & Emery, C. A. (2015). Risk factors for groin injury in sport: an updated systematic review. *Br J Sports Med*, 49(12), 803-809. doi:10.1136/bjsports-2014-094287
- Wilkinson, S. B., Tarnopolsky, M. A., Grant, E. J., Correia, C. E., & Phillips, S. M. (2006). Hypertrophy with unilateral resistance exercise occurs without increases in endogenous anabolic hormone concentration. *Eur J Appl Physiol*, 98(6), 546-555. doi:10.1007/s00421-006-0300-z

-
- Windt, J., & Gabbett, T. J. (2017). How do training and competition workloads relate to injury? The workload-injury aetiology model. *Br J Sports Med*, *51*(5), 428-435. doi:10.1136/bjsports-2016-096040
- Witvrouw, E., Danneels, L., Asselman, P., D'Have, T., & Cambier, D. (2003). Muscle flexibility as a risk factor for developing muscle injuries in male professional soccer players. A prospective study. *Am J Sports Med*, *31*(1), 41-46. doi:10.1177/03635465030310011801
- Wollin, M., Pizzari, T., Spagnolo, K., Welvaert, M., & Thorborg, K. (2018a). The effects of football match congestion in an international tournament on hip adductor squeeze strength and pain in elite youth players. *J Sports Sci*, *36*(10), 1167-1172. doi:10.1080/02640414.2017.1363452
- Wollin, M., Thorborg, K., Welvaert, M., & Pizzari, T. (2018b). In-season monitoring of hip and groin strength, health and function in elite youth soccer: Implementing an early detection and management strategy over two consecutive seasons. *J Sci Med Sport*. doi:10.1016/j.jsams.2018.03.004
- Östenberg, A., & Roos, H. (2000). Injury risk factors in female European football. A prospective study of 123 players during one season. *Scand J Med Sci Sports*, *10*(5), 279-285.

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Paper III

The Adductor Strengthening Programme prevents groin problems among male football players: a cluster-randomised controlled trial

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ABSTRACT

Background Groin injuries represent a considerable problem in male football. Previous groin-specific prevention programmes have not shown a significant reduction in groin injury rates. An exercise programme using the Copenhagen Adduction exercise increases hip adduction strength, a key risk factor for groin injuries. However, its preventive effect is yet to be tested.

Aim To evaluate the effect of a single-exercise approach, based on the Copenhagen Adduction exercise, on the prevalence of groin problems in male football players.

Methods 35 semiprofessional Norwegian football teams were cluster-randomised into an intervention group (18 teams, 339 players) and a control group (17 teams, 313 players). The intervention group performed an Adductor Strengthening Programme using one exercise, with three progression levels, three times per week during the preseason (6–8 weeks), and once per week during the competitive season (28 weeks). The control group were instructed to train as normal. The prevalence of groin problems was measured weekly in both groups during the competitive season using the Oslo Sports Trauma Research Center Overuse Injury Questionnaire.

Results The average prevalence of groin problems during the season was 13.5% (95% CI 12.3% to 14.7%) in the intervention group and 21.3% (95% CI 20.0% to 22.6%) in the control group. The risk of reporting groin problems was 41% lower in the intervention group (OR 0.59, 95% CI 0.40 to 0.86, $p=0.008$).

Conclusion The simple Adductor Strengthening Programme substantially reduced the self-reported prevalence and risk of groin problems in male football players.

Trial registration number ISRCTN98514933.

INTRODUCTION

Groin injuries represent a considerable problem in male football, accounting for 4%–19% of all time-loss injuries.¹ At the elite level, approximately one in five male players incur a groin injury causing time loss each season.² To date, the effect of groin-specific prevention programmes has not been established.³ A recent systematic review and meta-analysis indicates that the FIFA 11+ may have a preventive effect on hip and groin injuries.⁴ However, this analysis was based on two studies only. A significant reduction in groin injury rate was observed among collegiate male players,⁵ while there was no difference in a study on young female players.⁶

One limitation of previous groin-specific prevention studies is the use of a time-loss injury definition, an inadequate approach as only about one-third of all groin problems result in time loss.⁷ Injuries causing time loss may only represent the ‘tip of the iceberg’ as a large proportion of players continue to participate despite having groin-related complaints with associated impairments or reduced performance.^{1,7–9} To address this, we have developed a new method to improve the recording of groin problems, using an ‘all physical complaints’ approach, in order to capture all cases leading to pain, decreased participation or performance, not only those resulting in time loss.¹⁰

In football, two out of three cases of groin injuries are adductor-related.^{2,11–14} Low hip adduction strength has been identified as an important and modifiable risk factor associated with an increased risk of groin injury.^{15,16} Furthermore, >20% deficit in eccentric strength of the hip adductor muscles has been observed among players with groin pain.¹⁷ Thus, strengthening the hip adductors may play an important role in reducing the prevalence and rate of groin injuries in football players. In recent studies, the muscle activation patterns and strength effects of various hip adductor exercises have been examined.^{18–21} The Copenhagen Adduction exercise (CA) has demonstrated high activation of the adductor longus muscle,²¹ as well as considerable eccentric adduction strength gains following standardised protocols.^{18,19} The apparent advantage of this exercise is that no equipment is needed and the CA can be performed on the pitch just prior to or after training. However, its preventive effect has not been tested.

Thus, the purpose of this cluster-randomised controlled trial (RCT) was to test the effect of a single-exercise approach, based on the CA, to reduce the prevalence of groin problems in male players.

METHODS

Study design and participants

This cluster-RCT was registered with the International Standard Randomised Controlled Trial Number registry (ISRCTN98514933) and took place from February 2016 to October 2016. During the 2016 preseason (February and March), we invited teams from the second and third levels (semiprofessional) in Norway to take part in the study. We visited all teams who agreed to participate to inform and invite players to participate. All players under contract with the team were eligible for participation, except those not expected to train



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or play during the first 6–8 weeks of the season due to injury or illness. The players received verbal and written information about the study purpose and procedures and provided written consent to participation. All players included at baseline were followed until the end of the season (October).

This report is prepared according to the TIDieR checklist and the Consort Statement recommendations with extension for reporting cluster-randomised trials.^{22,23}

Baseline questionnaires

We registered demographic data, playing position, dominant leg (kicking leg) and years as a senior player. Players also registered current hip and groin symptoms using the Oslo Sports Trauma Research Center (OSTRC) Overuse Injury Questionnaire¹⁰ and the Copenhagen Hip and Groin Outcome Score (HAGOS) at baseline.²⁴

Randomisation

We cluster-randomised on a team level to minimise the risk of contamination bias between players in the intervention and control groups. A statistician, who was blinded to the study protocol, performed a computer-generated block randomisation, with block sizes of 4 and 6 in random order. After a team agreed to participate, the principal investigator opened a sealed envelope revealing their group assignment.

Blinding

It was not possible to blind players, coaches or the principal investigator to group allocation. However, a research assistant was blinded and managed all data during the collection period,

and outcome measures were not available to any party until all data had been collected.

Intervention

The Adductor Strengthening Programme consisted of a single exercise with multiple levels of difficulty. The exercise was based on the CA as this has previously been shown to be a high-intensity exercise targeting the adductors.²¹ As the CA might be painful or difficult to perform for symptomatic players, we created two easier levels that players could choose from: level 1 (easiest): side-lying hip adduction; level 2 (moderate): the CA as previously described,²¹ but with a shorter lever arm; and level 3 (hardest): the CA as previously described²¹ (figure 1). Videos with detailed information on the performance of each level are available as an online supplementary appendix.

Players were asked to start at level 3. However, if they experienced groin pain during the exercise >3 on an 11-point numeric rating scale (0–10, where 0 is no pain and 10 is maximal pain),²⁵ they were instructed to perform level 2 instead. Similarly, if level 2 provoked pain >3/10, the player was informed to perform level 1. The exercise was performed on both sides.

Teams in the intervention group were asked to perform the programme as a part of their regular warm-up, 2–3 times a week for a minimum of 6 weeks during the preseason and maintain the programme once a week throughout the regular season (table 1). At a team visit during preseason, players and coaches in the intervention group were shown how to perform the different levels of the programme by the principal investigator. Team medical staff were also included in the instruction session whenever

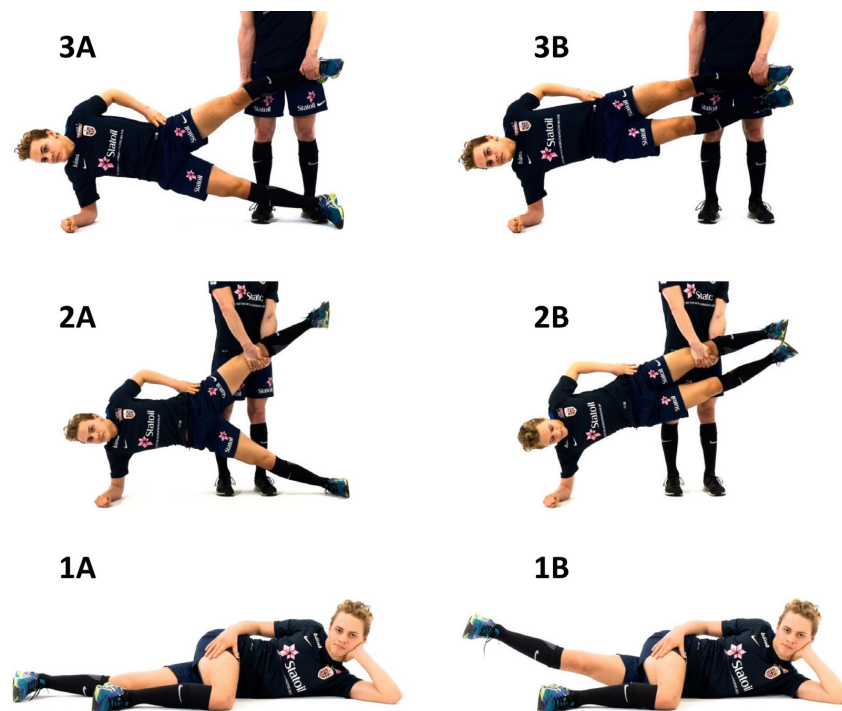


Figure 1 (A) Starting/ending position and (B) mid position for the different levels of the Adductor Strengthening Programme.

Table 1 Training protocol for the Adductor Strengthening Programme

Week	Weekly sessions	Sets per side	Repetitions per side
Preseason (weeks)			
1	2	1	3–5
2	3	1	3–5
3–4	3	1	7–10
5–6	3	1	12–15
7–8	2	1	12–15
In season	1	1	12–15

possible (75% of the time). We encouraged the players, coaches and medical staff to contact us if they experienced problems or any other adverse events when performing the exercise.

Compliance

Compliance to the training programme was based on players' self-reported number of sessions completed. This information was collected weekly as a part of an electronic questionnaire, which also measured groin injury consequences (see below). To calculate the overall compliance, the total number of completed sessions was summed and divided by the number of respondents. However, to avoid overestimation, players who performed more than the recommended number of sessions were assigned the maximum recommended number.

Outcome measures

The primary outcome measure was the weekly prevalence of all groin problems registered during the competitive season (28 weeks) using the OSTRC Overuse Injury Questionnaire.¹⁰ The secondary outcome measure was the weekly prevalence of substantial groin problems registered during the competitive season. Players were categorised as having a groin problem if they recorded any hip or groin symptoms in the questionnaire, including 'pain, ache, stiffness, clicking/catching or other complaints related to the groin', or if they reported reduced training participation, training volume or performance due to groin problems.¹⁰ Players were categorised as having a substantial groin problem if they reported moderate or severe reductions in training volume or football performance, or a complete inability to participate due to groin problems.¹⁰ The complete questionnaire is available as an online supplementary appendix.

The questionnaire was distributed using a smartphone application (Spartanova; Spartanova NV, Ghent, Belgium) during the competitive season. Each player received a notification through the smartphone application to complete the questionnaire every Sunday evening and a short message service (SMS) notification every Monday. Non-responders received an SMS reminder the following Thursday. Players who failed to respond through the smartphone application were contacted by telephone and asked to complete the questionnaire verbally. During the last four weeks of the season (September/October), we visited each club and asked players to respond to the questionnaire retrospectively for weeks with missing responses from the start of the competitive season to the beginning of September. To assist recall, each player was shown a document summarising all their questionnaire responses and match fixtures. The retrospective registration represents a deviation from the original protocol.

Each week, we calculated the prevalence of all groin problems and substantial groin problems by dividing the number of reported problems by the number of questionnaire respondents.¹⁰

At the end of the season, the average prevalence of all problems and substantial problems was calculated, as well as a 95% CI. Finally, we calculated the cumulative incidence for all groin problems and substantial groin problems as the number of new cases each during the study period divided by the number of players included in the intention-to-treat (ITT) analysis.

Exposure

Each week, players reported their exposure to football training (hours), individual training (hours), match play (minutes) and the number of games in which they had participated. The average weekly exposure was calculated for each measure for both groups.

Sample size

The sample size calculation was based on the average prevalence of all groin problems among male Norwegian football players (29%).⁷ Based on an analysis of variance of within-subject and within-team prevalence, an inflation factor of 1.65, a cluster size of 20 players, a power of 80% and a 5% significance level (α), we estimated the ability to detect a 40% reduction in prevalence with 380 players (19 teams) in each group.

Statistical analyses

To assess the effect of the intervention, we performed two generalised estimating equation (GEE) analyses, one for all groin problems and one for substantial groin problems. GEE was performed using an exchangeable covariance matrix and an α of 0.05 for all analyses. All anthropometric and demographic variables were treated as potential effect modifiers and included as candidate variables in a final multivariable GEE model built using a forward selection procedure. Analyses were performed for the 28-week period during the competitive season (April–October).

Missing data on groin problems were imputed using multivariate imputation by a chained equation algorithm in combination with a predictive mean matching approach, which led to the pooled results of five multiple imputed data sets.²⁶ In order to perform imputation with sufficient data, we chose to remove players having <75% response rate (equivalent to <21 weekly reports). The cut-off was based on an assessment of the distribution of total responses, which showed a distinct cut-off at 21 reports. This decision represents a deviation from the original protocol; however, it was made prior to performing the GEE analyses.

Primary analyses were performed using an ITT principle. We also performed secondary per-protocol (PP) analyses, in which we excluded players who performed <67% of the programme during the preseason or <50% during the competitive season.

We assessed between-group differences in baseline characteristics and exposure using an independent t-test or Mann-Whitney U test, as appropriate. We also assessed differences in baseline characteristics between players included in the ITT analysis and those excluded due to an insufficient response rate (<75%). All analyses were performed using SPSS Statistics for Windows, V.24.0 (SPSS).

RESULTS

Participants

A total of 35 teams (652 players) were enrolled in the study; however, one team withdrew shortly after randomisation. The flow of the teams/players is shown in figure 2. Baseline characteristics for players included in the ITT analysis are shown in table 2. At the time of inclusion, there were no group

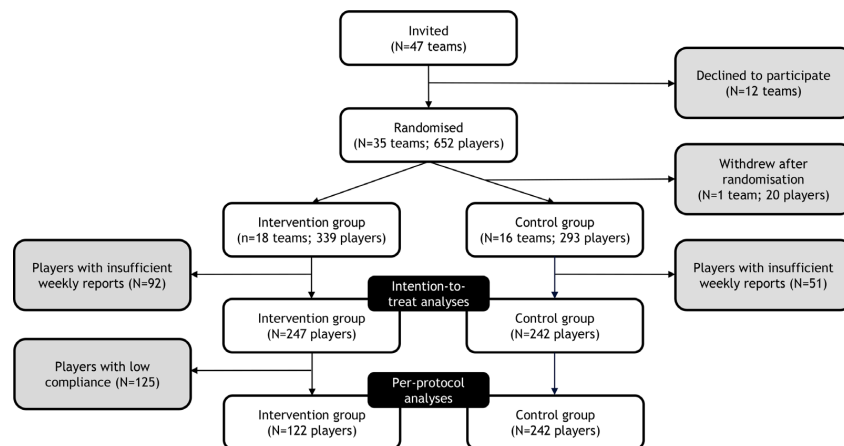


Figure 2 Flow of the teams and players throughout the intervention.

differences in the prevalence of groin problems or any of the HAGOS subscale scores. Players included in the ITT analysis did not differ from the players not meeting the 75% response rate criteria in any baseline characteristic or the prevalence of groin problems. However, the excluded players reported lower scores in three subscales of the HAGOS: sport and recreational activities (median 87.5 points vs 93.8 points), participation in physical activity (87.5 vs 100.0) and quality of living (85.0 vs 90.0) at baseline. There were no differences in any of the subscales when comparing excluded players from the intervention group with the ones excluded from the control group.

There were no differences in exposure to football training, individual training, match minutes or number of games played during the competitive season between the intervention and control groups (table 3).

Response rate to the weekly questionnaire

A total of 13 628 weekly reports were registered, of which 17% were registered retrospectively. The average weekly response rate was 74% (range 47%–93%) in the intervention group and 80% (52%–96%) in the control group. Seventy-seven per cent

Table 2 Baseline characteristics for players included in the intention-to-treat analysis

	Intervention (n=247)	Control (n=242)	P values
Age (years)*	22.0 (4.3)	23.7 (4.3)	<0.001
Height (cm)*	181.9 (6.7)	182.3 (6.4)	0.45
Body mass (kg)*	75.7 (7.5)	78.0 (7.5)	0.001
Senior player (years)*	5.3 (4.1)	6.2 (4.4)	0.023
Prevalence (%)			
Groin problems	32.8	32.6	>0.99
Substantial groin problems	12.6	13.6	0.71
HAGOS†‡			
Pain	95.0 (15.0)	95.0 (15.0)	0.69
Symptoms	82.1 (25.0)	82.1 (25.0)	0.70
Activities of daily living	100 (5.0)	100.0 (10.0)	0.53
Sport and recreational activities	90.6 (21.9)	93.8 (21.1)	0.20
Participation in physical activity	100.0 (25.0)	100.0 (12.5)	0.48
Quality of living	90.0 (25.0)	95.0 (25.0)	0.79
Playing positions			0.80
Goalkeepers	13%	11%	
Defenders	31%	30%	
Midfielders	36%	35%	
Attackers	20%	23%	
Leg dominance			0.24
Left leg	17%	21%	
Right leg	83%	79%	

*Values expressed as mean (SD).

†Intervention group (n=225), control group (n=216).

‡Values expressed as median (IQR).

Table 3 Average weekly exposure for players included in the intention-to-treat analysis, shown as the mean (SD)

	Intervention (n=247)	Control (n=242)	P values
Football training (hours)	6.0 (2.0)	6.2 (2.2)	0.23
Individual training (hours)	3.5 (2.4)	3.6 (2.3)	0.82
Match minutes	65.7 (26.9)	67.0 (25.5)	0.60
Number of games	0.8 (0.3)	0.8 (0.3)	0.40

of players included at baseline responded to at least 75% of the weekly questionnaires and were included in the ITT analyses. The average weekly response rate for players included in the ITT analyses was 90% (weekly range 62%–100%) in the intervention group and 90% (61%–100%) in the control group. Furthermore, 21% retrospective data was included in the ITT analyses and 10% missing data were imputed using multi-variate imputation.

Primary outcome: all groin problems

The average weekly prevalence of all groin problems during the competitive season was 13.5% (95% CI 12.3% to 14.7%) in the

intervention group and 21.3% (95% CI 20.0% to 22.6%) in the control group. The 28 in-season prevalence measures in both groups are illustrated in figure 3. GEE analyses revealed a 41% lower risk of reporting groin problems in the intervention group compared with the control group (table 4).

Secondary outcome: substantial groin problems

The average weekly prevalence of substantial groin problems during the competitive season was 5.7% (95% CI 5.1% to 6.3%) in the intervention group and 8.0% (95% CI 7.5% to 8.5%) in the control group. The 28 in-season prevalence measures in both groups are illustrated in figure 3. An 18% lower risk of reporting substantial groin problems was detected; however, this was not significant (table 4).

Per protocol analyses: all and substantial groin problems

When we removed the players not meeting the PP criteria ($\geq 67\%$ of the programme during the preseason and $\geq 50\%$ during the competitive season), the average weekly prevalence of groin problems in the intervention group was 11.7% (95% CI 10.9% to 12.5%) while that of substantial groin problems was 4.5% (95% CI 4.1% to 5.1%). Results from GEE analysis are shown in table 4.

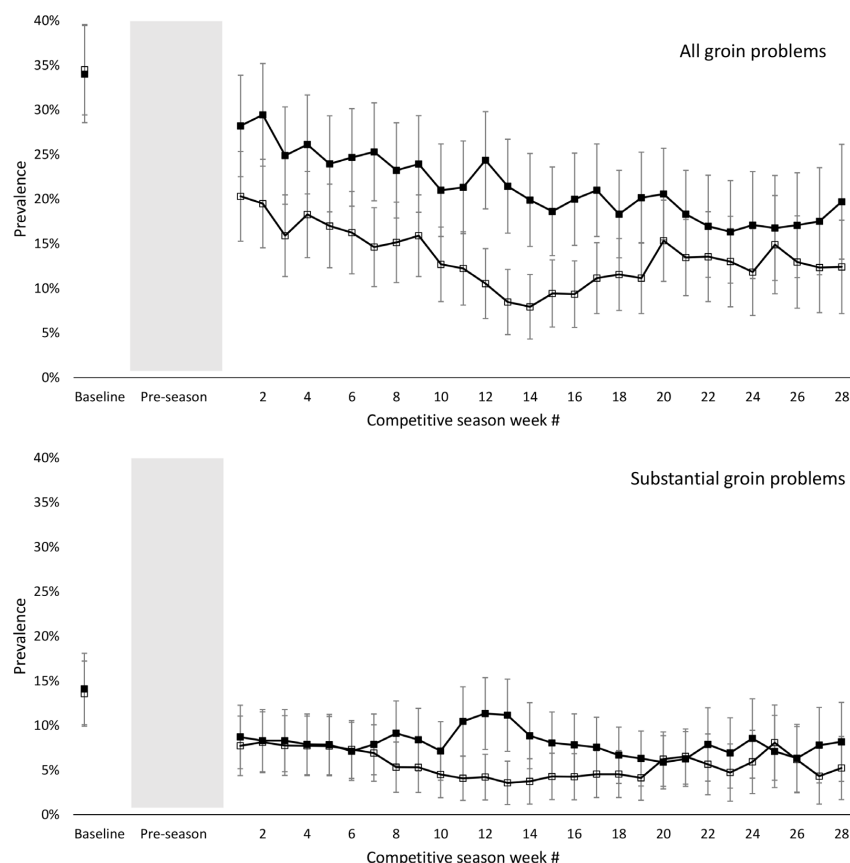


Figure 3 Prevalence of all groin problems (upper panel) and substantial groin problems (lower panel) in the intervention group (open squares) and control group (filled squares) with 95% CI, measured at baseline and 28 times during competitive season for players included in the intention-to-treat analyses. The shaded area represents the period 6–8 weeks the preseason protocol of the Adductor Strengthening Programme was performed.

Table 4 Generalised estimating equation (GEE) model for both intention-to-treat and per-protocol analyses.

	Mean difference in prevalence (%)	OR*	95% CI	P values
All problems				
Intention-to-treat	7.8	0.59	0.40 to 0.86	0.008
Per-protocol	9.6	0.53	0.36 to 0.78	0.001
Substantial problems				
Intention-to-treat†	2.3	0.82	0.51 to 1.33	0.42
Per-protocol‡	3.4	0.70	0.40 to 1.23	0.22

*All analyses performed using intervention group as reference value.

†Age, years as senior, height and weight were included as covariates in the GEE model.

‡Height was included as a covariate in the GEE model.

Characteristics of the reported groin problems

Groin problems were reported in 2458 of the 13 628 questionnaire responses. The cumulative incidence of all groin problems for players included in the ITT analysis was 55% in the intervention group and 67% in the control group. A substantial groin problem was reported by 28% of the players in the intervention group and 37% in the control group. Characteristics of the reported problems are shown in table 5.

Compliance to the exercise programme

Players in the intervention group included in the ITT analysis completed on average 73% of the recommended preseason protocol. During the competitive season, the Adductor Strengthening Programme was completed on average 0.7 times per week (range 0.6–0.9), equivalent to 70% of the recommended exercise prescription. Forty-two per cent of the players had an average in-season weekly compliance higher than our recommendations, two players (1%) did not complete any of the recommended preseason training sessions and seven players (3%) did not complete any of the recommended in-season training sessions. Players included in the PP analyses completed 93% of the recommended preseason training sessions and on average completed the programme 0.9 times per week (range 0.7–1.0) in-season.

Adverse effects

We had no reports on any adverse events related to performing the study intervention.

DISCUSSION

This is the first study investigating the effect of an Adductor Strengthening Programme using a single-exercise approach to reduce the prevalence of groin problems in football players. Our main finding was that the Adductor Strengthening Programme reduced the prevalence of groin problems among male football

Table 5 Characteristics of the groin problems reported during the 28 weeks of the competitive season for players included in the intention-to-treat analysis

	Intervention group (n=844 groin problems)	Control group (n=1321 groin problems)
Time loss (%)	41	33
Gradual onset (%)	78	79
Acute onset (%)	22	21
Dominant leg (%)	45	44
Non-dominant leg (%)	35	34
Both legs (%)	20	22

players; the risk of reporting groin problems during the competitive season was 41% lower, in favour of the intervention group in the ITT analysis and 47% in the PP analysis.

Our Adductor Strengthening Programme is the first groin-specific exercise-based programme to demonstrate efficacy in reducing the risk of groin injuries in male footballers. The hip adductors were specifically targeted in this programme, while previous studies have had a combined focus on hip adductors, abdominals and flexors.^{20 27 28} Furthermore, the intensive protocol implemented during the preseason is considered vital to gain effect of the programme prior to the injury counting during the regular season. This is in contrast to previous studies, which have implemented the prevention programme and injury registration at the same time.^{27 28}

Another reason why we may have found an effect where previous studies have not is that the compliance reported in the present study was much higher than what is often seen in sports injury prevention trials.^{3 29–31} On average, the players completed approximately 70% of the recommended protocol during both preseason and the competitive season. Actually, 42% of the players included in the ITT analysis had an average in-season weekly compliance higher than our recommendations. However, compliance was self-reported by the players and we do not know if they performed the exercise as often as reported. The compliance reported in other studies examining the preventive effect of an exercise programme on groin injury rate varies. Engebretsen *et al* reported that players had a 19% compliance with a programme including static and dynamic hip adduction strength and abdominal exercises,²⁷ while studies examining the effect of the FIFA 11 have reported from 52% to 73% compliance with the programme.^{30 31} Silvers-Granelli *et al* reported a mean utilisation of the FIFA 11+ of 30 sessions during a season, which they interpreted as moderate.⁵ Hölmich *et al* did not report any data on compliance with their programme including static and dynamic hip adduction strength, abdominal exercises and stretching.²⁸ Compliance is believed to be a key factor. In two large RCTs on the FIFA 11+ programme, the risk of sustaining an injury was lower for the high compliance group, compared with players having intermediate or low compliance.^{5 6} This is also indicated in our analysis, where the PP analysis showed an even lower risk of groin problems than the ITT analysis.

The single-exercise approach in the present study must be considered a large advantage as the time required by the teams is short. The in-season protocol of the Adductor Strengthening Programme consists of only 1 weekly session, which takes <5 min to perform. However, this may also be considered a limitation as we have only specifically targeted one of four defined clinical entities for groin pain.³² We would argue that targeting the adductors addresses the main problem as adductor-related groin pain accounts for >2/3 of all hip and groin injuries in football.^{2 11–14} It is unknown specifically which entities were affected by the Adductor Strengthening Programme.

The effect of the exercise prescription dosage on hip adduction strength is unknown. We have data on different protocols of the CA, as used at level 3 in the current programme. A 36% increase in eccentric hip adduction strength was found in players performing the CA intensively for 8 weeks,¹⁹ whereas a less intensive 8-week protocol used in a different study showed an 8% increase.¹⁸ The preseason protocol used in the present study, with only one set per side per session, is likely to induce a strength increase in the lower range of these results. Additionally, we did not register the level of the protocol performed by each player. As previous studies indicate a dose–response relationship on eccentric adduction strength,^{18 19} it can be speculated that a

higher intensity protocol would result in an even lower risk of groin problems. The optimal exercise prescription to maximise the effects on injury risk needs, however, further exploration.

Although we had no reports of any adverse effects, the lack of a systematic approach to register events should be considered a limitation of the study. However, our findings are similar to other studies showing no reports of any adverse effects when performing the CA.^{18,19} Furthermore, players in these studies reported very low delayed-onset muscle soreness (DOMS) in the hip adductors when performing the exercise. The individual highest values were related to the starting date, increase in load or associated with football training.^{18,19} Thus, we think that the Adductor Strengthening Programme is safe to perform and the careful progression in the exercise prescription was important to reduce the risk of DOMS and adverse events to a minimum.

The preventive effect from structured interventions like the FIFA 11+ is well known;⁴ however, the specific effects of these general programmes are unclear. Only two papers report effects on hip/groin injuries, with conflicting results.^{5,6} In the same way that the Nordic Hamstring exercise is included in the FIFA 11+ to specifically target hamstring injuries, the three progression levels of the Adductor Strengthening Programme are suggested to be included in the FIFA 11+ programme to specifically target the adductor muscles and their associated groin problems most often seen in male football.

Methodological considerations

A strength of this trial is the use of the OSTRC Overuse Injury Questionnaire. This method has been shown to be more sensitive than injury recording based on a time-loss definition, capturing all groin problems.^{7,33} Actually, a promising non-significant 31% reduction in groin injury rates was shown in 977 Danish amateur male football players.²⁸ The results from this trial indicate that the study has been underpowered to detect an effect on time-loss injuries. Our data therefore represent a more complete picture of the extent of groin problems in football, with a large share of problems leading to reduced training participation, training volume or performance but fewer leading to time loss.

Another strength of this trial is the inclusion of players already having groin problems. Traditionally, players with problems at baseline are excluded, recording only new cases during the intervention period. From a previous study, we know that >50% of the players reporting groin pain in the previous season still had pain at the beginning of the new season.⁹ Removing players having groin symptoms at baseline would have resulted in a group not being representative for the population of footballers where groin problems are very common.

There are some methodological limitations in this study. First, the retrospective registration during the last month of the study may induce a recollection bias and represents a limitation to the injury registration. The decision to register retrospectively groin problems was done to ensure sufficient data for the analyses. Aiming to reduce recall bias, players had access to a document summarising their previous questionnaire responses and match fixtures when completing the retrospective registration. Still, there is a potential for recall bias; however, it seems highly unlikely that this would affect players in the intervention and control groups differently.

Second, deviations from the registered protocol should be considered a limitation of any trial. The decision to remove players with a low response rate was done to ensure sufficient data to perform imputation. The majority (77%) of the enrolled players were included in the GEE analyses. Although

the postrandomised change of criteria for the analyses may introduce bias,³⁴ the decision to diverge from the protocol was taken prior to the analyses and was based on the response rate, irrespective of whether or not they had actually performed the Adductor Strengthening Programme. In addition, difference in subscales scores of the HAGOS between the players removed from the analysis, compared with the once included, indicates that players with lower response rate (<75%) had more severe symptoms at baseline. However, we considered these small differences not clinically relevant. Furthermore, there were no differences in any of the subscales when comparing removed players from the intervention group with the ones removed from the control group.

Third, a limitation of the injury registration method used in the present study is the lack of detailed diagnostic information on each case. Reliable medical follow-up was not feasible given the scale of the study. Instead we attempted to obtain diagnostic information by inviting players reported to have a groin problem affecting match play for more than two consecutive weeks to a standardised examination. However, as most of the teams already had their own medical teams, only 26 players contacted us and were examined. In a future study, the self-reported groin problems should be examined, classified and reported according to the Doha agreement on terminology and definitions.³²

Perspectives

The results from the present study suggest that the Adductor Strengthening Programme should be included in football training, among senior male football players. Whether the preventive effect from the Adductor Strengthening Programme can be generalised to female or youth-level football players, as well players at the highest professional level, is not known. Other types of athletes may also benefit from the programme as low hip adduction strength is also considered a risk factor associated with groin problems in other sports with similar movement patterns, such as ice hockey, rugby and Australian rule football.³⁵⁻³⁸

CONCLUSION

The Adductor Strengthening Programme substantially reduced the prevalence and risk of groin problems in male football players. We recommend that the programme be implemented as a part of normal football training.

What are the findings?

- ▶ The Adductor Strengthening Programme, based on one single exercise with different progression levels, reduced the prevalence and risk of groin problems in male football players by 41%.

How might it impact on clinical practice in the future?

- ▶ The Adductor Strengthening Programme should be implemented as a part of normal football training.
- ▶ We suggest to include the three progression levels of the Adductor Strengthening Programme in the FIFA 11+ programme to specifically target the adductor muscles.

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Contributors With exception of EGW and MGØ, all authors have been involved in the planning of the study. JH, BC, EGW, MGØ, TEA and RB performed the data collection. All authors have been involved in the data analyses, drafting and revision of the manuscript, and have approved the final version.

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Competing interests None declared.

Patient consent Not required.

Ethics approval This cluster-randomised controlled trial was registered with the International Standard Randomised Controlled Trial Number registry (ISRCTN98514933). The study was approved by the South-Eastern Norway Regional Committee for Medical Research Ethics (2015/1922/REK) and the Norwegian Data Inspectorate (45388/3/LT/LR).

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement The players were not involved in the design of research question, outcome measures, design or recruitment to the study. The results from the study will be disseminated to all teams that were included in the project. Applications for data sharing can be made.

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REFERENCES

- Waldén M, Häggglund M, Ekstrand J. The epidemiology of groin injury in senior football: a systematic review of prospective studies. *Br J Sports Med* 2015;49:792–7.
- Werner J, Häggglund M, Waldén M, et al. UEFA injury study: a prospective study of hip and groin injuries in professional football over seven consecutive seasons. *Br J Sports Med* 2009;43:1036–40.
- Esteve E, Rathleff MS, Bagur-Calafat C, et al. Prevention of groin injuries in sports: a systematic review with meta-analysis of randomised controlled trials. *Br J Sports Med* 2015;49:785–91.
- Thorborg K, Krommes KK, Esteve E, et al. Effect of specific exercise-based football injury prevention programmes on the overall injury rate in football: a systematic review and meta-analysis of the FIFA 11 and 11+ programmes. *Br J Sports Med* 2017;51:562–71.
- Silvers-Granelli H, Mandelbaum B, Adeniji O, et al. Efficacy of the FIFA 11+ Injury prevention program in the collegiate male soccer player. *Am J Sports Med* 2015;43:2628–37.
- Soligard T, Myklebust G, Steffen K, et al. Comprehensive warm-up programme to prevent injuries in young female footballers: cluster randomised controlled trial. *BMJ* 2008;337:a2469.
- Harøy J, Clarsen B, Thorborg K, et al. Groin Problems in Male Soccer Players Are More Common Than Previously Reported. *Am J Sports Med* 2017;45:1304–8.
- Thorborg K, Branci S, Nielsen MP, et al. Copenhagen five-second squeeze: a valid indicator of sports-related hip and groin function. *Br J Sports Med* 2017;51:594–9.
- Thorborg K, Rathleff MS, Petersen P, et al. Prevalence and severity of hip and groin pain in sub-elite male football: a cross-sectional cohort study of 695 players. *Scand J Med Sci Sports* 2017;27.
- Clarsen B, Myklebust G, Bahr R. Development and validation of a new method for the registration of overuse injuries in sports injury epidemiology: the Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire. *Br J Sports Med* 2013;47:495–502.
- Hölmich P, Thorborg K, Dehlendorff C, et al. Incidence and clinical presentation of groin injuries in sub-elite male soccer. *Br J Sports Med* 2014;48:1245–50.
- Mosler AB, Weir A, Eirale C, et al. Epidemiology of time loss groin injuries in a men's professional football league: a 2-year prospective study of 17 clubs and 606 players. *Br J Sports Med* 2018;52.
- Serner A, Tol JL, Jomaah N, et al. Diagnosis of acute groin injuries: a prospective study of 110 athletes. *Am J Sports Med* 2015;43:1857–64.
- Taylor R, Vuckovic Z, Mosler A, et al. Multidisciplinary Assessment of 100 Athletes With Groin Pain Using the Doha Agreement: High Prevalence of Adductor-Related Groin Pain in Conjunction With Multiple Causes. *Clin J Sport Med* 2017.
- Engebretsen AH, Myklebust G, Holme I, et al. Intrinsic risk factors for groin injuries among male soccer players: a prospective cohort study. *Am J Sports Med* 2010;38:2051–7.
- Whittaker JL, Small C, Maffey L, et al. Risk factors for groin injury in sport: an updated systematic review. *Br J Sports Med* 2015;49:803–9.
- Thorborg K, Branci S, Nielsen MP, et al. Eccentric and isometric hip adduction strength in male soccer players with and without adductor-related groin pain: an assessor-blinded comparison. *Orthop J Sports Med* 2014;2:232596711452177.
- Harøy J, Thorborg K, Serner A, et al. Including the Copenhagen Adduction Exercise in the FIFA 11+ Provides Missing Eccentric Hip Adduction Strength Effect in Male Soccer Players: a randomized controlled trial. *Am J Sports Med* 2017;45:3052–9.
- Ishoi L, Sørensen CN, Kaae NM, et al. Large eccentric strength increase using the Copenhagen Adduction exercise in football: A randomized controlled trial. *Scand J Med Sci Sports* 2016;26.
- Krommes K, Bandholm T, Jakobsen MD, et al. Dynamic hip adduction, abduction and abdominal exercises from the holmich groin-injury prevention program are intense enough to be considered strengthening exercises - a cross-sectional study. *Int J Sports Phys Ther* 2017;12:371–80.
- Serner A, Jakobsen MD, Andersen LL, et al. EMG evaluation of hip adduction exercises for soccer players: implications for exercise selection in prevention and treatment of groin injuries. *Br J Sports Med* 2014;48:1108–14.
- Campbell MK, Piaggio G, Elbourne DR, et al. Consort 2010 statement: extension to cluster randomised trials. *BMJ* 2012;345:e5661.
- Hoffmann TC, Glasziou PP, Boutron I, et al. Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. *BMJ* 2014;348:g1687.
- Thorborg K, Hölmich P, Christensen R, et al. The Copenhagen Hip and Groin Outcome Score (HAGOS): development and validation according to the COSMIN checklist. *Br J Sports Med* 2011;45:478–91.
- Hawker GA, Mian S, Kendzerska T, et al. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). *Arthritis Care Res* 2011;63(Suppl 11):S240–52.
- van Buuren S. *Flexible Imputation of Missing Data*. Hoboken: Taylor and Francis, 2012.
- Engebretsen AH, Myklebust G, Holme I, et al. Prevention of injuries among male soccer players: a prospective, randomized intervention study targeting players with previous injuries or reduced function. *Am J Sports Med* 2008;36:1052–60.
- Hölmich P, Larsen K, Krosgaard K, et al. Exercise program for prevention of groin pain in football players: a cluster-randomized trial. *Scand J Med Sci Sports* 2010;20:814–21.
- Goode AP, Reiman MP, Harris L, et al. Eccentric training for prevention of hamstring injuries may depend on intervention compliance: a systematic review and meta-analysis. *Br J Sports Med* 2015;49:349–56.
- Steffen K, Myklebust G, Olsen OE, et al. Preventing injuries in female youth football—a cluster-randomized controlled trial. *Scand J Med Sci Sports* 2008;18:605–14.
- van Beijsterveldt AM, van de Port IG, Krist MR, et al. Effectiveness of an injury prevention programme for adult male amateur soccer players: a cluster-randomised controlled trial. *Br J Sports Med* 2012;46:1114–8.
- Weir A, Brukner P, Delahunt E, et al. Doha agreement meeting on terminology and definitions in groin pain in athletes. *Br J Sports Med* 2015;49:768–74.
- Clarsen B, Bahr R, Heymans MW, et al. The prevalence and impact of overuse injuries in five Norwegian sports: Application of a new surveillance method. *Scand J Med Sci Sports* 2015;25.
- Nüesch E, Trelle S, Reichenbach S, et al. The effects of excluding patients from the analysis in randomised controlled trials: meta-epidemiological study. *BMJ* 2009;339:b3244.
- Crow JF, Pearce AJ, Veale JP, et al. Hip adductor muscle strength is reduced preceding and during the onset of groin pain in elite junior Australian football players. *J Sci Med Sport* 2010;13:202–4.
- Emery CA, Meeuwisse WH. Risk factors for groin injuries in hockey. *Med Sci Sports Exerc* 2001;33:1423–33.
- O'Connor D. Groin injuries in professional rugby league players: a prospective study. *J Sports Sci* 2004;22:629–36.
- Tyler TF, Nicholas SJ, Campbell RJ, et al. The association of hip strength and flexibility with the incidence of adductor muscle strains in professional ice hockey players. *Am J Sports Med* 2001;29:124–8.

Paper IV

1 **IMPLEMENTATION OF THE ADDUCTOR STRENGTHENING PROGRAMME: PLAYERS PRIMED FOR**

2 **ADOPTION BUT RELUCTANT TO MAINTAIN**

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13

14 **ABSTRACT**

15 Groin injuries represent a considerable problem in male football, accounting for 4 to 19% of all time-
16 loss injuries. The Adductor Strengthening Programme is the first groin specific prevention
17 programme shown to reduce the risk of groin problems. We aimed to use the RE-AIM framework to
18 examine the players experiences with the implementation of the programme and player attitude
19 towards groin injury prevention in football. Of the 632 players involved in the trial examining the
20 effect of the Adductor Strengthening Programme, 501 agreed to participate in a survey at the end of
21 the season. Most players thought that footballers are at moderate to high risk for groin injuries (87%)
22 and that there is a need for preventive measures (96%). They also believed that a preventive
23 programme with strengthening exercises would reduce the risk of groin injuries (91%). Majority of
24 the players reported using less than 5 minutes to complete the programme (73%) and only 11%
25 wanted additional exercises. However, only 46% reported to have performed the programme as
26 recommended, and an even smaller proportion (31%) planned to continue using it as recommended
27 the next season. Our results suggest that footballers believe that prevention of groin injuries is
28 needed. Attitude towards implementation of the Adductor Strengthening Programme were positive
29 and the single-exercise approach was considered an important facilitator. However, in future
30 dissemination of the programme, the players' reluctance to maintain the exercise protocol may be a
31 potential barrier to implementation that should be addressed.

32 **KEY WORDS**

33 Injury prevention, groin injury, implementation, attitudes, football

34 **INTRODUCTION**

35 Groin injuries represent a considerable problem in male football, accounting for 4 to 19% of all time-
36 loss injuries.¹ At the elite level, 14 to 17% of all players incur a groin injury causing time-loss each
37 season.² During a period with match congestion, 59% of males reported at least one episode with
38 groin problems.³

39 Several preventive measures have been suggested to reduce the high groin injury rates. Until
40 recently, exercise programmes aiming to prevent groin injuries have shown little effect on injury
41 rates.⁴ The groin-specific interventions have had a combined focus on hip adductors, flexors and
42 abdominals.^{5,6} However, recently, the Adductor Strengthening Programme, a simple, single-exercise
43 programme based on the Copenhagen Adduction exercise,⁷ was shown to reduce the risk of groin
44 problems among male football players with 41%.⁸

45 In this study, the compliance with the Adductor Strengthening Programme was higher than what has
46 previously been reported in groin specific injury prevention trials.⁴⁻⁶ On average, the players
47 completed approximately 70% of the prescribed protocol during both the pre-season and the regular
48 season.⁸

49 However, it is well known that compliance with prevention programmes represents a challenge.⁹⁻¹²
50 From elite European level, it has been shown that players compliance with prevention programmes is
51 low, despite coaches being positive.¹⁰ Poor compliance with the effective prevention programmes
52 may be considered being a gap between science and best practices. The RE-AIM framework has been
53 developed to describe five key components to successfully close the gap: Reach, Efficacy, Adoption,
54 Implementation and Maintenance.^{13,14} The framework is a useful tool that allows decision-makers to
55 assess how interventions are implemented in practice, and their impact at the individual and
56 organisational levels. Furthermore, it can help determine which interventions are feasible in real-
57 world settings.¹³⁻¹⁵ A recent systematic review concluded that information on the RE-AIM
58 components in published trials on injury prevention exercise programmes was insufficient, especially

59 regarding the adoption and maintenance of the programmes.¹³ By using the RE-AIM framework to
60 evaluate the implementation of the Adductor Strengthening Programme, we may reveal factors
61 important for future successful dissemination.

62 Thus, the primary aim of this study was to use the RE-AIM framework to examine the players'
63 experiences with the implementation of the Adductor Strengthening Programme among male sub-
64 elite football players. Furthermore, we investigated player attitudes towards groin injury prevention.

65 **METHODS**

66 **Study design and participants**

67 This survey took place from September to October 2016, as part of a randomised controlled trial
68 (RCT) examining the preventive effect of the Adductor Strengthening Programme on the risk of groin
69 problems in male football players.⁸ The RCT was registered with the International Standard
70 Randomised Controlled Trial Number registry (ISTRCTN98514933) and approved by the South-
71 Eastern Norway Regional Committee for Medical Research Ethics (2015/1922/REK) and the
72 Norwegian Data Inspectorate (45388/3/LT/LR).

73 During the last weeks of the 2016 season, we invited all 34 teams (632 players) enrolled in the RCT to
74 take part in the study. Teams that agreed to participate received a personal visit, where we informed
75 players about the study and each player was invited to participate. All players enrolled in the RCT
76 were eligible for participation. All players received oral and written information about the purposes
77 and procedures of the project before providing their written consent.

78 This report is prepared according to the STROBE checklist for observational studies.¹⁶

79 **Questionnaire**

80 The survey was based on the different dimensions of the RE-AIM framework¹⁵, and was developed
81 based on a similar survey used to examine the implementation of the OSTRC Shoulder Injury
82 Prevention Programme in handball players¹⁷. We included a separate section with questions about

83 the implementation of the Adductor Strengthening Programme for players in the intervention group
84 and questions regarding knowledge about the programme for players in the control group. In
85 addition, we included questions about attitudes towards groin injuries and groin injury prevention
86 for both groups. The survey was developed in Norwegian, and an English version was provided for
87 players who did not understand Norwegian. The full survey is available as an online supplementary
88 file.

89 **Procedure**

90 Players were asked to complete a paper version of the questionnaire. Players who did not attend
91 training were contacted through mail or phone and asked to complete an online-version of the
92 questionnaire using Questback (Questback V. 9692, Questback AS, Oslo, Norway).

93 **Analysis**

94 All returned questionnaires were included in the analysis regardless of missing data. All responses
95 were exported into SPSS Statistics for Windows, version 24.0 (SPSS Inc., Chicago, Ill., USA) and
96 analysed using descriptive statistics. Player characteristics were obtained from the RCT (at the time
97 of inclusion in February and March 2016).⁸ All data are presented as mean and standard deviation
98 (SD).

99 **RESULTS**

100 **Participant characteristics**

101 Three of the 34 teams in the RCT declined to participate. In total 501 (79%) of the players enrolled at
102 baseline were included, 255 from the intervention group (75%) and 246 from the control group
103 (84%). Of the 501, 408 (81%) responded to the questionnaire during our team visit, while 93
104 responded to the online-version of the questionnaire within two weeks. Player characteristics at
105 baseline are shown in table 1.

106 [Table 1 near here]

107 **Player attitudes towards groin injuries and groin injury prevention**

108 Overview of the player responses regarding their attitude towards groin injuries and groin injury
109 prevention are shown in tables 2 and 3. Of the players included in the intervention, 87.3% considered
110 footballers to be exposed to groin problems to a moderate or high extent. The players perceived low
111 muscle strength (23.0%), reduced mobility (21.1%) and playing on artificial turf (18.4%) as the most
112 important causes of groin injuries. Furthermore, prevention of groin injuries was considered at least
113 moderately important by 95.5% of the players. However, when asked about their squad's attitude
114 towards preventive measures, their impression was that only 50.1% of the players were positive.

115 [Table 2 near here]

116 [Table 3 near here]

117 **Player experience with the Adductor Strengthening Programme**

118 The questions and responses from players in the intervention group to the questions about the
119 Adductor Strengthening Programme are shown in tables 4 and 5. Strengthening of the adductor
120 muscles was considered important in reducing groin problems by 90.6% of the players in the
121 intervention group. Of the players in the intervention group, 72.5% reported that they spent less
122 than five minutes to complete the programme. Two-thirds (66.7%) of the players reported that they
123 appreciated that the programme consisted of a single exercise and believed motivation for doing the
124 programme would decrease if it were more time-consuming. Only 11.4% of the players wanted
125 additional exercises. Sixty-six percent of the players reported that the programme was performed in
126 connection with organised football training. The players reported that coaches (52.0%) and players
127 (36.8%) were responsible for initiating the Adductor Strengthening Programme during training.
128 Coaches (40.7%) and players (46.8%) were also responsible for the players performing the exercises
129 with the same quality as instructed. The exercise protocol was conducted as recommended or more
130 frequently than recommended by 45.9% of the players. When players were asked whether they

131 thought they would perform the programme the next season, 64.7% of the players confirmed this;
132 however, 33.7% reported that they would do the programme less often.

133 [Table 4 near here]

134 [Table 5 near here]

135 **Groin injury prevention done by players in the control group**

136 Of the players in the control group, 30.5% reported having knowledge about the content of the
137 Adductor Strengthening Programme and 53.3% reported that they had performed the programme or
138 other exercises to prevent groin injuries during the season the study took place.

139 **DISCUSSION**

140 The main findings of this survey of Norwegian semi-professional football players were that most
141 players believed that footballers are at moderate to high risk for groin injuries and that there is a
142 need for groin injury preventive training or other measures. Most players thought that a preventive
143 programme with strengthening exercises would reduce the prevalence of groin injuries. Majority of
144 the players reported using less than 5 minutes to complete the programme and very few wanted
145 additional exercises. On the other hand, less than 50% of the players reported to have performed the
146 programme as much as recommended during the trial, and an even smaller proportion planned to
147 continue using it as prescribed the next season.

148 The recently reported preventive effect of the Adductor Strengthening Programme suggests that
149 dissemination and widespread use in the football community would be beneficial.⁸ However, to
150 succeed in a real world setting, knowledge regarding attitudes, beliefs and current behaviours
151 towards groin injury prevention among the delivery agents and football players is crucial, as is
152 identification of facilitators and barriers to implementation.^{18,19} Most players in the present study
153 agreed that footballers are at least moderately exposed to groin problems. Their understanding is in
154 accordance with the literature, which documents that groin injuries are prevalent in football.¹⁻³

155 Overall, more than 90% of the players believed that there is a moderate to great need for prevention
156 of groin injuries. This result is line with studies recommending preventive initiatives in football.^{1-4,20}
157 Furthermore, the surveyed players believed that a programme targeting hip adduction strength
158 would reduce the risk of groin problems. Hence, the footballers seemed to be primed for adoption
159 and implementation of the Adductor Strengthening Programme, which is an important premise to
160 succeed with prevention measures.²¹

161 Despite these results, suggesting that reach of the programme was successful, the players reported
162 to deviate from the recommended protocol. In the present study, about 45% of the players reported
163 to have performed the programme at least as often as prescribed, while data from the RCT
164 documented an average weekly completion of the programme of 70%.⁸ Although player compliance
165 with the programme was somewhat lower than our recommendations, the reported compliance in
166 this trial was much higher than that seen in previous groin-specific prevention trials.⁴⁻⁶ Compliance is
167 thought to be a key success factor; in two large RCTs testing the effects of the FIFA 11+ programme,
168 the risk of sustaining an injury was lower for the high compliance group, compared to players having
169 intermediate or low compliance.^{22,23}

170 The single-exercise approach should be considered as an important facilitator for the successful
171 implementation of the Adductor Strengthening Programme. Only 11% of the players wanted more
172 exercises. They also believed that a programme with several exercises, requiring more time to be
173 spent, would decrease their motivation. The majority of the players reported using less than 5
174 minutes to complete the programme. In other studies reporting on the uptake of the injury
175 prevention exercise programmes in football, the length of the programme has been emphasised as
176 one important barrier to implementation.^{5,24} However, a simple exercise programme is no guarantee
177 for successful implementation. The preventive effect of the Nordic Hamstring exercise is well
178 known²⁵⁻²⁷ and in two RCTs, compliance with the programme was 91%.^{26,27} Despite this, elite clubs
179 chose other strategies to prevent hamstring injuries.⁹ Bahr et al. speculated that limited influence by

180 the medical team on coaching practices and a lack of focus on injury prevention in education
181 programmes targeting coaching staff could be the reason.⁹

182 A common understanding among the different stakeholders within a club is emphasised as an
183 important premise to succeed with implementation of preventive measures.¹⁸ Players reported that
184 the coaching staff and players initiated and were responsible for the quality of the Adductor
185 Strengthening Programme, while medical staff members were not much involved. This indicates that
186 coaches and players were the most important facilitators for implementation and compliance with
187 the programme, perhaps because the study was done at a sub-elite level, where medical staff
188 resources are limited. The reluctant motivation to continue performing the Adductor Strengthening
189 Programme represent a potential barrier to maintenance. This should be addressed when
190 implementing the programme in football teams, in particular at lower levels of play where access to
191 medical teams is limited.

192 Interestingly, 31% of the players in the control group reported to have knowledge about and more
193 than 50% to have performed the Adductor Strengthening Programme or other prevention exercises
194 to reduce the risk of groin injuries during the study period. This suggests that there was a crossover
195 effect in the RCT, suggesting that the 41% reduction in risk of groin problems observed may
196 represent an underestimation.

197 From elite level we know that the main challenges with exercise programmes to prevent injury are
198 concerns about muscle soreness and 'heavy legs'.¹⁰ Players in the present study were from lower
199 level, and although we do not know, we would be surprised if they were less concerned about
200 muscle soreness and 'heavy legs'. Thus, when introducing the Adductor Strengthening Programme
201 players should be informed that the CA, which is the highest level of the programme hardly causes
202 any muscle soreness, when using a similar exercise protocol as in pre-season.²⁸ Players in the present
203 study were positive to the preventive effect from the Adductor Strengthening Programme; in
204 contrast to reports from elite players, which have shown scepticism towards the effect from

205 preventive programmes.¹⁰ Although, players in the present study were positive, in future
206 dissemination of the programme, the documented preventive effect of the Adductor Strengthening
207 Programme⁸ should be highlighted as a positive effect on performance. Increased participation of
208 players without groin problems may increase the individual and team performance positively by
209 increasing player availability.^{29,30} Unfortunately, there is no guarantee that increased knowledge
210 about prevention among players automatically will translate into changed behaviour, as the learning
211 process and experiences of each individual will affect adoption and implementation of the
212 programme.³¹ In order to succeed with behavioural modifications, it is suggested that programmes
213 should be introduced from an early age to become an accepted part of their training or warm-up
214 routine and culture.³¹ Thus, dissemination of the programme should target young players and
215 instructions on how to perform the Adductor Strengthening Programme or other programmes and
216 exercises should be a mandatory part of football coach education at all levels.

217 **Methodological limitation**

218 There are some methodological limitations that should be kept in mind when interpreting the
219 current results. First, this survey included only perceptions of the players. The RE-AIM framework is a
220 tool for decision-makers to assess how interventions are implemented in practice, and their impact
221 at the individual and organizational level. The understanding and perceptions of other stakeholders
222 in the club are not known. Furthermore, this study included only teams from the sub-elite level; we
223 do not know if teams at other levels of play (for example elite or amateur) or females would have
224 had different perceptions and views.

225 **PERSPECTIVES**

226 Players in sub-elite football teams experience that they are at high risk of sustaining groin injuries
227 and believe that the Adductor Strengthening Programme will be effective in reducing the risk of groin
228 problems, suggesting that there is fertile ground for implementation. The single-exercise approach
229 was an important facilitator for the successful implementation and the majority of the players spent

230 less than 5 minutes to complete the programme. However, in future dissemination the players'
231 reluctant motivation for maintain the exercise protocol may be considered a potential barrier to
232 implementation that should be addressed.

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238 **CONTRIBUTORS**

239 JH, RB, EGW and TEA were involved in the design of the study and the data collection. The authors
240 jointly interpreted the data and wrote the paper.

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246 **COMPETING INTERSTS**

247 None declared.

248 **ETHICS APPROVAL**

249 This study has been approved by the South-Eastern Norway Regional Committee for Medical
250 Research Ethics (2015/1922/REK) and the Norwegian Data Inspectorate (45388/3/LT/LR).

- 251 1. Waldén M, Hägglund M, Ekstrand J. The epidemiology of groin injury in senior football: a
252 systematic review of prospective studies. *British journal of sports medicine*. 2015;49(12):792-
253 797.
- 254 2. Werner J, Haggglund M, Ekstrand J, Walden M. Hip and groin time-loss injuries decreased
255 slightly but injury burden remained constant in men's professional football: the 15-year
256 prospective UEFA Elite Club Injury Study. *British journal of sports medicine*. 2018.
- 257 3. Harøy J, Clarsen B, Thorborg K, Hölmich P, Bahr R, Andersen TE. Groin Problems in Male
258 Soccer Players Are More Common Than Previously Reported. *The American journal of sports*
259 *medicine*. 2017:0363546516687539.
- 260 4. Esteve E, Rathleff MS, Bagur-Calafat C, Urrutia G, Thorborg K. Prevention of groin injuries in
261 sports: a systematic review with meta-analysis of randomised controlled trials. *British journal*
262 *of sports medicine*. 2015.
- 263 5. Engebretsen AH, Myklebust G, Holme I, Engebretsen L, Bahr R. Prevention of injuries among
264 male soccer players: a prospective, randomized intervention study targeting players with
265 previous injuries or reduced function. *The American journal of sports medicine*.
266 2008;36(6):1052-1060.
- 267 6. Hölmich P, Larsen K, Krogsgaard K, Gluud C. Exercise program for prevention of groin pain in
268 football players: a cluster-randomized trial. *Scandinavian journal of medicine & science in*
269 *sports*. 2010;20(6):814-821.
- 270 7. Serner A, Jakobsen MD, Andersen LL, Holmich P, Sundstrup E, Thorborg K. EMG evaluation of
271 hip adduction exercises for soccer players: implications for exercise selection in prevention
272 and treatment of groin injuries. *British journal of sports medicine*. 2014;48(14):1108-1114.
- 273 8. Harøy J, Clarsen B, Wiger EG, et al. The Adductor Strengthening Programme prevents groin
274 problems among male football players: a cluster-randomised controlled trial. *British journal*
275 *of sports medicine*. 2018.
- 276 9. Bahr R, Thorborg K, Ekstrand J. Evidence-based hamstring injury prevention is not adopted by
277 the majority of Champions League or Norwegian Premier League football teams: the Nordic
278 Hamstring survey. *British journal of sports medicine*. 2015;49(22):1466-1471.
- 279 10. McCall A, Dupont G, Ekstrand J. Injury prevention strategies, coach compliance and player
280 adherence of 33 of the UEFA Elite Club Injury Study teams: a survey of teams' head medical
281 officers. *British journal of sports medicine*. 2016;50(12):725-730.
- 282 11. van Beijsterveldt AM, van der Horst N, van de Port IG, Backx FJ. How effective are exercise-
283 based injury prevention programmes for soccer players? : A systematic review. *Sports*
284 *medicine (Auckland, NZ)*. 2013;43(4):257-265.
- 285 12. Goode AP, Reiman MP, Harris L, et al. Eccentric training for prevention of hamstring injuries
286 may depend on intervention compliance: a systematic review and meta-analysis. *British*
287 *journal of sports medicine*. 2015;49(6):349-356.
- 288 13. O'Brien J, Finch CF. A systematic review of core implementation components in team ball
289 sport injury prevention trials. *Injury prevention : journal of the International Society for Child*
290 *and Adolescent Injury Prevention*. 2014;20(5):357-362.
- 291 14. O'Brien J, Finch CF. The implementation of musculoskeletal injury-prevention exercise
292 programmes in team ball sports: a systematic review employing the RE-AIM framework.
293 *Sports medicine (Auckland, NZ)*. 2014;44(9):1305-1318.
- 294 15. Glasgow RE, Vogt TM, Boles SM. Evaluating the public health impact of health promotion
295 interventions: the RE-AIM framework. *American journal of public health*. 1999;89(9):1322-
296 1327.
- 297 16. von Elm E, Altman DG, Egger M, Pocock SJ, Gotsche PC, Vandenbroucke JP. The
298 Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement:
299 guidelines for reporting observational studies. *Annals of internal medicine*. 2007;147(8):573-
300 577.

- 301 17. Andersson SH, Bahr R, Clarsen B, Myklebust G. Preventing overuse shoulder injuries among
302 throwing athletes: a cluster-randomised controlled trial in 660 elite handball players. *British*
303 *journal of sports medicine*. 2016.
- 304 18. Finch CF, Donaldson A. A sports setting matrix for understanding the implementation context
305 for community sport. *British journal of sports medicine*. 2010;44(13):973-978.
- 306 19. Finch CF, White P, Twomey D, Ullah S. Implementing an exercise-training programme to
307 prevent lower-limb injuries: considerations for the development of a randomised controlled
308 trial intervention delivery plan. *British journal of sports medicine*. 2011;45(10):791-796.
- 309 20. Whittaker JL, Small C, Maffey L, Emery CA. Risk factors for groin injury in sport: an updated
310 systematic review. *British journal of sports medicine*. 2015;49(12):803-809.
- 311 21. Janz NK, Becker MH. The Health Belief Model: a decade later. *Health education quarterly*.
312 1984;11(1):1-47.
- 313 22. Silvers-Granelli H, Mandelbaum B, Adeniji O, et al. Efficacy of the FIFA 11+ Injury Prevention
314 Program in the Collegiate Male Soccer Player. *The American journal of sports medicine*. 2015.
- 315 23. Soligard T, Myklebust G, Steffen K, et al. Comprehensive warm-up programme to prevent
316 injuries in young female footballers: cluster randomised controlled trial. *Bmj*.
317 2008;337:a2469.
- 318 24. Soligard T, Nilstad A, Steffen K, et al. Compliance with a comprehensive warm-up programme
319 to prevent injuries in youth football. *British journal of sports medicine*. 2010;44(11):787-793.
- 320 25. Arnason A, Andersen TE, Holme I, Engebretsen L, Bahr R. Prevention of hamstring strains in
321 elite soccer: an intervention study. *Scandinavian journal of medicine & science in sports*.
322 2008;18(1):40-48.
- 323 26. Petersen J, Thorborg K, Nielsen MB, Budtz-Jorgensen E, Holmich P. Preventive effect of
324 eccentric training on acute hamstring injuries in men's soccer: a cluster-randomized
325 controlled trial. *The American journal of sports medicine*. 2011;39(11):2296-2303.
- 326 27. van der Horst N, Smits DW, Petersen J, Goedhart EA, Backx FJ. The preventive effect of the
327 nordic hamstring exercise on hamstring injuries in amateur soccer players: a randomized
328 controlled trial. *The American journal of sports medicine*. 2015;43(6):1316-1323.
- 329 28. Harøy J, Thorborg K, Serner A, et al. Including the Copenhagen Adduction Exercise in the FIFA
330 11+ Provides Missing Eccentric Hip Adduction Strength Effect in Male Soccer Players: A
331 Randomized Controlled Trial. *The American journal of sports medicine*.
332 2017:363546517720194.
- 333 29. Häggglund M, Walden M, Magnusson H, Kristenson K, Bengtsson H, Ekstrand J. Injuries affect
334 team performance negatively in professional football: an 11-year follow-up of the UEFA
335 Champions League injury study. *British journal of sports medicine*. 2013;47(12):738-742.
- 336 30. Eirale C, Tol JL, Farooq A, Smiley F, Chalabi H. Low injury rate strongly correlates with team
337 success in Qatari professional football. *British journal of sports medicine*. 2013;47(12):807-
338 808.
- 339 31. Van Tiggelen D, Wickes S, Stevens V, Roosen P, Witvrouw E. Effective prevention of sports
340 injuries: a model integrating efficacy, efficiency, compliance and risk-taking behaviour. *Br J*
341 *Sports Med*. 2008;42(8):648-652.
- 342

343 **Table 1** Baseline characteristics and hip and groin symptoms for players included in the study. Values are expressed as mean
 344 (SD).

	Intervention (n=255)	Control (n=246)
Age (years)	22.0 (4.4)	23.8 (4.4)
Height (cm)	181.9 (6.5)	182.4 (6.4)
Body mass (kg)	75.8 (7.5)	78.1 (7.5)
Senior player (years)^a	5.4 (4.1)	6.3 (4.5)

345 ^a Years playing senior football

346

347 **Table 2** Questions and responses from players about their attitude to groin injuries and groin injury prevention. Data are
 348 presented as number of players (%).

	Intervention (n=255)	Control (n=246)	Total (n=501)
To what extent do you think footballers are exposed to groin injuries?			
Highly	114 (44.7)	123 (50.0)	237 (47.3)
Moderately	107 (42.0)	94 (38.2)	201 (40.1)
Low	24 (9.4)	20 (8.1)	44 (8.8)
Don't know	4 (1.6)	6 (2.4)	10 (2.0)
Missing	6 (2.4)	3 (1.2)	9 (1.8)
To what extent do you think footballers need to prevent groin injuries?			
Highly	159 (62.4)	160 (65.0)	319 (63.7)
Moderately	84 (33.0)	75 (30.5)	159 (31.8)
Low	8 (3.1)	8 (3.3)	16 (3.2)
Don't know	1 (0.4)	3 (1.2)	4 (0.8)
Missing	3 (1.2)	0 (0.0)	3 (0.6)
What do you think are the most common causes of groin injuries among footballers?^a			
Too little training	57 (4.6)	61 (4.8)	118 (4.7)
Too much training	108 (8.7)	157 (12.5)	265 (10.6)
Too many matches	68 (5.5)	67 (5.3)	135 (5.4)
Hard tackles	2 (0.2)	4 (0.3)	6 (0.2)
Low muscle strength	302 (24.2)	275 (21.8)	577 (23.0)
Reduced mobility	273 (21.9)	256 (20.3)	529 (21.1)
Reduced recovery time between matches	96 (7.7)	91 (7.2)	187 (7.5)
Artificial turf	212 (17.0)	250 (19.9)	462 (18.4)
Other	43 (3.5)	51 (4.0)	94 (3.8)
Missing	86 (6.9)	48 (3.8)	134 (5.4)
It is more important to use the training time to play football than to conduct injury prevention			

Fully agree	58 (22.7)	38 (15.4)	96 (19.2)
Agree	125 (49.0)	95 (38.6)	220 (43.9)
Not sure	32 (12.5)	43 (17.5)	75 (15.0)
Disagree	11 (4.3)	56 (22.8)	67 (13.4)
Totally disagree	2 (0.8)	8 (3.3)	10 (2.0)
Don't know	19 (7.5)	3 (1.2)	22 (4.4)
Missing	8 (3.1)	3 (1.2)	11 (2.2)

The motivation of the coach affects the players motivation to conduct prevention exercises

Fully agree	58 (22.7)	50 (20.3)	108 (21.5)
Agree	125 (49.0)	133 (54.0)	258 (51.5)
Not sure	32 (12.5)	43 (17.5)	75 (15.0)
Disagree	11 (4.3)	11 (4.5)	22 (4.4)
Totally disagree	2 (0.8)	2 (0.8)	4 (0.8)
Don't know	19 (7.5)	4 (1.6)	23 (4.6)
Missing	8 (3.1)	3 (1.2)	11 (2.2)

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^a Multiple responses possible. Total number of answers: Intervention n=1247; control n=1260; total n=2507.

How do you perceive the general attitude to preventive measures in the following group in your club?	Very positive							Positive							Neutral							Negative							Very negative							Don't know							Missing						
Intervention (n=255)																																																	
Coaches	73 (28.6)							112 (43.9)							50 (19.6)							1 (0.4)							0 (0.0)							11 (4.3)							8 (3.1)						
Medical teams	90 (35.3)							101 (39.6)							28 (11.0)							1 (0.4)							0 (0.0)							27 (10.6)							8 (3.1)						
Players	40 (15.7)							96 (37.6)							90 (35.3)							11 (4.3)							0 (0.0)							9 (3.5)							9 (3.5)						
Administration	32 (12.5)							39 (15.3)							60 (23.5)							1 (0.4)							2 (0.8)							112 (43.9)							9 (3.5)						
Control (n=246)																																																	
Coaches	54 (22.0)							112 (45.5)							57 (23.1)							14 (5.7)							3 (1.2)							3 (1.2)							3 (1.2)						
Medical teams	85 (34.5)							100 (40.6)							39 (15.9)							6 (2.4)							2 (0.8)							11 (4.5)							3 (1.2)						
Players	30 (12.2)							85 (34.5)							107 (43.5)							16 (6.5)							2 (0.8)							3 (1.2)							3 (1.2)						
Administration	21 (8.5)							45 (18.3)							92 (37.4)							12 (4.9)							5 (2.0)							68 (27.7)							3 (1.2)						
Total (n=501)																																																	
Coaches	127 (25.4)							224 (44.7)							107 (21.4)							15 (3.0)							3 (0.6)							14 (2.8)							11 (2.2)						
Medical teams	175 (35.0)							201 (40.1)							67 (13.4)							7 (1.4)							2 (0.4)							38 (7.6)							11 (2.2)						
Players	70 (14.0)							181 (36.1)							197 (39.2)							27 (5.4)							2 (0.4)							12 (2.4)							12 (2.4)						
Administration	53 (10.6)							84 (16.8)							152 (30.3)							13 (2.6)							7 (1.4)							180 (36.0)							12 (2.4)						

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Table 4 Questions and response from players from the intervention group (n=255) about the Adductor Strengthening Programme.

	Number of players (%)
Are you familiar with the Adductor Strengthening Programme intended to prevent groin injuries?	
Yes	242 (94.9)
No	6 (2.4)
Don't know	2 (0.8)
Missing	5 (2.0)
Do you believe that the Adductor Strengthening Programme can reduce groin injuries?	
Yes, definitely	137 (53.7)
Yes, somewhat	94 (36.9)
No, I don't think so	6 (2.4)
Don't know	13 (5.0)
Missing	5 (2.0)
Which players have primarily conducted the programme?	
All or most players	134 (52.5)
Players with groin problems	30 (11.8)
Players with previous groin problems	21 (8.2)
No players	7 (2.7)
Don't know	56 (22)
Missing	7 (2.7)
How has the execution of the programme been organized?	
When the players wanted, but not connected to organized training	68 (26.7)
When the players wanted, but connected to organized training (before or after training)	55 (21.6)
Together as a team connected to organized training	114 (44.7)
Don't know	9 (3.5)
Missing	9 (3.5)
Have you conducted the programme with the recommended frequency?	
More often	16 (6.3)
As recommended	101 (39.6)
Less often	114 (44.7)
Don't know	18 (7.0)
Missing	6 (2.4)
How much time did you spend conducting the Adductor Strengthening Programme?	
0-5 min	185 (72.5)
5-10 min	53 (20.8)

10-15 min	3 (1.2)
Don't know	9 (3.5)
Missing	5 (2.0)
Will you use the programme after the current season?	
Yes, definitely	79 (31.0)
Yes, but not as frequently as this season	86 (33.7)
No	49 (19.2)
Don't know	40 (15.7)
Missing	1 (0.4)
Do you think the motivation to perform the Adductor Strengthening Programme would have been greater if the exercise was not a partner exercise?	
Yes, it is better to train alone	35 (13.7)
It does not matter	119 (46.7)
No, it is better to train with a team-mate	77 (30.2)
Don't know	20 (7.8)
Missing	4 (1.6)
Do you think the motivation to perform the programme would have been greater if it had contained several exercises?	
Yes, the more exercises the better	29 (11.4)
No, one exercise is sufficient	170 (66.7)
Don't know	51 (20.0)
Missing	5 (2.0)
How would the motivation to perform the programme have changed if it had taken less time?	
It would have increased	90 (35.3)
It would have decreased	7 (2.7)
Don't know	152 (59.6)
Missing	6 (2.4)
How would the motivation to perform the programme have changed if it had taken more time?	
It would have increased	20 (7.8)
It would have decreased	151 (59.2)
Don't know	80 (31.4)
Missing	4 (1.6)

Table 5 Questions and response from players from the intervention group (n=255) about the implementation of the Adductor Strengthening Programme.

Are the following staff members familiar with the Adductor Strengthening Programme?		Yes	No	Don't know	Missing response	
Head and assistant coach		219 (85.9)	3 (1.2)	27 (10.6)	6 (2.4)	
Medical team		202 (79.2)	9 (3.5)	36 (14.1)	8 (3.1)	
Other coaches (fitness coach, goalkeeper trainer etc.)		180 (70.6)	11 (4.3)	52 (20.4)	12 (4.7)	
How do you perceive the attitudes to the Adductor Strengthening Programme in the following groups?		Positive	Neutral	Negative	Don't know	Missing response
Head and assistant coach		126 (49.4)	88 (34.5)	4 (1.6)	23 (9.0)	14 (5.5)
Medical team		137 (53.7)	62 (24.3)	3 (1.8)	37 (14.5)	16 (6.3)
Players		63 (24.7)	128 (50.2)	33 (13.0)	15 (5.9)	16 (6.3)
Administration		46 (18.0)	64 (25.1)	3 (1.2)	128 (50.2)	14 (5.5)
Who has mainly initiated the programme? Rate from 1 to 3, where 1 is the one who has initiated it the most.		Most	Second most	Third		
Head coach		35 (15.7)	39 (23.1)	39 (25.5)		
Assistant coach		3 (1.3)	27 (16.0)	18 (11.8)		
Fitness coach		78 (35.0)	28 (16.6)	13 (8.5)		
Health professional		17 (7.6)	20 (11.8)	12 (7.8)		
Team captain		11 (5.0)	7 (4.1)	14 (9.1)		
Another player of the team		6 (2.7)	26 (15.4)	14 (9.1)		
The players of the team		65 (29.1)	18 (10.7)	19 (12.4)		
Don't know		8 (3.6)	4 (2.3)	24 (15.7)		
Who has mainly been responsible for the quality of the Adductor Strengthening Programme? Rate from 1 to 3, where 1 is the one who had most.		Most	Second most	Third		
Head coach		8 (3.7)	31 (18.4)	47 (31)		
Assistant coach		4 (1.8)	19 (11.2)	19 (12.5)		

Fitness coach	76 (35.2)	31 (18.4)	17 (11.2)
Health professional	16 (7.4)	27 (16.0)	7 (4.6)
Team captain	8 (3.7)	9 (5.3)	8 (5.3)
Another player of the team	4 (1.9)	27 (16.0)	13 (8.6)
The players of the team	89 (41.2)	19 (11.2)	15 (9.9)
Don't know	11 (5.1)	6 (3.6)	26 (17.1)

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Appendix I

Approval letters from the Regional Committee for Medical Research Ethics (REK) and the Norwegian Data Inspectorate (NSD) – Project 1

Region: REK sør-øst	Saksbehandler: Hege Holde Andersson	Telefon: 22845514	Vår dato: 01.06.2015	Vår referanse: 2015/719 REK sør-øst B
			Deres dato: 24.03.2015	Deres referanse:

Vår referanse må oppgis ved alle henvendelser

Joar Harøy
Norges idrettshøgskole

2015/719 Hva er omfanget av lyskeproblemer på ulike nivå og kjønn i norsk fotball?

Forskningsansvarlig: Norges idrettshøgskole

Prosjektleder: Joar Harøy

Vi viser til søknad om forhåndsgodkjenning av ovennevnte forskningsprosjekt. Søknaden ble behandlet 11.05.2015 av leder og nestleder i Regional komité for medisinsk og helsefaglig forskningsetikk, sør-øst B, på delegert fullmakt. Fullmakt ble gitt i komiteens møte 06.05.2015.

Prosjektleders prosjektbeskrivelse

Formål med prosjektet er å undersøke omfanget av lyskeproblemer på ulike nivå og kjønn i norsk fotball. Resultatene vil også benyttes for å avgjøre hvilket nivå, og kjønn, en kommende intervensjonsstudie skal gjennomføres på. Prosjektet er et delprosjekt av større studie med formål om å forebygge lyskeskader i norsk fotball. Gjennomføring av en prospektiv kohort studie på ulike nivå og kjønn i norsk fotball. Totalt 15 lag, omtrent 300 spillere blir invitert til en 6 ukers studie med ukentlig besvarelse av OSTRC Overuse Injury Questionnaire (for lyskeplager) gjennom SpartaNova app på smartphone. Hovedutfallsmål vil være prevalens av lyskeproblemer ved ulike nivå og kjønn. Totalt antall skader og alvorlighetsgrad vil bli presentert for hvert nivå.

Komiteens vurdering

Komiteen har ingen forskningsetiske innvendinger til at prosjektet gjennomføres.

Vedtak

Komiteen godkjenner prosjektet i henhold til helseforskningsloven § 9 og § 33.

Tillatelsen gjelder til 01.08.2018. Av dokumentasjonshensyn skal opplysningene likevel bevares inntil 01.08.2023. Opplysningene skal lagres aidentifisert, dvs. atskilt i en nøkkel- og en opplysningsfil. Opplysningene skal deretter slettes eller anonymiseres, senest innen et halvt år fra denne dato.

Forskningsprosjektets data skal oppbevares forsvarlig, se personopplysningsforskriften kapittel 2, og Helsedirektoratets veileder "Personvern og informasjonssikkerhet i forskningsprosjekter innenfor helse- og omsorgssektoren"

Sluttmelding og søknad om prosjektendring

Dersom det skal gjøres endringer i prosjektet i forhold til de opplysninger som er gitt i søknaden, må prosjektleder sende endringsmelding til REK. Prosjektet skal sende sluttmelding på eget skjema, se helseforskningsloven § 12, senest et halvt år etter prosjektslutt.

Klageadgang

Du kan klage på komiteens vedtak, jf. forvaltningslovens § 28 flg. Klagen sendes til REK sør-øst B. Klagefristen er tre uker fra du mottar dette brevet. Dersom vedtaket opprettholdes av REK sør-øst B, sendes klagen videre til Den nasjonale forskningsetiske komité for medisin og helsefag for endelig vurdering.

Komiteens avgjørelse var enstemmig.

Med vennlig hilsen

Grete Dyb
førsteamanuensis dr. med.
leder REK sør-øst B

Hege Holde Andersson
komitésekretær

Kopi til:

- *Norges idrettshøgskole ved øverste administrative ledelse*
- *Professor Roald Bahr, Norges idrettshøgskole*



Joar Harøy
Seksjon for idrettsmedisinske fag Norges idrettshøgskole
Postboks 4014 Ullevål Stadion
0806 OSLO

Vår dato: 29.04.2015

Vår ref: 42841 / 3 / MSS

Deres dato:

Deres ref:

TILBAKEMELDING PÅ MELDING OM BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 18.03.2015. Meldingen gjelder prosjektet:

42841 *Hva er omfanget av lyskeproblemer på ulike nivå og kjønn i norsk fotball?*
Behandlingsansvarlig *Norges idrettshøgskole, ved institusjonens øverste leder*
Daglig ansvarlig *Joar Harøy*

Personvernombudet har vurdert prosjektet, og finner at behandlingen av personopplysninger vil være regulert av § 7-27 i personopplysningsforskriften. Personvernombudet tilrår at prosjektet gjennomføres.

Personvernombudets tilråding forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldeskjemaet, korrespondanse med ombudet, ombudets kommentarer samt personopplysningsloven og helseregisterloven med forskrifter. Behandlingen av personopplysninger kan settes i gang.

Det gjøres oppmerksom på at det skal gis ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernombudets vurdering. Endringsmeldinger gis via et eget skjema, <http://www.nsd.uib.no/personvern/meldeplikt/skjema.html>. Det skal også gis melding etter tre år dersom prosjektet fortsatt pågår. Meldinger skal skje skriftlig til ombudet.

Personvernombudet har lagt ut opplysninger om prosjektet i en offentlig database, <http://pvo.nsd.no/prosjekt>.

Personvernombudet vil ved prosjektets avslutning, 01.06.2018, rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen

Katrine Utaaker Segadal

Marie Strand Schildmann

Kontaktperson: Marie Strand Schildmann tlf: 55 58 31 52

Vedlegg: Prosjektvurdering

Dokumentet er elektronisk produsert og godkjent ved NSDs rutiner for elektronisk godkjenning.

Avdelingskontorer / District Offices:

OSLO: NSD, Universitetet i Oslo, Postboks 1055 Blindern, 0316 Oslo. Tel: +47-22 85 52 11. nsd@uio.no

TRONDHEIM: NSD, Norges teknisk-naturvitenskapelige universitet, 7491 Trondheim. Tel: +47-73 59 19 07. kyrre.svarva@svt.ntnu.no

TROMSØ: NSD, SVF, Universitetet i Tromsø, 9037 Tromsø. Tel: +47-77 64 43 36. nsdmaa@sv.uit.no

Personvernombudet for forskning



Prosjektvurdering - Kommentar

Prosjektnr: 42841

Formålet med prosjektet er å undersøke omfanget av lyskeproblemer på ulike nivå og kjønn i norsk fotball. Resultatene vil også benyttes for å avgjøre hvilket nivå, og kjønn, en kommende intervensjonsstudie skal gjennomføres på. Prosjektet er et delprosjekt av større studie med formål om å forebygge lyskeskader i norsk fotball.

Utvalget består av spillere fra klubber i Tippeligaen, Toppserien, OBOS-ligaen, Oddsen-ligaen, 3. divisjon og U19 interkrets. Utvalget informeres skriftlig og muntlig om prosjektet og samtykker til deltakelse. Informasjonsskrivet er godt utformet, men det må påføres at datamaterialet anonymiseres innen prosjektslutt den 01.06.2018. Videre bør det fremgå hvordan de skal returnere svarslipp og skjema med bakgrunnsinformasjon.

Revidert informasjonsskriv sendes oss (personvernombudet@nsd.uib.no) innen utvalget kontaktes.

Det behandles sensitive personopplysninger om helseforhold, jf. personopplysningsloven § 2, punkt 8 c).

Personvernombudet legger til grunn at forsker etterfølger Norges idrettshøgskole sine interne rutiner for datasikkerhet. Dersom personopplysninger skal lagres på mobile enheter, bør opplysningene krypteres tilstrekkelig.

Spartanova er databehandler for prosjektet. Norges idrettshøgskole skal inngå skriftlig avtale med Spartanova om hvordan personopplysninger skal behandles, jf. personopplysningsloven § 15. For råd om hva databehandleravtalen bør inneholde, se Datatilsynets veileder: <http://www.datatilsynet.no/Sikkerhet-internkontroll/Databehandleravtale/>.

Forventet prosjektslutt er 01.06.2018. Ifølge prosjektmeldingen skal innsamlede opplysninger da anonymiseres. Anonymisering innebærer å bearbeide datamaterialet slik at ingen enkeltpersoner kan gjenkjennes. Det gjøres ved å:

- slette direkte personopplysninger (som navn/koblingsnøkkel)
- slette/omskrive indirekte personopplysninger (identifiserende sammenstilling av bakgrunnsopplysninger som f.eks. bosted/arbeidssted, alder og kjønn)

Vi gjør oppmerksom på at også databehandler (Spartanova) må slette personopplysninger tilknyttet prosjektet i sine systemer. Dette inkluderer eventuelle logger og koblinger mellom IP-/epostadresser og besvarelser.

Appendix II

Approval letters from the Regional Committee for Medical Research Ethics (REK) and the Norwegian Data Inspectorate (NSD) – Project 2

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK sør-øst	Jakob Elster	22845530	19.11.2015	2015/1921 REK sør-øst B
			Deres dato:	Deres referanse:
			22.09.2015	

Vår referanse må oppgis ved alle henvendelser

Joar Harøy
Norges Idrettshøgskole

2015/1921 Bør Copenhagen adduction legges til The 11+

Forskningsansvarlig: Norges Idrettshøgskole
Prosjektleder: Joar Harøy

Vi viser til søknad om forhåndsgodkjenning av ovennevnte forskningsprosjekt. Søknaden ble behandlet av Regional komité for medisinsk og helsefaglig forskningsetikk (REK sør-øst) i møtet 28.10.2015. Vurderingen er gjort med hjemmel i helseforskningsloven (hfl.) § 10, jf. forskningsetikkloven § 4.

Prosjektleders prosjektbeskrivelse

"Dette prosjektet bygger videre på resultatene fra prevalensstudien som vist høy forekomst av lyskeproblemer på flere nivå i norsk fotball. Vi mener at The 11+ mangler øvelser som øker styrken i hoftedduktorene og ønsker derfor å undersøke om 8 uker med The 11+ med copenhagen adduction kan gi en styrkeøkning i hoftedduktorene. Et eventuelt positivt resultat vil brukes til å anbefale at copenhagen adduction bør inn i the 11+. Vi ønsker å gjennomføre en randomisert kontrollert studie med fotballspillere som deltagere der en gruppe gjennomfører The 11+ som normalt tre ganger i uken, mens den andre gruppen gjennomfører The 11+ der vi bytter nordic hamstrings med copenhagen adduction. Også denne gruppen gjennomfører tre ganger i uken. I begge gruppene vil en fysioterapeut stå for gjennomføringen av alle treningsøktene. Alle deltagere vil før og etter treningsperioden bli testet i hamstringsstyrke (nordboard) og styrke i hofteddaksjon (dynamometer) og 40m sprint."

Komiteens vurdering

Helseforskningsloven gjelder for medisinsk og helsefaglig forskning, det vil si «virksomhet som utføres med vitenskapelig metodikk for å skaffe til veie ny kunnskap om helse og sykdom», jf. helseforskningsloven § 2, jf. § 4. Dette prosjektet skal prøve ut et nytt treningsprogram for unge fotballspillere og måler styrkeeffekt som en følge av dette. Formålet med prosjektet er å redusere omfanget av lyskeskade, og måling av styrke er relevant, da redusert styrke i hoftedduktorer i henhold til søknaden er en risikofaktor for lyskeskader. Siden formålet med prosjektet er å undersøke effekten av at skadereduserende tiltak, anser komiteen at prosjektet omfattes av helseforskningslovens virkeområde.

Frivillighet

Deltakere i prosjektet er mannlige fotballspillere som er tilknyttet fotballklubb i junior interkrets (U19) serie. Dette inkluderer deltakere mellom 16 og 18 år. Man skal inkludere 40-50 deltakere.

Deltakerne rekrutteres ved at man inviterer til fotballklubber med 20-25 spillere hver til å delta. Det ser her ut til at man regner med at alle som inviteres til å delta vil takke ja, i og med at man trenger 40-50 deltakere og skal invitere to klubber med til sammen 40-50 deltakere. Når spillerne rekrutteres via fotballklubben, kan

det også oppstå et visst press om å delta. Komiteen vil understreke at deltakelse i forskning skal være frivillig, og forutsetter at man bestreber seg på å unngå enhver form for press på fotballspillerne.

Under denne forutsetningen har prosjektet ingen forskningsetiske innvendinger til at prosjektet gjennomføres.

Informasjons- og samtykkeskriv

Det vedlagte informasjons- og samtykkeskrivet bør revideres på enkelte punkter:

- Det står at studien er «en viktig brikke i arbeidet med å redusere omfanget av skulderproblemer». Dette ser ikke ut til å passe med den aktuelle studien.

- Det står at hvis man trekker sitt samtykke, vil dette ikke få konsekvenser for videre behandling. I og med at det her ikke dreier seg om behandling, bør dette endres.

- Det kreves ikke skriftlig samtykke fra foresatte, i og med at deltakerne er fylt 16 år. Plass for underskrift fra foresatt bør derfor fjernes fra samtykkeskjemaet.

Ut fra dette setter komiteen følgende vilkår for prosjektet:

- Informasjonsskrivet revideres i tråd med komiteens merknader og sendes komiteen til orientering.

Vedtak

Komiteen godkjenner prosjektet i henhold til helseforskningsloven § 9 og § 33 under forutsetning av at ovennevnte vilkår oppfylles.

I tillegg til ovennevnte vilkår, er godkjenningen gitt under forutsetning av at prosjektet gjennomføres slik det er beskrevet i søknaden.

Tillatelsen gjelder til 01.08.2016. Av dokumentasjonshensyn skal opplysningene likevel bevares inntil 01.08.2021. Opplysningene skal lagres avidentifisert, dvs. atskilt i en nøkkel- og en opplysningsfil. Opplysningene skal deretter slettes eller anonymiseres, senest innen et halvt år fra denne dato.

Forskningsprosjektets data skal oppbevares forsvarlig, se personopplysningsforskriften kapittel 2, og Helsedirektoratets veileder ”Personvern og informasjonssikkerhet i forskningsprosjekter innenfor helse- og omsorgssektoren”

Sluttmelding og søknad om prosjektendring

Dersom det skal gjøres endringer i prosjektet i forhold til de opplysninger som er gitt i søknaden, må prosjektleder sende endringsmelding til REK. Prosjektet skal sende sluttmelding på eget skjema, se helseforskningsloven § 12, senest et halvt år etter prosjektslutt.

Klageadgang

Du kan klage på komiteens vedtak, jf. forvaltningslovens § 28 flg. Klagen sendes til REK sør-øst B. Klagefristen er tre uker fra du mottar dette brevet. Dersom vedtaket opprettholdes av REK sør-øst B, sendes klagen videre til Den nasjonale forskningsetiske komité for medisin og helsefag for endelig vurdering.

Komiteens avgjørelse var enstemmig.

Med vennlig hilsen

Grete Dyb
førsteamanuensis dr. med.
leder REK sør-øst B

Jakob Elster
Seniorrådgiver

Kopi til:

- *Norges idrettshøgskole ved øverste administrative ledelse*
- *Professor Roald Bahr, Norges Idrettshøgskole*

Norsk samfunnsvitenskapelig datatjeneste AS

NORWEGIAN SOCIAL SCIENCE DATA SERVICES



Harald Hårfages gate 29
N-5007 Bergen
Norway
Tel: +47-55 58 21 17
Fax: +47-55 58 96 50
nsd@nsd.uib.no
www.nsd.uib.no
Org.nr. 985 321 884

Joar Harøy
Seksjon for idrettsmedisinske fag
Norges idrettshøgskole
Postboks 4014 Ullevål Stadion
0806 OSLO

Vår dato: 27.11.2015

Vår ref: 45393/3/LT/LR

Deres dato:

Deres ref:

AVSLUTTET SAKSBEHANDLING

Personvernombudet for forskning viser til meldeskjema mottatt 28.10.2015, samt godkjenning fra Regional komité for medisinsk og helsefaglig forskningsetikk, REK sør-øst B mottatt 24.11.2015 for prosjektet;

45393 Bør Copenhagen adduction inkluderes i FIFA 11+?

Personvernombudet tar til orientering at prosjektet faller inn under helseforskningslovens bestemmelser, og at prosjektet er godkjent av REK sør-øst B.

Personvernombudet avslutter dermed saksbehandlingen av meldingen uten å realitetsbehandle denne. Vi avslutter også all videre oppfølging av prosjektet.

Ta gjerne kontakt dersom noe er uklart.

Vennlig hilsen


Katrine Utaaker Segadal


Lis Tenold

Kopi: Seksjon for idrettsmedisinske fag, Norges idrettshøgskole

Avdelingskontorer / District Offices:

OSLO: NSD, Universitetet i Oslo, Postboks 1055 Blindern, 0316 Oslo, Tel: +47-22 85 52 11, nsd@uio.no

TRONDHEIM: NSD, Norges teknisk-naturvitenskapelige universitet, 7491 Trondheim, Tel: +47-73 59 19 07, kyrre.svarva@svt.ntnu.no

TROMSØ: NSD, HSL, Universitetet i Tromsø, 9037 Tromsø, Tel: +47-77 64 61 53, solvi.anderssen@uit.no

Appendix III

Approval letters from the Regional Committee for Medical Research Ethics (REK) and the Norwegian Data Inspectorate (NSD) – Project 3

Region: REK sør-øst	Saksbehandler: Jakob Elster	Telefon: 22845530	Vår dato: 19.11.2015	Vår referanse: 2015/1922 REK sør-øst B
			Deres dato: 22.09.2015	Deres referanse:

Vår referanse må oppgis ved alle henvendelser

Joar Harøy
Norges Idrettshøgskole

2015/1922 Forebygging av lyskeproblem i Norsk fotball. En klusterrandomisert kontrollert studie

Forskningsansvarlig: Norges Idrettshøgskole
Prosjektleder: Joar Harøy

Vi viser til søknad om forhåndsgodkjenning av ovennevnte forskningsprosjekt. Søknaden ble behandlet av Regional komité for medisinsk og helsefaglig forskningsetikk (REK sør-øst) i møtet 28.10.2015. Vurderingen er gjort med hjemmel i helseforskningsloven (hfl.) § 10, jf. forskningsetikkloven § 4.

Prosjektleders prosjektbeskrivelse

Dette prosjektet vil være en videreføring av resultatene fra studien som ble gjennomført på flere nivå og begge kjønn i norsk fotball i vårsesongen 2015. Det ble her avdekket at lyskeproblemer er et utbredt problem, og tiltak for å forebygge lyskeproblemer bør iverksettes. I løpet av perioden hadde 30% av spillerne symptomer fra lysken. De oppgav at de måtte redusere treningsmengden og opplevde at de ikke presterte optimalt. Fra tidligere studier vet vi også at redusert styrke i hofteadduktorene er assosiert med lyskeproblemer. Vi ønsker derfor å følge opp disse resultatene og undersøke effekten av et forebyggingsprogram på utbredelsen av lyskeproblemer blant mannlige fotballspillere. Resultatene fra dette prosjektet vil være til stor nytte for norsk fotball, da lyskeplager er et utbredt problem i fotball, på ulike nivå.

Komiteens vurdering

Redegjørelse for prosjektet

Deltakere i prosjektet er mannlige fotballspillere fra klubber i 2. divisjon. Dette inkluderer deltakere mellom 16 og 18 år. Man skal inkludere 800-900 deltakere. Prosjektet innebærer en klyngerandomisering av fotballag til enten å trene som vanlig eller å, i tillegg til vanlig trening, bruke øvelsen «The Copenhagen Adduction». Studien foregår fra februar til november i 2016-sesongen. Deltakerene skal ukentlig fylle ut spørreskjema om skade. Alle spillere som rapporterer betydelige lyskeplager i to påfølgende uker vil få tilbud om å gjennomgå en hofte/lyskeundersøkelse hos en spesialist for å legge tilrette for tilbake til idrett.

Faller prosjektet inn under helseforskningslovens virkeområde?

Helseforskningsloven gjelder for medisinsk og helsefaglig forskning, det vil si «virksomhet som utføres med vitenskapelig metodikk for å skaffe til veie ny kunnskap om helse og sykdom», jf. helseforskningsloven § 2, jf. § 4. Dette prosjektet skal prøve ut et nytt treningsprogram for fotballspillere og skal registrere omfang av lyskeskade ved hjelp av et spørreskjema. Siden formålet med prosjektet er å undersøke effekten av at skadereduserende tiltak, anser komiteen at prosjektet omfattes av helseforskningslovens virkeområde.

Frivillighet

I og med at spillerne rekrutteres via fotballklubber, kan det også oppstå et visst press om å delta. Komiteen vil understreke at deltakelse i forskning skal være frivillig, og forutsetter at man bestreber seg på å unngå enhver form for press på fotballspillerne.

Under denne forutsetningen har prosjektet ingen forskningsetiske innvendinger til at prosjektet gjennomføres.

Oppbevaring av opplysninger

Det er lagt ved søknaden et skjema som heter «Personlige opplysning», som deltakerne skal fylle ut, og hvor de blant annet skal føre opp høyde, vekt og om de har hatt tidligere lyskeskade. På samme skjema skal deltakerne føre opp navn, e-post og telefonnummer.

Komiteen gjør oppmerksom på at helseopplysninger som innsamles og oppbevares i et forskningsprosjekt ikke skal oppbevares med en større grad av personidentifikasjon enn det som er nødvendig for å oppnå prosjektets formål, jf. helseforskningsloven § 32. Opplysninger om deltakerne skal derfor fylles ut på et skjema som kun inneholder et løpenummer, og ikke direkte personidentifiserende opplysninger. Koblingsnøkkelen bør oppbevares separat fra disse skjemaene.

Informasjons- og samtykkeskriv

Det vedlagte informasjons- og samtykkeskrivet bør revideres på enkelte punkter:

- Det står at studien er «en viktig brikke i arbeidet med å redusere omfanget av skulderproblemer». Dette ser ikke ut til å passe med den aktuelle studien.

- Det står at hvis man trekker sitt samtykke, vil dette ikke få konsekvenser for videre behandling. I og med at det her ikke dreier seg om behandling, bør dette endres.

Ut fra dette setter komiteen følgende vilkår for prosjektet:

- Informasjonsskrivet revideres i tråd med komiteens merknader og sendes komiteen til orientering.

- Alle innsamlede opplysninger skal lagres aidentifisert, og ikke sammen med direkte personidentifiserende opplysninger.

Vedtak

Komiteen godkjenner prosjektet i henhold til helseforskningsloven § 9 og § 33 under forutsetning av at ovennevnte vilkår oppfylles.

I tillegg til ovennevnte vilkår, er godkjenningen gitt under forutsetning av at prosjektet gjennomføres slik det er beskrevet i søknaden.

Tillatelsen gjelder til 15.11.2016. Av dokumentasjonshensyn skal opplysningene likevel bevares inntil 15.11.2021. Opplysningene skal lagres aidentifisert, dvs. atskilt i en nøkkel- og en opplysningsfil. Opplysningene skal deretter slettes eller anonymiseres, senest innen et halvt år fra denne dato.

Forskningsprosjektets data skal oppbevares forsvarlig, se personopplysningsforskriften kapittel 2, og Helsedirektoratets veileder ”Personvern og informasjonssikkerhet i forskningsprosjekter innenfor helse- og omsorgssektoren”

Klageadgang

Du kan klage på komiteens vedtak, jf. forvaltningslovens § 28 flg. Klagen sendes til REK sør-øst B.

Klagefristen er tre uker fra du mottar dette brevet. Dersom vedtaket opprettholdes av REK sør-øst B, sendes

klagen videre til Den nasjonale forskningsetiske komité for medisin og helsefag for endelig vurdering.

Komiteens avgjørelse var enstemmig.

Sluttmelding og søknad om prosjektendring

Prosjektleder skal sende sluttmelding til REK sør-øst på eget skjema senest 15.05.2017, jf. hfl. § 12. Prosjektleder skal sende søknad om prosjektendring til REK sør-øst dersom det skal gjøres vesentlige endringer i forhold til de opplysninger som er gitt i søknaden, jf. hfl. § 11.

Klageadgang

Du kan klage på komiteens vedtak, jf. forvaltningsloven § 28 flg. Klagen sendes til REK sør-øst. Klagefristen er tre uker fra du mottar dette brevet. Dersom vedtaket opprettholdes av REK sør-øst, sendes klagen videre til Den nasjonale forskningsetiske komité for medisin og helsefag for endelig vurdering.

Med vennlig hilsen

Grete Dyb
førsteamanuensis dr. med.
leder REK sør-øst B

Jakob Elster
Seniorrådgiver

Kopi til:

- Norges idrettshøgskole ved øverste administrative ledelse
- Professor Roald Bahr, Norges Idrettshøgskole

Emne: Sv: RE: REK sør-øst Informasjon om vedtak(2015/1922-3)
Fra: post@helseforskning.etikkom.no
Dato: 26.11.2015 10:06
Til: joar.haroy@nih.no
Kopi: roald.bahr@nih.no

Hei Joar

Vi viser til din e-post innsendt 24.11.2015, inkludert revidert informasjonsskriv. Komiteen tar til orientering at vilkår for godkjenning nå er oppfylt.

Med vennlig hilsen

Harsha

--

Harsha Gajjar Mikkelsen
Seniorkonsulent
Regional komité for medisinsk forskningsetikk sør-øst Norge (REK Sør-Øst)
T: + 47 22 84 55 13

-----Original melding-----

Emne: RE: REK sør-øst Informasjon om vedtak(2015/1922-3)
Fra: joar.haroy@nih.no
Dato: 24.11.2015 10:44:29
Til: post@helseforskning.etikkom.no
Kopi:

Hei.

Sender revidert informasjonsskriv som ønsket.

Med vennlig hilsen

Joar Harøy, spesialist i idrettsfysioterapi MSc

PhD kandidat

Norges Idrettshøgskole

Seksjon for idrettsmedisinske fag

Senter for idrettsskedeforskning

Postboks 4014 Ullevåll Stadion

0806 Oslo, Norway

Mob: +47 97 19 54 35

joar.haroy@nih.no | www.klokeavskade.no

From: post@helseforskning.etikkom.no [mailto:post@helseforskning.etikkom.no]
Sent: 20. november 2015 11:29
To: Joar Harøy <joar.haroy@nih.no>
Cc: Roald Bahr <roald.bahr@nih.no>; postmottak <postmottak@nih.no>
Subject: REK sør-øst Informasjon om vedtak(2015/1922-3)

Vedlagt følger brev fra REK sør-øst.

Vennlig hilsen

Harsha Gajjar Mikkelsen
REK sør-øst

[Forespørsel om deltakelse i lyskeprosjektet spillere.pdf](#)



Harald Hårfagres gate 29
N-5007 Bergen
Norway
Tel: +47-55 58 21 17
Fax: +47-55 58 96 50
nsd@nsd.uib.no
www.nsd.uib.no
Org.nr. 985 321 884

Joar Harøy
Seksjon for idrettsmedisinske fag
Norges idrettshøgskole
Postboks 4014 Ullevål Stadion
0806 OSLO

Vår dato: 27.11.2015

Vår ref: 45388/3/LT/LR

Deres dato:

Deres ref:

AVSLUTTET SAKSBEHANDLING

Personvernombudet for forskning viser til meldeskjema mottatt 28.10.2015, samt godkjenning fra Regional komité for medisinsk og helsefaglig forskningsetikk, REK sør-øst B mottatt 24.11.2015 for prosjektet;

45388 Forebygging av lyskeproblemer blant fotballspillere - En randomisert kontrollert studie

Personvernombudet tar til orientering at prosjektet faller inn under helseforskningslovens bestemmelser, og at prosjektet er godkjent av REK sør-øst B.

Personvernombudet avslutter dermed saksbehandlingen av meldingen uten å realitetsbehandle denne. Vi avslutter også all videre oppfølging av prosjektet.

Ta gjerne kontakt dersom noe er uklart.

Vennlig hilsen


Katrine Utaaker Segadal


Lis Tenold

Kopi: Seksjon for idrettsmedisinske fag, Norges idrettshøgskole

Avdelingskontorer / District Offices:

OSLO: NSD, Universitetet i Oslo, Postboks 1055 Blindern, 0316 Oslo, Tel: +47-22 85 52 11, nsd@uio.no

TRONDHEIM: NSD, Norges teknisk-naturvitenskapelige universitet, 7491 Trondheim, Tel: +47-73 59 19 07, kyrre.svarva@svt.ntnu.no

TROMSØ: NSD, HSL, Universitetet i Tromsø, 9037 Tromsø, Tel: +47-77 64 61 53, solvi.anderssen@uit.no

Appendix IV

Approval letters from the Regional Committee for Medical Research Ethics (REK) and the Norwegian Data Inspectorate (NSD) – Project 4

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK sør-øst	Mariann Glenna Davidsen	22845526	08.09.2016	2015/1922/REK sør-øst B
			Deres dato:	Deres referanse:
			04.09.2016	

Joar Harøy
Norges Idrettshøgskole

Vår referanse må oppgis ved alle henvendelser

2015/1922 Forebygging av lyskeproblem i Norsk fotball. En klusterrandomisert kontrollert studie

Forskningsansvarlig: Norges Idrettshøgskole

Prosjektleder: Joar Harøy

Vi viser til endringsmelding av 19.08.2016, og utsettende vedtak fra REK sør-øst datert 02.09.2016. Søknaden er behandlet av leder for REK sør-øst på fullmakt, med hjemmel i helseforskningsloven § 11

De omsøkte endringene gjengis her:

"En mastergrad student involvert i prosjektet ønsker skal på vårt initiativ innhente informasjon om spillernes gjennomføring av prosjektet og holdninger til skadeforebyggende arbeid. Dette ønsker vi å gjennomføre ved å be hver enkelt spiller gjennomføre en spørreundersøkelse (etter mal fra tidligere et tidligere studie) rett før sesongslutt. Vi planlegger å besøke hver enkelt fremfor utsendelse på mail."

Komiteens vurdering

Komiteen skrev i sin tilbakemelding til prosjektleder at det måtte utarbeides et informasjonsskriv samt innhentes samtykke til denne delstudien.

Prosjektleder har nå utarbeidet et informasjon- og samtykkeskriv som er gjennomgått av komiteen.

Samtykkeskrivet synes dekkende. Komiteen har ingen innvendinger til at prosjektet gjennomføres slik det nå fremstilles.

Vedtak:

Komiteen har vurdert endringsmeldingen og godkjenner prosjektet slik det nå foreligger med hjemmel i helseforskningsloven § 11.

Godkjenningen er gitt under forutsetning av at prosjektet gjennomføres slik det er beskrevet i endringsmeldingen.

Komiteens vedtak kan påklages til Den nasjonale forskningsetiske komité for medisin og helsefag, jf. Forvaltningslovens § 28 flg. Eventuell klage sendes til REK Sør-øst. Klagefristen er tre uker fra mottak av dette brevet.

Vi ber om at alle henvendelser sendes inn via vår saksportal: <http://helseforskning.etikkom.no> eller på e-post til post@helseforskning.etikkom.no.

Vennligst oppgi vårt referansenummer i korrespondansen.

Med vennlig hilsen

Grete Dyb
professor, dr. med.
leder REK sør-øst B

Mariann Glenna Davidsen
rådgiver

Kopi til:

- *Norges idrettshøgskole ved øverste administrative ledelse*
- *Professor Roald Bahr, Norges Idrettshøgskole*



Joar Harøy
Seksjon for idrettsmedisinske fag
Norges idrettshøgskole
Postboks 4014 Ullevål Stadion
0806 OSLO

Vår dato: 27.11.2015

Vår ref: 45388/3/LT/LR

Deres dato:

Deres ref:

AVSLUTTET SAKSBEHANDLING

Personvernombudet for forskning viser til meldeskjema mottatt 28.10.2015, samt godkjenning fra Regional komité for medisinsk og helsefaglig forskningsetikk, REK sør-øst B mottatt 24.11.2015 for prosjektet;

45388 Forebygging av lyskeproblemer blant fotballspillere - En randomisert kontrollert studie

Personvernombudet tar til orientering at prosjektet faller inn under helseforskningslovens bestemmelser, og at prosjektet er godkjent av REK sør-øst B.

Personvernombudet avslutter dermed saksbehandlingen av meldingen uten å realitetsbehandle denne. Vi avslutter også all videre oppfølging av prosjektet.

Ta gjerne kontakt dersom noe er uklart.

Vennlig hilsen


Katrine Utaaker Segadal


Lis Tenold

Kopi: Seksjon for idrettsmedisinske fag, Norges idrettshøgskole

Appendix V

Informed consent project 1

Forespørsel om deltakelse i forskningsprosjektet

"Omfang av lyskeskader på ulike nivå i norsk fotball – En prospektiv kohortstudie"

Bakgrunn for prosjektet

Lyskeskader i fotball har over lang tid vært et aktuelt tema. Dette skyldes først og fremst det store omfanget med til tider langvarige skadeforløp. Vi har økt kunnskap om risikofaktorer for lyskeskader, men vi mangler informasjon om omfang og alvorlighetsgrad. Denne informasjonen er viktig når vi forsøker å forebygge skader, spesielt for å vite hvilket nivå som har størst nytte av forebyggende trening, men også for å kunne utvikle et mest mulig effektivt treningsprogram.

Senter for idrettsskedeforskning er en forskningsgruppe bestående av fysioterapeuter, leger og biomekanikere med erfaring og kunnskap innen idrettsmedisin. Senteret har som formål å forebygge skader og andre helseproblemer i idrett med spesiell satsning på fotball, håndball og ski/snowboard. Denne studien er en viktig brikke for å undersøke omfanget av lyskeskader fotball, og på hvilket nivå problemet er størst. Resultatene fra dette prosjektet skal bidra til innføring av et skadeforebyggende treningsprogram i 2016 sesongen, med mål om å redusere antall lyskeskader i fotball.

Gjennomføring av prosjektet

Vi inviterer klubber fra Tippeligaen, Toppserien, OBOS-ligaen, Oddsen-ligaen, 3. divisjon og U19 interkrets til å delta på en skaderegistrering over 6 uker i mai og juni 2015. Vi ber deg om å laste ned SpartaNova, i App-store eller Google Play, på din smarttelefon og logge inn med tildelt brukernavn og passord.

Hver uke kommer et push-varsel med link til spørreskjema du skal fylle ut. Det består av fire spørsmål om lyskeplager, spørsmål om treningsmengde og eventuelle skader forrige uke. Utfylling av skjemaet tar maksimalt fem minutter. Dersom det er usikkerhet omkring rapporterte skader vil vi kontakte deg på telefon. I tillegg vil du ved oppstart få utdelt et skjema der vi spør om spillerposisjon, dominant bein (skuddbein), antall år som seniorspiller, posisjon, tidligere skader samt alder, høyde og vekt.

Hva skjer med informasjonen om deg?

Informasjonen som registreres om deg skal kun brukes slik som beskrevet i hensikten med studien. Alle opplysningene vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennerende opplysninger. En kode knytter deg til dine opplysninger gjennom en navneliste. Det er kun autorisert personell knyttet til prosjektet som har adgang til navnelisten og som kan finne tilbake til deg. Det vil ikke være mulig å identifisere deg i resultatene av studien når disse publiseres. Datamaterialet anonymiseres innen prosjektslutt den 01.06.2018.

Angrer du?

Det er frivillig å delta i studien. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke til å delta i studien. Dette vil ikke få konsekvenser for din videre behandling. Dersom du ønsker å delta, undertegner du samtykkeerklæringen på siste side. Om du nå sier ja til å delta, kan du senere trekke tilbake ditt samtykke uten at det påvirker din øvrige behandling.

Spørsmål?

Ring gjerne til Joar Harøy, tlf.: 971 95 435 hvis du har spørsmål om prosjektet, eller send e-post til joar.haroy@nih.no. Ferdig utfylte skjema om personopplysning og samtykkeerklæring returneres til Norges idrettshøgskole Seksjon for idrettsmedisinske fag v/Joar Harøy, Postboks 4014 Ullevål Stadion 0806 Oslo.

Appendix VI

Informed consent project 2

FORESPØRSEL OM DELTAKELSE I PROSJEKTET:

“Bør Copenhagen adduction legges til i 11+? - En randomisert kontrollert studie”

Bakgrunn for prosjektet

Lyskeproblemer i fotball har over lang tid vært et aktuelt tema både i media og i forskningsammenheng. I en kartleggingsstudie vi gjennomførte på ulike nivå og begge kjønn i løpet av vårsesongen i 2015 fikk vi bekreftet at lyskeproblemer er et utbredt problem, og at forebyggende tiltak er nødvendig. I løpet av sesongen hadde gjennomsnittlig 30% av spillerne, på alle nivå, symptomer fra lysken. De oppgav at de måtte redusere treningsmengden og opplevde at de ikke presterte optimalt. Formålet med det kommende prosjektet vil være å følge opp disse resultatene og undersøke om oppvarmingsprogrammet "11+" har med øvelser som bidrar til å øke styrken i lyskemuskulaturen. Resultatene fra denne undersøkelsen vil være til stor nytte for norsk fotball, da "11+" benyttes til oppvarming i mange klubber på ulike nivå.

Senter for idrettsskadeforskning er en forskningsgruppe bestående av fysioterapeuter, kirurger og biomekanikere med kunnskap innen idrettsmedisin. Vår hovedmålsetting er å forebygge skader i norsk idrett, med spesiell satsning på håndball, fotball, ski og snowboard. Denne studien er en viktig brikke i arbeidet med å redusere omfanget av lyskeproblemer. Vi ønsker nå å undersøke effekten av et forebyggingsprogram som har til hensikt å redusere utbredelsen av lyskeproblemer i norsk fotball.

Gjennomføring av prosjektet

Vi ønsker at du som spiller i junior interkrets deltar i denne studien, og deltakelsen er frivillig. I løpet av en trening i sesongoppkjøring til 2016 sesongen vil vi gjennomføre tester for å måle styrken i muskulatur rundt hofteleddet samt 40m sprinttest. Testing vil ta ca. 1 time og bli gjennomført på samme måte også etter at prosjektet er avsluttet om 8 uker. I tillegg vil laget 3 ganger i uken gjennomføre "11+" som oppvarming før trening.

Hva skjer med informasjonen om deg?

Vi vil etter den 8 ukers treningsperioden undersøke om det er forskjell i styrke og hurtighet før og etter laget benyttet "11+" til oppvarming. Informasjonen som registreres om deg skal kun brukes slik som beskrevet i hensikten med studien. Alle opplysningene vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennende. Dataene vil bli behandlet konfidensielt, kun i forskningsøyemed og vil bli anonymisert ved prosjektets slutt, 01.08.2018. Alle som deltar i gjennomføring av prosjektet og forskere som benytter dataene er underlagt taushetsplikt.

Angrer du?

Det er frivillig å delta i studien. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke til å delta i studien. Dersom du ønsker å delta, undertegner du samtykkeerklæringen på siste side. Om du nå sier ja til å delta, kan du senere trekke tilbake ditt samtykke uten at det påvirker din øvrige behandling.

Spørsmål?

Ring gjerne til Joar Harøy, tlf.: 971 95 435 dersom du har spørsmål om prosjektet, eller send e-post til joar.haroy@nih.no.

***“Bør Copenhagen adduction legges til i 11+?
- En randomisert kontrollert studie”***

SAMTYKKEERKLÆRING

Jeg har mottatt skriftlig og muntlig informasjon om studien *“Bør Copenhagen adduction legges til i 11+? - En randomisert kontrollert studie”*.

Jeg er klar over at jeg kan trekke meg på et hvilket som helst tidspunkt.

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Appendix VII

Informed consent project 3

FORESPØRSEL OM DELTAKELSE I PROSJEKTET:

“ Forebygging av lyskeproblemer blant fotballspillere - En randomisert kontrollert studie ”

Bakgrunn for prosjektet

Lyskeproblemer i fotball har over lang tid vært et aktuelt tema både i media og i forskningsammenheng. I en kartleggingsstudie vi gjennomførte på ulike nivå og begge kjønn i løpet av vårsesongen i 2015 fikk vi bekreftet at lyskeproblemer er et utbredt problem, og at forebyggende tiltak er nødvendig. I løpet av sesongen hadde gjennomsnittlig 30% av spillerne, på alle nivå, symptomer fra lysken. De oppgav at de måtte redusere treningsmengden og opplevde at de ikke presterte optimalt. Formålet med det kommende prosjektet vil være å følge opp disse resultatene og undersøke effekten av et forebyggingsprogram på utbredelsen av lyskeproblemer blant fotballspillere. Resultatene fra denne undersøkelsen vil være til stor nytte for norsk fotball, da lyskeproblemer er et utbredt problem i fotball, i alle aldersklasser.

Senter for idrettsskadeforskning er en forskningsgruppe bestående av fysioterapeuter, kirurger og biomekanikere med kunnskap innen idrettsmedisin. Vår hovedmålsetting er å forebygge skader i norsk idrett, med spesiell satsning på håndball, fotball, ski og snowboard. Denne studien er en viktig brikke i arbeidet med å redusere omfanget av lyskeproblemer. Vi ønsker nå å undersøke effekten av et forebyggingsprogram som har til hensikt å redusere utbredelsen av lyskeproblemer i norsk fotball.

Gjennomføring av prosjektet

Vi ønsker at du som spiller i OBOS-ligaen eller PostNord-ligaen deltar i denne studien, og deltakelsen er frivillig. I sesongoppkjøring til 2016 sesongen vil vi besøke alle klubbene, og spillerne i halvparten av klubbene vil bli instruert i et forebyggende treningsprogram mot lyskeproblemer. Gjennom hele 2016 sesongen vil du hver uke motta spørreskjema gjennom en app på din smarttelefon. Spørreskjemaet består av fire spørsmål om lyskeplager, spørsmål om treningsmengde og eventuelle skader forrige uke. Utfylling av skjemaet tar omtrent 1-2 minutter.

Hva skjer med informasjonen om deg?

Vi vil den neste sesongen følge opp alle lag og spillere for å registrere alle lyskeproblemer som oppstår. Informasjonen som registreres om deg skal kun brukes slik som beskrevet i hensikten med studien. Alle opplysningene vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennende. Dataene vil bli behandlet konfidensielt, kun i forskningsøyemed og vil bli anonymisert ved prosjektets slutt, 01.08.2018. Alle som deltar i gjennomføring av prosjektet og forskere som benytter dataene er underlagt taushetsplikt.

Angrer du?

Det er frivillig å delta i studien. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke til å delta i studien. Dersom du ønsker å delta, undertegner du samtykkeerklæringen på siste side. Om du nå sier ja til å delta, kan du senere trekke tilbake ditt samtykke uten at det påvirker din øvrige behandling.

Spørsmål?

Ring gjerne til Joar Harøy, tlf.: 971 95 435 dersom du har spørsmål om prosjektet, eller send e-post til joar.haroy@nih.no.

***” Forebygging av lyskeproblemer blant fotballspillere
- En randomisert kontrollert studie”***

SAMTYKKEERKLÆRING

Jeg har mottatt skriftlig og muntlig informasjon om studien *Forebygging av lyskeproblemer blant fotballspillere -En randomisert kontrollert studie*.

Jeg er klar over at jeg kan trekke meg på et hvilket som helst tidspunkt.

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Appendix VIII

Informed consent project 4

FORESPØRSEL OM DELTAKELSE I PROSJEKTET:

“ Forebygging av lyskeproblemer blant fotballspillere - Gjennomføring av prosjektet og holdninger til skadeforebyggende arbeid ”

Bakgrunn for prosjektet

Lyskeproblemer i fotball har over lang tid vært et aktuelt tema både i media og i forskningssammenheng. I en kartleggingsstudie vi gjennomførte på ulike nivå og begge kjønn i løpet av vårsesongen i 2015 fikk vi bekreftet at lyskeproblemer er et utbredt problem, og at forebyggende tiltak er nødvendig. I løpet av en seksukersperiode hadde gjennomsnittlig 28% av spillerne, på alle nivå, symptomer fra lysken. Gjennom 2016 sesongen har du deltatt i *“Forebygging av lyskeproblemer blant fotballspillere” (lyskeprosjektet)*, et prosjekt med mål om å forebygge lyskeproblemer i fotball. Formålet med det kommende delprosjektet vil være å undersøke gjennomføringen av lyskeprosjektet og holdninger til skadeforebyggende arbeid. Resultatene vil gi viktig informasjon om implementeringen og gjennomføringen av lyskeprosjektet samt i planlegging av nye intervensjoner som har til hensikt å forebygge skader i fotball og andre idretter.

Senter for idrettsskedeforskning er en forskningsgruppe bestående av fysioterapeuter, kirurger og biomekanikere med kunnskap innen idrettsmedisin. Vår hovedmålsetting er å forebygge skader i norsk idrett, med spesiell satsning på håndball, fotball, ski og snowboard. Denne studien er en viktig brikke i arbeidet med å redusere omfanget av lyskeproblemer. Vi ønsker nå å undersøke effekten av et forebyggingsprogram som har til hensikt å redusere utbredelsen av lyskeproblemer i norsk fotball.

Gjennomføring av prosjektet

Vi ønsker at du som har deltatt i prosjektet *“Forebygging av lyskeproblemer blant fotballspillere”* deltar i dette delprosjektet, og deltagelse er frivillig. Du vil bli bedt om å svare på et spørreskjema med spørsmål om gjennomføringen av lyskeprosjektet og holdninger til skadeforebyggende arbeid. Undersøkelsen vil bli gjennomført i løpet av de siste ukene av 2016 sesongen ved at vi kommer ut til klubben. Selve utfyllingen av spørreskjemaet vil ta ca. 5-10 minutter.

Hva skjer med informasjonen om deg?

Informasjonen som registreres om deg skal kun brukes slik som beskrevet i hensikten med studien. Alle opplysningene vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennende. Dataene vil bli behandlet konfidensielt, kun i forskningsøyemed og vil bli anonymisert ved prosjektets slutt, 01.08.2018. Alle som deltar i gjennomføring av prosjektet og forskere som benytter dataene er underlagt taushetsplikt.

Angrer du?

Det er frivillig å delta i studien. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke til å delta i studien. Dersom du ønsker å delta, undertegner du samtykkeerklæringen på siste side. Om du nå sier ja til å delta, kan du senere trekke tilbake ditt samtykke uten at det påvirker din øvrige behandling.

Spørsmål?

Ring gjerne til prosjektleder Joar Harøy, tlf.: 971 95 435 dersom du har spørsmål om prosjektet, eller send e-post til joar.haroy@nih.no.

***“ Forebygging av lyskeproblemer blant fotballspillere
- Gjennomføring av prosjektet og holdninger til skadeforebyggende arbeid ”***

SAMTYKKEERKLÆRING

Jeg har mottatt skriftlig og muntlig informasjon om prosjektet *Gjennomføring av lyskeprosjektet og holdninger til skadeforebyggende arbeid* som en del av prosjektet *Forebygging av lyskeproblemer blant fotballspillere*. Jeg er klar over at jeg kan trekke meg på et hvilket som helst tidspunkt.

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Appendix IX

Oslo Sports Trauma Research Center Overuse Injury Questionnaire

Oslo Sports Trauma Research Centre Overuse Injury Questionnaire for groin problems

Have you had any difficulties participating in normal football training or matches due to groin problems?

- Full participation without groin problems
- Full participation, but with groin problems
- Reduced participation due to groin problems
- Haven't been able to participate due to groin problems

To what extent have you reduced your training volume due to groin problems?

- No reduction
- To a minor extent
- To a moderate extent
- To a major extent
- Haven't be able to participate at all

To what extent have groin problems affected your performance in football matches/training?

- No effect
- To a minor extent
- To a moderate extent
- To a major extent
- Haven't be able to participate at all

To what extent have you experienced groin pain related to football participation?

- No pain
- Mild pain
- Moderate pain
- Severe pain

The following questions are not asked to players who selected answer option 1.1, 2.1, 3.1 and 4.1 in the 4 previous questions.

On which side have you experienced groin problems?

- Dominant leg (kicking leg)
- Non-dominant leg
- Both legs

How did your groin problems first begin?

- Gradual onset (overuse injury)
- Sudden onset (completely symptom-free prior to a single injury event)

How many days in the past week have you had to completely miss training or matches due to groin problems?

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7

The following questions are asked to all players.

How many hours of football training have you completed during the past week? (include all normal team training)

How many hours of individual training have you completed the past week? (strength, endurance, injury prevention)

How many minutes of football match-play have you completed during the past week?

In how many football games did you play last week?

Appendix X

Questionnaire – Implementation of the Adductor Strengthening Programme

Questions asked to all players

To what extent do you think footballers are exposed to groin injuries?

- Highly
- Moderately
- Low
- Don't know

To what extent do you think footballers need to prevent groin injuries?

- Highly
- Moderately
- Low
- Don't know

**What do you think are the most common causes of groin injuries among footballers?
(Multiple answers possible)**

- Too little training
- Too much training
- Too many matches
- Hard tackles
- Low muscle strength
- Reduced mobility
- Reduced recovery time between matches
- Artificial turf
- Other

Is it more important to use the training time to play football than to conduct injury prevention?

- Fully agree
- Agree
- Not sure
- Disagree
- Totally disagree
- Don't know

The motivation of the coach affects the players motivation to conduct prevention exercises?

- Fully agree
- Agree
- Not sure
- Disagree
- Totally disagree
- Don't know

How do you perceive the general attitude to preventive measures in the following group in your club?

	Very positive	Positive	Neutral	Negative	Very negative	Don't know
Coaches	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Medical teams	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Players	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Administration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Questions asked to players in the intervention group

Are you familiar with the Adductor Strengthening Programme intended to prevent groin injuries?

- Yes
- No
- Don't know

Do you believe that the Adductor Strengthening Programme can reduce groin injuries?

- Yes, definitely
- Yes, somewhat
- No, I don't think so
- Don't know

Which players have primarily conducted the programme?

- All or most players
- Players with groin problems
- Players with previous groin problems
- No players
- Don't know

How has the execution of the programme been organized?

- When the players wanted, but not connected to organized training
- When the players wanted, but connected to organized training (before or after training)
- Together as a team connected to organized training
- Don't know

Have you conducted the programme with the recommended frequency?

- More often
- As recommended
- Less often
- Don't know

How much time did you spend conducting the Adductor Strengthening Programme?

- 0-5 min
- 5-10 min
- 10-15 min
- Don't know

Will you use the programme after the current season?

- Yes, definitely
- Yes, but not as frequency as this season
- No
- Don't know

Do you think the motivation to perform the Adductor Strengthening Programme would have been greater if the exercise was not a partner exercise?

- Yes, it is better to train alone
- It does not matter
- No, it is better to train with a team-mate
- Don't know

Do you think the motivation to perform the programme would have been greater if it had contained several exercises?

- Yes, the more exercise the better
- No, one exercise is sufficient
- Don't know

How would the motivation to perform the programme have changed if it had taken less time?

- It would have increased
- It would have decreased
- Don't know

How would the motivation to perform the programme have changed if it had taken more time?

- It would have increased
- It would have decreased
- Don't know

Are the following staff members familiar with the Adductor Strengthening Programme?

	Yes	No	Don't know
Head and assistant coach	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Medical team	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other coaches (fitness coach, goalkeeper trainer etc.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How do you perceive the attitudes to the Adductor Strengthening Programme in the following groups?

	Positive	Neutral	Negative	Don't know
Head and assistant coach	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Medical team	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Players	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Administration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Who has mainly initiated the programme? Rate from 1 to 3, where 1 is the one who has initiated it the most.

	Most	Second most	Third
Head coach	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Assistant coach	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fitness coach	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Health professional	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Team captain	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Another player of the team	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The players of the team	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Don't know	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Who has mainly been responsible for the quality of the Adductor Strengthening Programme? Rate from 1 to 3, where 1 is the one who had most.

	Most	Second most	Third
Head coach	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Assistant coach	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fitness coach	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Health professional	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Team captain	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Another player of the team	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The players of the team	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Don't know	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Questions asked to players in the control group

Are you familiar with the content of the exercise program that players in the intervention group have conducted through the current season?

- Yes
- No
- Don't know

Have you conducted the preventive exercise program or other exercises to prevent groin problems during the current season?

- Yes
- No
- Don't know

