Injury prevention for adult male soccer players

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Injury prevention for adult male soccer players

Blessurepreventie voor volwassen, mannelijke voetballers
(met een samenvatting in het Nederlands)

Proefschrift

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General introduction

1

There is a saying in sports that "injury is just part of the game". In other words, injury is seen as an inevitable consequence of participation in sports. Sports injury prevention researchers and practitioners take a different view: sports injuries can be prevented and need not be part of the game. The ideal position should be that "injury prevention is just part of the game".[28]

Participating in sports on a regular basis is considered a vital component of an active and healthy life-style to reduce the risk of various diseases and contribute to better social and physical performance. Soccer is one of the most popular sports worldwide, with almost 300 million people in over 200 countries actively engaged in it.[68] Outdoor soccer was being played by 2,635 clubs and approximately 60,500 teams in the Netherlands during the 2011/2012 season. There are currently more than 1.2 million licenced members of the Royal Netherlands Football Association (KNVB), 45% of whom are adult male soccer players.[167]

Soccer challenges physical fitness by requiring a variety of skills at different intensities. Running, sprinting, jumping and kicking are important performance components, requiring maximal strength and anaerobic power of the neuromuscular system.[107,166] Consequently, this popular sport also has high injury rates.[169] Outdoor soccer causes the largest number of injuries in the Netherlands each year (18% of all sports injuries), totalling approximately 620,000.[186] Medical treatment is given for 45% of these soccer injuries (n=280,000). Almost one fifth of these so called "medical attention injuries" is treated at an Emergency Department (ED) (n=49,000). The average direct medical costs are €810 per ED soccer injury.[31] Some other negative consequences of soccer injuries are sports and/or work absenteeism, personal suffering by the injured players, and additional medical costs due to these injuries. Injuries also form a leading cause of the development of early osteoarthritis in later life. There is evidence that knee and ankle injuries in particular result in an increased risk of the development of osteoarthritis.[40,130] Finally, injuries can also influence the success of a team as evaluated by its final position in the league table.[12]

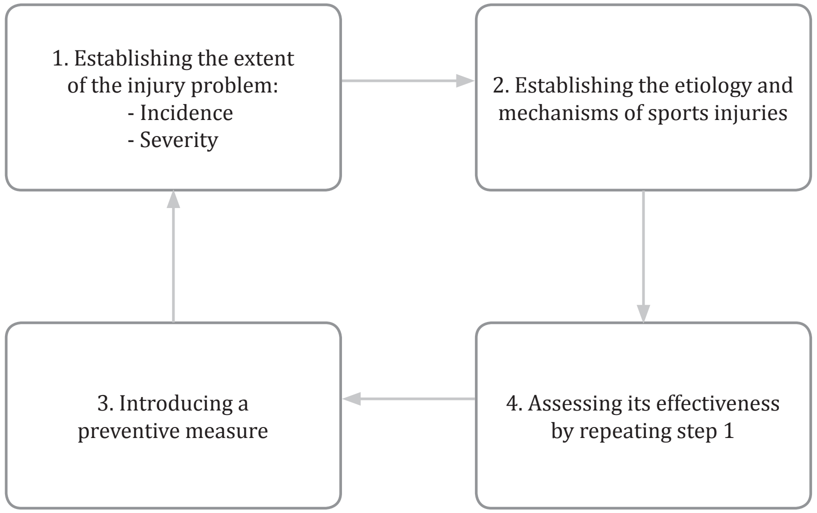
This dissertation focuses on injury prevention for adult male soccer players. The research project on which it is based investigated the effectiveness and cost-effectiveness of an injury prevention programme in terms of injury incidence and severity in adult male amateur players. The dissertation also presents information about the epidemiology and aetiology of soccer injuries.

Worldwide, the terms "football" and "soccer" are often used interchangeably; this dissertation uses the term "soccer" throughout.

Sports injury research

In 1992, Van Mechelen et al.[188] published the "sequence of prevention" model to analyse the rising injury problem. This four-step model describes how epidemiological sports injury research should ideally be performed (Figure 1.1). The first step involves identifying the magnitude of the sports injury problem and describing it in terms of incidence and severity. Secondly, the factors and mechanisms contributing to the occurrence of sports injuries have to be identified. The third step is to introduce measures that are likely to reduce the future risk and/or severity of sports injuries. This measure should be based on the aetiological factors and the mechanism(s) identified in the second step. Finally the effect of the measures must be evaluated by repeating the first step.[188]

Figure 1.1: Four-step model of sports injury research: sequence of prevention.[188] Reproduced from Bahr and Krosshaug with permission from the publisher.[19]



This dissertation addresses all the above-mentioned steps. Chapters 2 to 5 focus on steps three and four of the model: the main study reported in these chapters dealt with the introduction of an injury prevention programme and assessing its effectiveness. This programme was developed by the Fédération Internationale de Football Association (FIFA). Having found no positive effect of the intervention programme, we needed to return to steps one and two of the model by Van Mechelen et al.[188]. This work is presented in chapters 6 to 9.

Although the sequence of prevention is the most commonly cited model of sports injury research, Finch argued that there were limitations to this approach.[69] Her main concern was that the model does not include research regarding implementation issues, once preventive measures have been proven effective (step 4 in the Van Mechelen et al.[188] model). Such "proven" interventions might be less effective when they are implemented in real-world sports settings, rather than controlled scientific settings. The aim of directing research efforts towards an understanding of the implementation context for injury prevention led to the proposal of the new Translating Research into Injury Prevention Practice (TRIPP) framework (Table 1.1). Stages 5 and 6 of this framework may be particularly important for sports injury prevention, because such prevention measures need to be acceptable, adopted and complied with by the athletes and sports bodies they are targeted at, if they are to avoid injuries.[69,70]

Table 1.1: The Translating Research Into Injury Prevention Practice (TRIPP) framework, adapted from Finch.[70]

TRIPP stage	Research need	Research process
1	Counting and describing injuries	Injury surveillance
2	Understanding why injuries occur	Prospective studies to establish aetiology and mechanisms of injury
3	Developing "potential" preventive measures	Basic mechanistic and clinical studies to identify what could be done to prevent injuries
4	Understanding what works under "ideal" conditions	Efficacy studies to determine what works in a controlled setting (e.g. RCTs)
5	Understanding the intervention implementation context including personal, environmental, societal and sports delivery factors that may enhance or be barriers	Ecological studies to understand implementation context
6	Understanding what works in the "real world"	Effectiveness studies in context of real-world sports delivery (ideally in natural, uncontrolled settings)

Injury prevention research

In view of the frequency of injuries, the associated costs, and the personal suffering by the injured players, many studies have focused on injury prevention in soccer. Until now, shin guards, which are used to prevent shinbone (tibia) fractures, represent the only compulsory protective equipment to be worn during matches. In terms of step three of the sequence of prevention, 33 studies evaluating preventive measures for soccer players have been conducted.[#] These studies demonstrated several options for preventing soccer injuries, including orthoses, video-based awareness, balance training, strength training, and multi-component training programmes. The study populations of 17 studies consisted of male players, and 13 included female players, while three studies looked at mixed cohorts. Twenty-six of the studies found a reduction of the primary or secondary outcomes.[*] Examples of these outcomes are injuries overall, injuries to specific body parts (like ankle sprain, hamstring strain, and anterior cruciate ligament injuries), acute injuries and recurrent injuries.

Sixteen studies evaluated the effect of an intervention on one specific injury location, different studies examining ankle, knee, hamstring, or groin injuries in their study samples and the results can be summarized as follows.[^] There is evidence that ankle braces effectively reduce the recurrence of ankle sprains in both male and female soccer players.[96,172,180,182] Furthermore, balance training reduces the risk of (new or recurrent) ankle sprains in adult male amateur and youth players.[142,182] Additional eccentric hamstring exercise decreases the rate of overall, new and recurrent acute hamstring injuries in male elite and amateur soccer players.[159] The results of the intervention studies focusing on knee injuries in different populations have been ambiguous. Some studies reported preventive effects,[25,123,138,182] whereas others found no reduction of their primary outcome.[83,104,162] Finally, there is promising evidence that multi-component programmes can prevent overall soccer injuries, especially in (female) youth players.[60,101,120,122,131,132,175] These programmes are often performed during the warm-up of a soccer training and involve combinations of exercises to improve balance, strength, coordination and/or agility. However, the effectiveness of such programmes has never been proven for the largest group in soccer, adult male players.

In addition, research into injury prevention for soccer players has been affected by methodological limitations like inadequate sample size or sample size calculation,[§] lack of randomization[81,120,122,123,127,132,138,162,172] and lack of recording of exposure (whether overall or individual).[~] Since these shortcomings may influence the validity of the findings, there is a need for high methodological quality studies to confirm that soccer injuries can be prevented using particular strategies.

\# 9,10,14,25,33,50,60,62,76,81,83,92,101,104,108,120,122,123,127,131,132,138,142,148,159,162,172,174,175,177,180,182,196
* 14,25,33,50,60,81,83,92,101,104,108,120,122,123,127,131,132,138,142,148,159,172,175,180,182,196
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§ 14,81,83,101,104,108,122,131,132,142,162,172,174,196
~ 14,25,101,104,108,132,138,159,172,177

The first part of this dissertation deals with injury prevention. It starts with a systematic review describing the effect of injury prevention programmes to reduce soccer injuries (chapter 2). The purpose of this review was to systematically examine the evidence on the effect of preventive exercise-based training programmes to reduce soccer injuries in general. Chapter 3 describes the study design of our randomized controlled trial (RCT) investigating the effectiveness and cost-effectiveness of the FIFA injury prevention programme called “The11” for Dutch adult male amateur soccer players. We hypothesized that the The11 exercises, when integrated in the warm-up of each practice session, would have a preventive effect on injury incidence and/or injury severity compared to usual practice sessions without The11. The results of this study are reported in the next two chapters. Chapter 4 focuses on the effectiveness of The11 in terms of injury incidence and injury severity, and chapter 5 evaluates the cost-effectiveness of the The11 programme.

Injury and exposure surveillance

The principle of the sequence of prevention cannot be applied without proper injury surveillance (step 1 in the Van Mechelen et al.[188] model). Although the characteristics of soccer injuries, especially those of adult male soccer players, have been described in many studies, variations in definitions and methodologies make it difficult to compare the results and conclusions obtained from these studies.[+] Hence, an injury consensus group was established under the auspices of the FIFA Medical Assessment and Research Centre (F-MARC). In 2006, they published a consensus statement on injury definitions and data collection procedures in studies of soccer injuries. The most commonly used definitions are listed in Table 1.2. In addition, Fuller et al.[78] proposed criteria for classifying injuries in terms of location, type, diagnosis and causation.

Calculating the incidence of injuries requires information about numbers of injuries as well as exposure. According to the consensus statement, injuries should be classified by location, type and mechanism of injury (traumatic or overuse) and whether the injury was a recurrence.[78] If a specific diagnosis is required, a qualified medical practitioner should provide a specific written diagnosis or use a sport-specific injury coding system, such as the Orchard Sports Injury Classification System (OSICS).[165] The above-mentioned injury information can be documented by means of an injury form, which should ideally be completed by a medical professional as soon as possible after the event. In addition, an exposure form should include the date, type and duration (in minutes) of each exposure. Exposures can either be collected on an individual basis or for a group of players.[78] Collecting exposure data on an individual basis is more accurate,

\+ 6,10,11,13,48,55,65,98,99,114,117,118,121,135,140,141,149,152,161,163, 194,200,206 but also time-consuming.[18,78] The consensus statement by Fuller et al.[78] recommends that the exposure report form should preferably be filled in by a coach after each training session and match.

To minimize the occurrence of errors associated with recall of the injuries, a prospective design is preferred to a retrospective design in performing an epidemiological study. Furthermore, a prospective cohort study is usually superior to a case-control study as a prospective design enables exposure to risk of injury to be measured accurately.[19,78,87,115] The disadvantage of a cohort study design could be that study size is critical. It may be necessary to include and monitor a large number of players for an exceedingly long study period, particularly for less common injury types.[18]

Table 1.2: Commonly used definitions in studies of soccer injuries, according to the consensus statement by Fuller and colleagues.[78]

Injury	Any physical complaint sustained by a player that results from a soccer match or soccer training, irrespective of the need for medical attention or time loss form soccer activities.
Recurrent injury	An injury of the same type and at the same site as an index injury and which occurs after a player's return to full participation from the index injury.
Medical attention injury	An injury that results in a player receiving an assessment of his/her medical condition by a qualified medical practitioner.
Time loss injury	An injury that results in a player being unable to take full part in future soccer training or match play.
Injury severity	The number of days that have elapsed from the date of injury to the date of the player's return to full participation in team training and availability for match selection. Grouped in 6 categories according to severity: slight: 0 days; minimal: 1-3 days; mild: 4-7 days; moderate: 8-28 days; severe: >28 days; career ending.
Match exposure	Play between teams from different clubs.
Training exposure	Team-based and individual activities under the control or guidance of the team's coaching or fitness staff.
Injury incidence	Number of injuries per 1,000 player hours.

Soccer injuries in adult male soccer players

The incidence of outdoor soccer injuries is among the highest of all sports, particularly for adult male players.[112,119,170] International studies have observed large differences in the injury incidences. Specific injury risks for training and matches range from 2.0 to 11.2 injuries/1,000 soccer hours and from 11.4 to 44.6 injuries/1,000 soccer hours, respectively.[2,22,51,52,92,116,161] Although soccer injuries come in a wide variety, most soccer injuries affect the lower extremities (75-85%), the majority concerning the ankle, hamstrings or knee.[203] These injuries mainly consist of sprains and strains (50%) and contusions (33%).[13,51] Most soccer injuries are caused by trauma.

Three chapters of this dissertation describe prospective studies examining injury characteristics as well as the period of recovery from the injuries, by analysing outdoor soccer injuries sustained by Dutch adult male amateur (chapter 6) and elite (chapter 7) soccer players during one competitive season. In both studies, data were collected during the same season (2009/2010), using the same registration system. Chapter 8 presents a comparison between the results from amateur and elite data collections. These three studies followed the consensus statement on injury definitions and data collection procedures in studies of soccer injuries.[78]

Risk factors and injury mechanisms for soccer injuries

As a contact sport, soccer is associated with an inherent risk of injury. A risk factor or hazard is a condition, object, or situation that may be a potential source of harm to people.[77] According to step 2 of the Van Mechelen et al.[188] model injury surveillance must be followed by establishing the causes of an injury as the next step towards injury prevention. This includes obtaining information on the reason why a particular player may be at risk in a given situation (risk factors) or how injuries happen (injury mechanisms).[18]

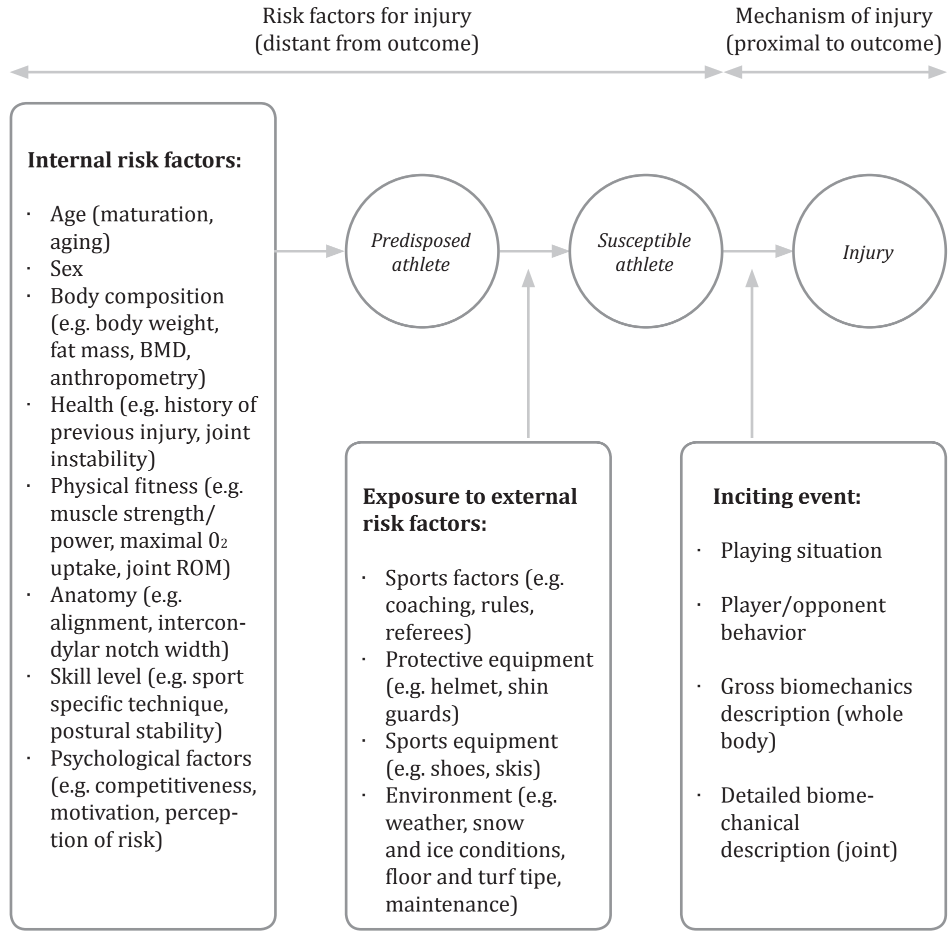
Injury causation is usually complex and multifactorial. Meeuwisse[144] introduced a model to understand this causation, which describes how multiple factors interact to cause an injury. Risk factors can be divided into intrinsic and extrinsic factors.[13,41,112,150,157,188] The model starts by identifying intrinsic risk factors that predispose a player. Such intrinsic or player-related factors include age, sex, physical fitness, anatomy and psychosocial factors. Examples of extrinsic or environment-related factors are training parameters, weather conditions, equipment and playing surfaces. The player may be more susceptible to injury when exposed to extrinsic risk factors. All these factors are considered to be distant from the outcome. In addition, it appears that most risk factors are sport-specific and interact with other factors to increase the risk of injury. Finally, there must be an inciting event producing an injury with, usually, an identifiable mechanism of injury that is proximal to the outcome.[144] Bahr and Krosshaug addressed some limitations of the model proposed by Meeuwisse (Figure 1.2), and identified that the inciting event can be a complex group of key components.[19]

A further distinction can be made between modifiable and non-modifiable risk factors. Non-modifiable factors (like age, sex, weather conditions) cannot be altered, but they may still affect the relationship between modifiable risk factors and injury. Modifiable risk factors may be more important for future intervention studies, because they can be influenced.[18,57,143]

In conclusion, soccer injuries result from a complex interaction of multiple risk factors and events. Many risk factors have been mentioned in the literature, but there as yet is no consensus with respect to all the findings. Commonly acknowledged non-modifiable risk factors for a soccer injury are: previous injury, age, sex, level of play, exposure time, surface and time of occurrence (in season or match). Muscle strength, flexibility, stability, and neuromuscular control seem to be potential modifiable risk factors. Chapter 9 presents a literature review about risk factors for hamstring injuries in male adult soccer players, as hamstring injuries are among the most frequently reported injuries in soccer.

Finally, the main findings of our studies are discussed in chapter 10. In this final chapter also two crucial themes in injury prevention research are discussed, namely optimizing injury prevention programmes and implementing such programmes. This chapter ends with several recommendations for future research.

Figure 1.2: Multifactorial model for injury causation, adapted from Meeuwisse.[144] Reproduced from Bahr and Krosshaug[19] with permission from the publisher.



BMD=body mass density, ROM=range of motion.

2

How effective are exercise-based injury prevention programmes for soccer players? A systematic review

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Abstract

Background: The incidence of soccer injuries is among the highest in sports. Despite this high rate, insufficient evidence is available on the efficacy of preventive training programmes on injury incidence.

Objective: To systematically study the evidence on preventive exercise-based training programmes to reduce the incidence of injuries in soccer.

Methods: The databases EMBASE/MEDLINE, PubMed, CINAHL, Cochrane Central Register of Controlled Trials, PEDro and SPORTDiscus were searched for relevant articles, from inception until 20 December 2011. The methodological quality of the included studies was assessed using the PEDro scale.

The inclusion criteria for this review were (1) randomized controlled trials or controlled clinical trials; (2) primary outcome of the study is the number of soccer injuries and/or injury incidence; (3) intervention focusing on a preventive training programme, including a set of exercises aimed at improving strength, coordination, flexibility or agility; and (4) study sample of soccer players (no restrictions as to level of play, age or sex). The exclusion criteria were (1) the article was not available as full text; (2) the article was not published in English, German or Dutch; and (3) the trial and/or training programme relates only to specific injuries and/or specific joints. To compare the effects of the different interventions, we calculated the incidence risk ratio (IRR) for each study.

Results: Six studies involving a total of 6,099 participants met the inclusion criteria. The results of the included studies were contradictory. Two of the six studies (one of high and one of moderate quality) reported a statistical significant reduction in terms of their primary outcome, i.e. injuries overall. Four of the six studies described an overall preventive effect (IRR<1), although the effect of one study was not statistically significant. The three studies that described a significant preventive effect were of high, moderate and low quality.

Conclusions: Conflicting evidence has been found for the effectiveness of exercise-based programmes to prevent soccer injuries. Some reasons for the contradictory findings could be: different study samples (in terms of sex and soccer type) in the included studies, differences between the intervention programmes implemented (in terms of content, training frequency and duration), and compliance with the programme. High-quality studies investigating the best type and intensity of exercises in a generic training programme are needed to reduce the incidence of injuries in soccer effectively.

Introduction

With approximately 265 million participants, soccer is the most popular sport in the world across both sexes and all age groups.[68] In addition to the social aspect of the sport, soccer also has beneficial health-related effects.[129] It challenges physical fitness by requiring a variety of skills at different intensities. Running, sprinting, jumping and kicking are important performance components, requiring maximal strength and anaerobic power of the neuromuscular system.[107,166] Consequently, this popular sport also has high injury rates.[169]

Soccer injuries come in a wide variety, but most injuries affect the lower extremities, including the upper leg, knee and ankle.[52,112] In view of the frequency of injury, the resulting costs and not least the personal suffering of the injured players, many studies have focused on injury prevention measures in soccer.[146,148,196] Several options for preventing soccer injuries have been developed, ranging from protective equipment (e.g. shin guards),[21,43,116] to warm-up and cool-down routines.[49,50,98,116]

Intervention programmes focusing on intrinsic risk factors for specific injuries have achieved significant reductions of soccer injuries. For instance, previous studies showed that eccentric strength training reduced the risk of hamstring injury in heterogeneous populations of soccer players.[9,14,159] It has also been shown that neuromuscular training appears to be effective to reduce the risk of anterior cruciate ligament (ACL) injury in both male and female soccer players.[4,86] A set of exercises focusing on balance, strength, flexibility and stability has been found to reduce the risk of ACL injuries in female youth soccer players.[123,138]

Despite the relatively high incidence of injuries in soccer, insufficient evidence is available on the efficacy of generic (non-specific) preventive training programmes in reducing injury incidence. These multifaceted programmes contain different exercises focusing on multiple joints and/or muscle groups and target prevention of the most common soccer injuries. The purpose of this review is to systematically examine the evidence on the effect of preventive exercise-based training programmes to reduce the incidence of soccer injuries in general.

Methods

Search methods

The databases EMBASE/MEDLINE, PubMed, CINAHL (Cumulative Index to Nursing and Allied Health Literature), Cochrane Central Register of Controlled trials, PEDro (the Physiotherapy Evidence Database) and SPORTDiscus were searched for relevant articles, from inception until 20 December 2011. The search strategy for MEDLINE was set by one author (NvdH), after which this strategy was modified for use in the other databases. The following combination of key words was used: ((prevention AND training) AND (soccer OR football) AND injury). The searches in CINAHL and SPORTDiscus were restricted to peer-reviewed articles. The full search strategy is available on the journal website. Subsequently, the databases were searched independently by two authors (NvdH, AvB). The results of these searches were combined and duplicates were removed. Reference lists of included studies and relevant systematic reviews were also screened for relevant studies.

Eligibility criteria

The relevant citations were first screened on the basis of title and abstract. Articles were independently selected by two authors (NvdH, AvB) if the study met the following criteria.

Inclusion:

- Randomized controlled trial (RCT) or controlled clinical trial (CCT).
- Primary outcome of the study is the number of soccer injuries and/or injury incidence.
- Intervention focusing on a preventive training programme, including a set of exercises aimed at improving strength, coordination, flexibility or agility.
- Study sample of soccer players (no restrictions as to level of play, age or sex).

Exclusion:

- The article was not available as full text.
- The article was not published in English, German or Dutch.
- The trial and/or training programme relates only to specific injuries and/or specific joints.

Full text of relevant articles was obtained and checked for inclusion and exclusion criteria independently by two authors (NvdH, AvB). Disagreements between the two authors regarding a study's eligibility were resolved by discussion until consensus was reached or, where necessary, a third author (IvdP) made the final decision.

Data collection

The following data were extracted by two authors (NvdH, AvB): first author; year of publication; follow-up period; number of participants; sex and age of participants; definition primary outcome; description of the intervention; and effect of the intervention.

Initially, the effect of the intervention was assessed by analysing the results in terms of the primary outcome of a study. If different methods are used to describe the primary outcomes in the included studies, the incidence risk ratios (IRRs) were calculated to compare the effects of the intervention between the studies. The IRR is the ratio of the injury rate (injured players divided by all players) in the intervention group divided by the corresponding rate in the control group. In addition, statistically significant results in terms of secondary outcomes were recorded.

Assessment of risk of bias in included studies

Two authors (NvdH, AvB) independently assessed the methodological quality of the included studies using the PEDro scale.[173] The PEDro scale is an 11-item checklist, based on expert consensus, which can be used to rapidly determine the internal validity and statistical quality of RCTs or CCTs.[137] The first item is not used to calculate the total PEDro score, so the maximum score was 10 points. Criteria were only scored as 'yes' or 'no'. Disagreements on the PEDro score were resolved by discussion between the two assessors. If consensus was not achieved, a third author (IvdP) was consulted. A study was considered of moderate quality if the PEDro score was at least 4, and of high quality if the score was 6 or higher.[133,189]

Results

Study selection

Electronic and manual searching yielded 925 relevant articles, with 265 duplicates. Of the remaining 660 articles, 639 were excluded after screening the title and abstract. Twenty-one articles were retrieved from the literature search and subsequently evaluated. After reading the full text we excluded a further 15 articles, without disagreements between the two authors regarding a study's eligibility. No additional reports were found by screening the reference lists and reviews. Articles were predominantly excluded because the intervention protocol used was not in agreement with our definition or the article did not describe an outcome in terms of injuries and/or injury incidence (Figure 2.1).

Study characteristics

Six studies with a total of 6,099 participants were included in this review.[60,101,122,174,175,177] Four studies were RCTs[60,174,175,177] and two CCTs.[101,122] The number of participants per study ranged from 194 to 2,540 players. The samples consisted of youth and adult soccer players, both male and female. Except for the study by Emery & Meeuwisse,[60] all studies involved outdoor soccer players. All included studies had a follow-up period of one season (ranging from 20 weeks to 8 months), except for the study by Junge et al.[122] (their follow-up period was one year during two seasons). Table 2.1 shows the main characteristics of the included studies.

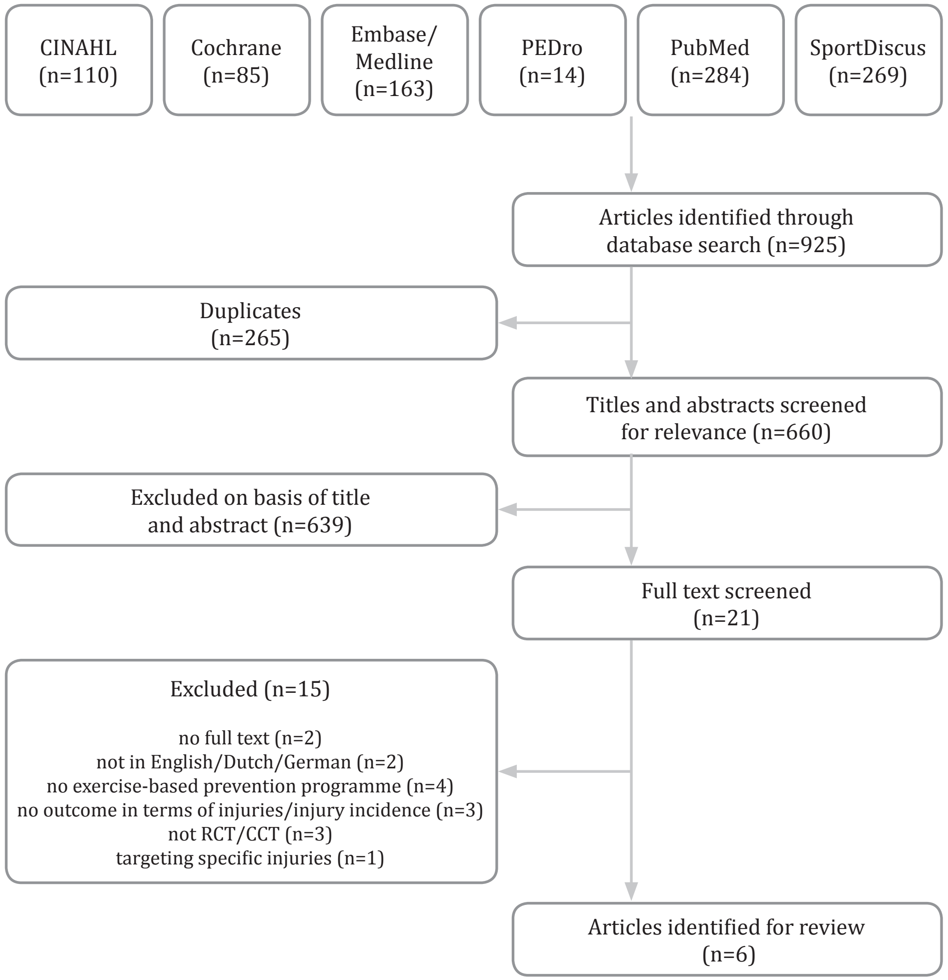
Table 2.1: Study characteristics of the included studies.

Study, year	Follow-up period	Participants [a]	Primary outcome	Intervention [b]	Effect of intervention	Incidence risk ratio (IRR)
Emery & Meeuwisse[60] 2010	One season of 20 weeks.	Male and female indoor soccer players, n=744 (intervention group: 380, control group 364), aged 13-18 years.	Injuries overall, defined as all soccer injuries resulting in medical attention and/or removal from a session and/or time loss.	Warm-up (15 min) including 5 min stretching and 10 min soccer-specific neuromuscular training programme and a 15 min home based balance training programme.	Significant reduction of the primary outcome (p=0.045): injury rate in intervention group = 2.08 (95% CI 1.54-2.74) injuries/1,000 hours, control group = 3.35 (95% CI 2.65-4.17).	0.66 (statistically significant)
Heidt et al.[101] 2000	One year of competitive soccer participation.	Female high-school soccer players, n=300 (intervention group: 42, control group: 258), aged 14-18 years.	Injuries overall, defined as all injuries which caused the player to miss a game or a practice.	Frappier Acceleration Training Programme: sport-specific programme of cardiovascular conditioning, plyometric work, sport cord drills, strength training, and flexibility exercises. Twenty sessions over 7 weeks during pre-season.	Significant reduction of the primary outcome (p<0.05).	0.42 (statistically significant)
Junge et al.[122] 2002	One year (during two seasons).	Male soccer players, n=194 (intervention group: 101, control group: 93), aged 14-19 years, age = 16.5±1.2 years.	Injuries overall, defined as any physical complaint caused by soccer that lasted for more than two weeks or resulted in absence from a subsequent match or training session.	General interventions such as improved warm-up, regular cool-down, taping of unstable ankles, adequate rehabilitation and promotion of the spirit of fair play as well as 'F-MARC Bricks': balance, flexibility, strength, coordination, reaction time, and endurance. Once a week supervised by a physiotherapist.	No significant reduction of the primary outcome. Statistically significant differences were found for number of injured players, mild injuries, overuse injuries, noncontact injuries, injuries incurred during training, and injuries of the groin.	0.64 (statistically significant)
Söderman et al.[174] 2000	One season of 7 months.	Female soccer players, n=221 (intervention group: 121, control group: 100), mean age (n=140) = 20.5±5 years.	Acute lower extremity injuries resulting in absence from at least one scheduled practice session or game.	Balance board training at home (10-15 min). Initially each day for 30 days and then three times a week during the rest of the season.	No reduction of the primary outcome. Significantly higher injury rate of severe injuries in intervention group.	1.16 (not statistically significant)
Soligard et al.[175] 2008	One season of 8 months.	Female soccer players, n=2,540 (intervention group: 1,320; control group: 1,220), youth, aged 13-17 years, mean age (n=1,892) = 15.4±0.7 years.	All lower extremity injuries causing the player to be unable to fully take part in the next match or training session.	The11+ intervention programme (20 min): running exercises, strength, balance, jumping, speed running. Every training session during the season (2-5 times a week).	No significant reduction of the primary outcome. The risk of severe injuries, overuse injuries and injuries overall was significantly reduced in the intervention group.	0.67 (not statistically significant)
Steffen et al.[177] 2008	One season of 8 months.	Female soccer players, n=2,092 (intervention group: 1,091; control group: 1,001), aged 13-17 years, mean age (n=2,020) = 15.4±0.8 years.	Injuries overall, defined as all injuries causing the player to be unable to fully take part in the next match or training session.	Warm-up (20 min) including 5 min of jogging and 15 min of The11intervention programme: core stability, balance, dynamic stabilization and eccentric hamstring strength. Initially every training session for 15 consecutive sessions and thereafter once a week during the rest of the season.	No reduction of the primary outcome.	1.20 (not statistically significant)

[a] *Age is presented as mean age±SD where stated.*
[b] *The control groups were generally asked to train (and warm-up) as usual.*

CI=confidence interval, F-MARC=FIFA Medical and Research Centre.

Figure 2.1: Flow diagram literature search and selection.



CCT=controlled clinical trial, RCT=randomized controlled trial.

Methodological quality

The PEDro scores ranged from 2 to 8 points, with a median of 5 points. The results of the quality assessment after consensus are presented in Table 2.2. Three of the six included studies were of high methodological quality,[60,175,177] two others of moderate quality,[101,174] and one of low quality.[122] Some limitations in the low- or moderate-quality studies were lack of randomization,[101,122] low statistical power or inadequate sample size calculation,[101,122,174] no intention-to-treat analysis,[101,122,174] no exposure registration,[101] and a high drop-out rate.[122,174]

Interventions and effects

The definition used for injury was similar in nearly all studies, viz. an injury that results in a player being unable to take full part in future soccer training or match play ('time-loss' injury).[78] Two studies also used this definition, but with the additional element of "or any physical complaint caused by soccer that lasted for more than two weeks"[122] and "soccer injuries resulting in medical attention and/or removal from a session and/or time loss".[60]

All six studies prescribed soccer-specific exercises aimed at improving strength, coordination, flexibility or agility. One study[174] required participants to do home-based wobble-board exercises, and one study[60] combined soccer-specific exercises with home-based wobble-board training. The participants in the control group of the latter study engaged in a home-based programme including only the stretching components. One study used a multi-modal intervention programme consisting of warm-up, cool-down, taping of unstable ankles, and rehabilitation combined with an exercise-based programme.[122] The exercises focused on balance, flexibility, strength, coordination, reaction time, and endurance. The other three studies implemented a preventive training programme during the warm-up of training sessions.[101,175,177] One programme, the Frappier Acceleration Training Programme, consists of exercises to improve speed and agility.[101] Another one, called The11, focuses on core stability, balance, dynamic stabilization, and eccentric hamstring strength,[177] while the last one, The11+, combines key exercises from The11 and additional exercises to provide variation and progression with running exercises.[175] The teams in the control groups of these studies were asked to continue their warm-up and training as usual during the season. More detailed information about the interventions studied is provided in Table 2.1.

Only two of the six studies reported a significant reduction in terms of their primary outcome, i.e. injuries overall. One of these studies was a high-quality study[60], the other was of moderate quality.[101] Emery & Meeuwisse[60] showed that the injury rate in the intervention group was significantly lower (2.08, 95% CI 1.54-2.74 injuries/1,000 hours) than in the control group (3.3, 95% CI 2.65-4.17 injuries/1,000 hours). Heidt et al.[101] reported a significantly lower injury incidence in the intervention group than

Table 2.2: Study characteristics of the included studies.

Study, year	Random allocation	Concealed allocation	Baseline comparability	Blinded subjects	Blinded therapists	Blinded assessors	Adequate follow-up	Intention-to-treat analysis	Between-group comparisons	Point estimates and variability	Total
Emery & Meeuwisse[60] 2010	1	1	1	0	0	1	0	1	1	1	7
Heidt et al.[101] 2000	1	0	0	0	0	1	1	0	1	0	4
Junge et al.[122] 2002	0	0	1	0	0	0	0	0	1	0	2
Söderman et al.[174] 2000	1	0	1	0	0	0	0	0	1	1	4
Soligard et al.[175] 2008	1	1	0	0	0	1	0	1	1	1	6
Steffen et al.[177] 2008	1	1	0	0	0	1	1	1	1	1	7

0=no, 1=yes.

in the control group (14.3% vs. 33.7%). The statistically significant results in terms of secondary outcomes are presented in Table 2.1.

To compare the effects of the different interventions we calculated the IRR for each of the included studies (see Table 2.1). Four of the six studies reported an overall preventive effect (IRR<1), although the effect in one study was not statistically significant.[60,101,122,175] The three studies which described a significant preventive effect were of high,[60] moderate[101] and low quality.[122] The mean reduction in injury rate in these studies was 44%.[60,101,122] The mean overall reduction (for the six included studies) was 19%.[60,101,122,174,175,177]

Discussion

This review systematically describes the evidence from RCTs and CCTs on the effect of generic exercise-based programmes to prevent soccer injuries. The conclusions of the six included studies were contradictory. Only two studies reported a significant reduction in terms of the primary outcome.[60,101] The result of our analysis is inconclusive, however, as different outcome measures and injury definitions were used. As regards the effect of the interventions in terms of one identical outcome, namely IRR, four of the six studies described a preventive effect, although the effect in one (high-quality) study was not significant.[60,101,122,175] The three studies which described a significant preventive effect were of high,[60] moderate[101] and low quality.[122] The other high-quality study reported no differences between the two groups at all.[177]

The possible effect of an intervention depends on several factors, which were not identical for all included studies. The first aspect is the study sample in the included studies. Only two studies included male soccer players,[60,122] and one of these showed a significant reduction in terms of the primary outcome, i.e. injuries overall.[60] The other four studies included only female players and two of them showed a significant preventive effect of the intervention.[101,175] Each sex may have its own risk factors and its own risks of sustaining an injury, or more specifically an ACL injury.[20] It is well-known that female players have a 2-3 times higher ACL injury risk than male players.[193,201]

Nevertheless, a recently published review reported that females benefit less from ACL prevention programmes than males (risk reduction of 52% vs. 85% respectively).[168]

Another important factor that deserves further attention is the content of the intervention programmes analysed in this review. Despite the fact that we defined the content in the inclusion criteria, the contents did differ, which limits their comparability. In the study by Junge et al.[122] the exercise programme was part of other general preventive interventions such as taping, rehabilitation, and promotion of fair play. This makes it difficult to identify the specific effect of the set of preventive exercises alone. Two other studies primarily focused on balance training,[60,174] while the remaining three studies described the effects of a training programme focusing on several aspects like core stability, balance, strength, and flexibility.[101,175,177] A general comment regarding the content of the programme is about the rationale for specific parts of the intervention programmes in the included studies. One can imagine that e.g. neuromuscular training cannot reduce head injuries. The hypothesis is that performing certain exercises on a regular basis would reduce the incidence of the most common (lower extremity) injuries. However, Soligard et al.[175] showed no significant reduction for their primary outcome (all lower extremity injuries), while a significant risk reduction was found for overall injuries in the intervention group. The majority of the included studies targeted prevention of all injury.[60,101,122,177]

Besides the content of the programme, training frequency and duration also varied greatly between the included studies. The frequency of the intervention programmes ranged from one to five sessions a week, during an intervention period that ranged from 7 weeks to 8 months. The three studies reporting a significant preventive effect of the intervention programme differ greatly.[60,101,122] The participants of one study had 20 sessions over a 7-week period.[101] In the second study a physiotherapist weekly visited one training session per team and supervised the performance of the intervention programme. It is not reported that the teams also perform the programme without supervision of the physiotherapist.[122] The third study did not report the training frequency, but the participants performed the intervention during a 20-week season.[60] Although the participants of the study by Söderman et al.[174] performed the intervention three times a week, the effect of preventive exercises in general may be positively influenced by a higher frequency (more than once a week). Since the differences in intensity of the programme compared with the effect of the intervention in the included studies it would be interesting to study any underlying dose-response relationship in more detail.

Compliance may also be a key factor in the potential effect of an intervention programme. Soligard et al.[175] confirmed in a previous study that the risk of overall and acute injuries was reduced by more than one-third among players with high compliance compared with players with intermediate compliance. Four of the six included studies recorded the participants' compliance with the intervention. The study by Emery & Meeuwisse,[60] the high-quality study which showed a preventive effect of the intervention, did not clearly report compliance. The authors stated that response in terms of self-reported compliance with the home-based programme was very poor (<15%). Completion of warm-up was indicated for every practice and game at all teams for which weekly exposure data were complete. It is unclear, however, whether all components of the prescribed warm-up were completed for each session.[60] In the two Norwegian studies, compliance with the The11 programme was 52%[177] vs. 77% for The11+.[175] Finally, Söderman et al.[174] excluded 30% of the participants who had completed the study but had performed the prescribed balance board training during fewer than 35 training sessions.

It is hard to conclude from the present review, which components are relevant in injury prevention programmes. To be able to develop effective training programmes, it is highly important to establish the aetiology and mechanisms of injuries before introducing and implementing a preventive measure.[69,191] The training programmes implemented in the studies included in this review involve different exercises focusing on the prevention of the most frequently reported soccer injuries. Since these injuries have their own aetiologies and risk factors, it is hard to design a 'one size fits all' intervention programme. Even when focusing on one common type of injury in soccer (knee injuries), it still seems difficult to decide which exercises should be implemented in a preventive programme. The literature reports contradictory effects of different exercises. Some studies reported positive, preventive effects on knee injuries,[25,123,138] while others reported only a trend towards reduction,[83,104] or no reduction at all.[62,162] Sadoghi et al.[168] recently reported on the effectiveness of ACL injury prevention training programmes. In their review, they suggested that such programmes have a substantial beneficial effect. However, they were not able to recommend a specific type of prevention programme on the basis of the currently published evidence.[168] This confirms the difficulties of designing an exercise-based intervention programme.

Before introducing and implementing a preventive training programme, it also seems relevant to improve the ability to identify players at risk for sustaining an injury.[169] This would make it possible to design such programmes specific enough to achieve the maximum effect. Finally, external factors like behaviour/fair play[44,191] and sports culture[69] play a role in sustaining injuries. A better understanding of these factors may lead to improvements in the prevention of soccer injuries.

A limitation of our review is that the generalizability of the results remains unclear. The included studies predominantly focused on young, female outdoor soccer players. The participants' age was below 19 years in five studies.[60,101,122,175,177] However, the largest group of active participants in soccer worldwide concerns is that of adult male players, who also have high injury rates.[68,169] It is also unclear if the results of our review can be generalized to other levels of play and/or across sexes. Only two studies included male participants: 44.6% of the sample in the study by Emery & Meeuwisse[60] (n=332) and the entire study sample used by Junge et al.[122] (n=194). Generalizing the results of our review to the largest soccer population (adult male players) must be done with considerable caution. Finally, it is unclear whether the results reported by Emery & Meeuwisse,[60] who included only indoor soccer players, can be generalized to outdoor soccer players. Although indoor and outdoor soccer have several similarities, it is not evident that the injuries are comparable. Some studies reported that indoor soccer has a higher injury incidence/risk than outdoor soccer,[106,169] while others described no differences between indoor and outdoor soccer in injury incidence or risk factors.[59]

Drawing conclusions about the effectiveness of an intervention programme also requires taking the choice of primary outcome in a study into account. We used the results in terms of the primary outcome in the included studies to describe the effect of an intervention, because there may be insufficient statistical power for conclusions based on the secondary outcomes. However, some studies only reported a preventive effect in terms of secondary outcomes.[122,175] Finally, the mean IRR of the six included studies (19% reduction) should be interpreted with care. By calculating this score the methodological quality of the included studies is not taken into account. Besides this, the calculation is not based on a meta-analysis. Ideally, relative weights should be given to each included study before calculating the overall IRR.

Conclusion

The calculated IRRs for the studies included in our review indicate that there is conflicting evidence for the effectiveness of exercise-based programmes to prevent soccer injuries. There is thus a need for more high-quality studies investigating the best type and intensity of exercises in a generic training programme (for a specific population in terms of sex, level of play, and age), in order to reduce the incidence of injuries in soccer effectively.

3

Effectiveness and cost-effectiveness of an injury prevention programme for adult male amateur soccer players: design of a cluster-randomized controlled trial

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Abstract

Background and aims: Approximately 16% of all sports injuries in the Netherlands are caused by outdoor soccer. A cluster-randomized controlled trial has been designed to investigate the effectiveness and cost-effectiveness of an injury prevention programme ("The11") for male amateur soccer players. The injury prevention programme The11, developed with the support of the World Football Association FIFA, aims to reduce the impact of intrinsic injury risk factors in soccer.

Methods: Teams playing at first-class amateur level in two districts in the Netherlands are participating in the study. Teams in the intervention group were instructed to apply The11 during each practice session throughout the 2009/2010 season. All participants of the control group continued their practice sessions as usual. All soccer-related injuries and related costs for each team were systematically reported online by a member of the medical staff. Player exposure to practice sessions and matches was reported weekly by the coaches. Also the use of The11 during the season after the intervention season will be monitored.

Discussion: Our hypothesis is that integrating the The11 exercises in the warm-up for each practice session is effective in terms of injury incidence, injury severity, health care use and its associated costs and/or absenteeism. Prevention of soccer injuries is expected to be beneficial to adult soccer players, soccer clubs, the Royal Dutch Football Association (KNVB), health insurance companies and society.

Introduction

Background and objectives

Sport is considered a vital component of an active and healthy life-style, reducing the risk of various diseases and contributing to better social and physical performance. The beneficial effects of playing sports must be balanced against injuries that are to some extent inevitable. The total number of acute and overuse sports injuries in the Netherlands is about 3.6 million per year and 38% of these injuries require medical treatment.[31] Estimated direct and indirect costs (medical costs and work absenteeism) are €1.3 billion a year.[32] In the Netherlands, soccer causes the largest number of injuries each year (19% of all sports injuries), i.e. 679,000 injuries.[31] Most soccer injuries are located in the lower extremities, the majority concerning the ankle, knee or hamstrings.[203] These injuries mainly consist of sprains and strains (50%) and contusions (33%).[13]

Outdoor soccer is a high intensity sport with continuous changes of direction and high-load unipodal actions. Participating in this sport puts high demands on neuromuscular control, agility and eccentric/plyometric strength. Some intrinsic and extrinsic risk factors associated with soccer injuries have been described, and potential prevention measures have been discussed.[1,4,66,113,116,158] Several studies have shown that intervention programmes containing specific exercises can significantly reduce injury risks to the lower extremities.[14,25,60,86,101,105,138,190] An injury prevention programme called The11, developed with the support of the World Football Association FIFA, significantly reduced injury rates (21% fewer injuries) in Swiss male junior soccer players.[122] However, this injury prevention effect was not observed in Norwegian female junior soccer players, most likely because compliance with the programme was low.[122,177] Our project focuses on male adult soccer players, the largest group of soccer players in the Netherlands.

We developed a research project to accompany the introduction of The11 to prevent injuries in Dutch amateur soccer. The first aim of the present study is to investigate the effectiveness and cost-effectiveness of the injury prevention programme The11. The hypothesis is that the The11 exercises, when integrated in the warm-up for each practice session, have a beneficial effect on injury incidence and injury severity, leading to lower medical costs and/or reduced absenteeism from sports, school and work among male adult soccer players. Given the effect in terms of injury risk reduction found in the Swiss study by Junge et al.[122], overall costs of soccer injuries in the Netherlands could be reduced by implementing the The11 exercises in outdoor soccer. Until now, cost analysis and cost-effectiveness data about injury prevention in soccer are lacking. The second aim of the study is to monitor the use (whether or not continued) of The11 by coaches during practice sessions in the season following the intervention season, to study long-term compliance.

Table 3.1: Instructions and repetitions for the exercises of The11.

Exercise	Instructions	Repetitions/ duration
1. The bench	Head, shoulders, back and hips in a straight line, parallel to the ground. Elbows directly under the shoulders. Lift one leg a few centimetres off the ground.	Hold the position for 15 seconds. Repeat twice for each leg.
2. Sideways bench	Upper shoulder, hip and upper leg in a straight line parallel to the ground. Elbow directly under the shoulders. From above, shoulders, elbow, hips and both knees are in a straight line. Don't drop the hips.	Hold the position for 15 seconds. Repeat twice for each side.
3. Hamstrings	Ankles pinned firmly to the ground by a partner. Slowly lean forward keeping upper body and hips straight. Keep thighs, hips and upper body in a straight line. Try to hold this straight body alignment, using the hamstrings, for as long as possible, then control your fall.	Repeat 5 times.
4. Cross country skiing	Flex and extend the knee of the supporting leg and swing the arms in opposite directions in the same rhythm. On extension, never lock the knee, and don't let it buckle inwards. Keep pelvis and upper body stable and facing forwards. Keep pelvis horizontal and don't let it tilt to the side. Flex and extend each leg.	15 times on each leg.
5. Chest-passing in single-leg stance	Keep knees and hips slightly bent. Keep weight only on the ball of the foot, or lift heel from the ground. From the front, hip, knee and foot of the supporting leg should be in a straight line. Throw a ball back and forth with a partner.	10 times on each leg.
6. Forward bend in single-leg stance	As for Exercise 5, but before throwing it back, touch the ball to the ground without putting weight on it. Always keep knee slightly bent and don't let it buckle inwards.	10 throws on each leg.
7. Figures-of-eight in single-leg stance	As for Exercise 5 but before throwing it back, swing the ball in a figure-of-eight through and around both legs: first around the supporting leg with the upper body leaning forward, and then around the other leg standing as upright as possible. Always keep knee slightly bent and don't let it buckle inwards.	10 throws on each leg.
8. Jumps over a line	Jump with both feet, sideways over a line and back, as quickly as possible. Land softly on the balls of both feet with slightly bent knees. Don't let knees buckle inwards.	Repeat side-to-side 10 times and then forwards-backwards 10 times.

Table 3.1, continued: Instructions and repetitions for the exercises of The11.

Exercise	Instructions	Repetitions/ duration
9. Zigzag shuffle	Bend knees and hips so upper body leans substantially forward. One shoulder should always point in the direction of movement. Shuffle sideways through the Zigzag course as fast as possible. Always take off and land on the balls of the feet. Don't let knees buckle inwards.	Complete course twice.
10. Bounding	Bring the knee of the trailing leg up as high as possible and bend the opposite arm in front of the body when bounding. Land softly on the ball of the foot with a slightly bent knee. Don't let knee buckle inwards during take-off or landing.	Cover 30 metres twice.

Here, we describe the study design of the study. At the moment of writing this the first part of the study (preparation and intervention season 2009/2010) has been accomplished. The other parts of the study (follow-up season 2010/2011, data analysis and economic evaluation) will be accomplished in subsequent years.

Methods

Trial design and randomization

This two-armed cluster randomized controlled trial (RCT) focuses on the effectiveness and cost-effectiveness of the injury prevention programme The11 for Dutch male amateur soccer players. In order to avoid contamination, randomization has taken place at cluster level, viz. the regional competitions. Randomization was done independently by drawing lots.

Intervention

The injury prevention programme The11 has been developed with the support of the World Football Association FIFA. The programme aims to reduce the impact of intrinsic injury risk factors in soccer.[42] It includes 10 exercises focusing on core stability, eccentric training of thigh muscles, proprioceptive training, dynamic stabilization and plyometrics with straight leg alignment. The 11th component, fair play advice, is not included in the present trial. The exercises of The11 are The bench, Sideways bench, Hamstrings, Cross country skiing, Chest-passing in single-leg stance, Forward bend in single-leg stance, Figures-of-eight in single-leg stance, Jumps over a line, Zigzag shuffle and Bounding (Table 3.1). The programme takes about 10-15 minutes after the players have familiarized themselves with the exercises. Coaches of the intervention group were asked to integrate this intervention programme in the warm-up for each practice session (at least two times a week) during the 2009/2010 soccer season. Full implementation of the programme in practice sessions took the coaches about five weeks during the pre-season. All teams in the intervention group received 18 exercise mats, to enable them to perform some of the ground exercises, especially if the field was in poor condition.

All coaches of the intervention group were informed by means of a course and practical demonstrations. The Coach Academy of the Royal Dutch Football Association (KNVB) provided instructions for the implementation of The11. This cooperation with the KNVB facilitates collaboration with participating clubs, coaches and players. In addition, individual consultations were provided by members of the research team. The main goal was to motivate coaches, to create awareness of injury prevention strategies and to impart the necessary knowledge and techniques to incorporate The11 in practice. In addition, the coaches received a detailed information package (DVD, poster and reader), presenting the basic elements of the injury prevention programme. In the control group, coaches were invited to participate in what they were told would be a study of injury prevention, injury incidence and characteristics of practice sessions.

Participants

Two, geographically separated but similar regional districts of Dutch first-class amateur soccer were invited to participate in the study. After allocation of these two districts by the Royal Dutch Football Association (KNVB), officials from the selected districts were contacted personally to ask their permission to conduct the study. Only teams with male players between 18 and 40 years of age were eligible for inclusion. The research team gave the clubs and their first team-coaches information about the aims of the trial. The control group was asked to participate in a study on injury incidence and characteristics of practice sessions. The intervention group was informed about the possibility of reducing injury risks by incorporating The11 in their practice sessions. All invited teams have practice sessions 2-3 times a week. Players from both groups were asked to sign an informed consent statement at the start of the intervention season.

Data collection: recording injury, health care use and exposure

During the pre-season (August 2009), all players were asked to fill in a questionnaire to record baseline characteristics: date of birth, height, weight, nationality, years of experience as a soccer player, educational level, profession, numbers of working hours per week, dominant leg, position in the soccer field, preventive measures taken (such as shin guards, taping, braces), chronic diseases, prior soccer injuries sustained during the previous year (number and localization).

During the season, information about exposure to soccer (each practice session and match) was reported by the coach using a weekly computer-based recording form. When a player was not present at a regular practice session or game, the reason for his absence was reported on the exposure form as 'injured' or 'other reason'. Additional time spent playing or practising outside the team context, such as a practice session or game with another team or individual recovery training, was also recorded on the exposure form (time and goal of individual exposure). In addition, the coach of each team in the intervention group reported the use of The11 (time in minutes) on this exposure form.

In both research groups, a paramedic of each team was responsible for recording the injuries using the Web-Based Injury System (BIS) developed by the Netherlands Organization for Applied Scientific Research (TNO Quality of Life).[178,187] BIS has been developed to record sports injuries and evaluate preventive measures and interventions. During the pre-season, the paramedics of the participating teams recorded injuries to get used to the system. Each team was provided with a laptop with Internet access, to support the soccer injury recording. The laptop enabled injury data to be entered directly into BIS, on a secure website. The system is capable of gathering epidemiological information on injuries (location, duration and type), aetiology (intrinsic and extrinsic risk factors), consequences of injuries (e.g. work/school/sports absenteeism) and the volume and type of medical treatment, using so-called injury and recovery forms. TNO provided instructions to the participating teams for monitoring data on injuries and associated health care use. BIS has adopted the basic guidelines of the Consensus statement on injury definitions and data collection procedures in soccer.[78] An injury was defined as: 'any physical complaint sustained by a player that results from a soccer match or soccer practice session, irrespective of the need for medical attention or time loss from soccer activities'.

Compliance

During the intervention season, practice sessions of each team, selected at random, were monitored by independent observers and members of the research team each month. The purpose of these visits was to verify the actual use and the quality of implementation of the injury prevention programme The11 in the intervention group. This information was used to analyse the consistency of the implementation by coaches. At the same time, coaches were encouraged to give more attention to the topic in order to maintain or enhance compliance. The purpose of the random visits in the control group was to check their actual warm-up (duration and type of exercises) and to record the self-initiated use of preventive measures (specific those of The11) by the teams in the control group. A standardized form was used to score and evaluate the practice sessions in terms of injury-preventive activities for both groups.

Half way through the season, a meeting was organized for the coaches of the intervention group to evaluate the practical aspects of using BIS and The11. A similar evaluation meeting was organized for the coaches of the control group, allowing them to share experiences with the use of BIS. In addition to monitoring and motivating participants in both research groups, we also attempted to enhance compliance to the study by providing extras such as regular newsletters for all participants (in a different version for each district to avoid contamination), free exercise mats for the teams in the intervention group, a free laptop for all participating teams after completion of the intervention season, talks by famous Dutch soccer coaches and free tickets for matches of the national soccer team for all participating coaches and paramedics. Finally, compliance was stimulated by providing regular feedback to all participating soccer clubs about the injuries recorded in BIS.

After the intervention season, the coaches from the intervention group took part in a survey to evaluate The11 and the actual use of the programme during the intervention season. Players have filled in a questionnaire to determine their positive and negative aspects of the The11 exercises. The participating coaches and paramedics of the control group have been fully informed about the aims of the study at the end of the intervention season. These coaches have received the same information package about The11 as the coaches in the intervention group.

Before the start of the follow-up season 2010/2011, also the coaches of the control group will be asked to fill in a similar questionnaire on their opinion about The11 and their expectations about using The11 during practice sessions in the next season. All coaches, of both research groups, will receive a second questionnaire in the first month of the competition season. This questionnaire will inquire after their actual use of The11. The results of the two questionnaires will provide information about the coaches' opinion of The11 and the expected and actual use (whether or not continued) of The11. To validate these results in both research groups, several practice sessions will be observed and scored (e.g. in terms of duration and type of exercises in the warm-up) during the second season to determine the actual use and the level of implementation of the The11 exercises in practice sessions.

Outcomes

The primary outcomes of the study include effectiveness and cost-effectiveness (see 'economic evaluation'). Injury characteristics were recorded during the 2009/2010 competitive season, from the first competition match (September 2009) till the last regular competition match of the season (May 2010) and compared between the intervention and control groups. The injury-prevention effect will be determined by monitoring the proportion of injured players in both research groups during one season (injury incidence), and injury severity will be derived from the necessity to have medical treatment and/or from absenteeism. Injury risks for players will be calculated and compared between both research groups.

Secondary outcome parameters are compliance and the quality of the implementation of the prevention programme during the intervention season and the subsequent season. Team compliance as well as player compliance will be calculated for the participating teams of the intervention group during the intervention season. In the follow-up season, the focus will be on quantitative aspects of the implementation of the prevention programme, measured by observations of practice sessions and completed questionnaires completed by participating coaches of both study populations. The questionnaires concern the actual use of the exercises of The11 and possible variations to the programme.

Sample size

On average, 45% of all soccer players in the Netherlands get injured at least once a year (ranging from minor to moderate and severe injuries). During the same period, approximately 70% of the soccer players (mainly males) between 18 and 40 years of age get injured. These conclusions were derived from the national survey on Injuries and Physical Activity in the Netherlands (IPAN), covering 6 years (2000-2005) of continuous recording of the nature and extent of sports injuries in the Netherlands.[169] We estimated that the programme The11 as used in our study would allow a 25% reduction of soccer injuries, in view of the results reported by Junge et al.[122] and Heidt et al.[101]. For a power of 0.80 and alpha of 0.05, an estimated 115 players in each group had to take part in the study during a whole soccer season. Assuming a drop-out risk of 26%, based on the study of Junge et al.[122], the research team aimed to include a minimum of 155 players in each research arm. Therefore, 12 teams were included in each arm.

Economic evaluation

The aim of the economic evaluation is to determine cost-effectiveness by relating net cost differences between the intervention and control groups to differences in injury incidence. The cost analysis of soccer injuries has to include health care costs and costs of production losses. All costs originating from the injury will be taken into account. Health care costs include the expenses of visits to medical specialists, additional visits to other health care providers (general practitioners and physiotherapists), prescription medication, resources to improve recovery, hospitalization, x-rays and other diagnostic procedures. The economic evaluation will assess the balance between costs and effects. Results of both cost and effect measurements will be integrated using cost-effectiveness analysis. All health care use will be valued according to Dutch guidelines for cost analysis in health care research.[154] If these guidelines do not apply, cost prices will be calculated using the bottom-up costing method. Costs of production losses are the result of work absenteeism for players with a paid job. Indirect costs of production losses due to soccer injuries will be estimated. These costs will be calculated using the friction cost approach.[125] Data regarding injury-related costs will be prospectively collected by means of volume questionnaires in BIS. The frequency of medical and paramedical treatment and work/school/soccer absenteeism, multiplied by unit costs, will yield an estimate of the costs at individual level. Severity, as derived from the necessity to have medical treatment and the duration of absenteeism, will be calculated. Subsequently, an estimate of the total costs and severity per research group will be obtained by adding up and averaging the individual records. Finally, intervention costs, that is, costs required to implement the intervention in practice sessions outside an evaluation study context, will be assessed as part of the cost analysis.

If this trial should provide evidence that integrating the The11 exercises in the warm-up results in better outcomes than regular practice sessions, an incremental cost-effectiveness analysis becomes will be warranted. The intervention will be dominant when both the proportion of injured players in the intervention group and net costs are lower than those for the control group. Bootstrapping will be used for pair-wise comparison of the mean differences in total costs between the intervention and control groups. Confidence intervals will be obtained by bias-corrected and accelerated (BCA) bootstrapping using 2000 replications. Incremental cost-effectiveness ratios will be calculated by dividing the difference between the mean net costs in the intervention group and the control group by the difference in the mean effects of the intervention and the regular soccer practice sessions. These ratios quantify the additional costs (if any) related to the additional health effects that are expected from the intervention. Uncertainty about the cost-effectiveness ratios will be presented using cost-effectiveness planes. Acceptability curves showing the probability that The11 is cost-effective will also be presented, given various thresholds for the investment in costs of the intervention programme (in a situation without cost savings).

Statistical methods

The intervention effect with a single-factor design will be calculated using both parametric (t-test) and non-parametric (Mann-Whitney or Chi-square test) analysis for the following effect parameters: injury profile (body part and type of injury: chronic/acute); injury incidence; injury incidence per 1,000 hours of sports and costs related to sports injuries. Cox regression will also be used to compare the two research groups. Descriptive statistics of self-reported use of the prevention programme during the RCT in the intervention group will be used to describe compliance. Data on the use of The11, as observed by independent observers and reported by the coaches, will be compared and data from the observations of practice sessions in the control group and intervention group will also be compared.

Continuation of the use of the intervention programme during the second season will be determined from observations and self-reports by the coaches. These data will be compared with the self-reported and observed use of the intervention programme during the trial season.

Discussion

Prevention of soccer injuries is expected to benefit the players and clubs involved, as well as Royal Dutch Football Association (KNVB), health insurance companies and society. This cluster RCT has been designed to evaluate the effects of a structured injury prevention programme in adult male amateur soccer. If positive, the findings will support extensive implementation of the intervention programme in training courses for soccer coaches by the KNVB Coach Academy. The strengths of our study include the large study population (2x12 participating teams) and the use of a web-based recording system (BIS), as direct, online input into BIS without intermediate steps will avoid data modification or data loss. The addition of a cost-effectiveness analysis to the effectiveness study will provide unique knowledge for the field of soccer injury prevention.

One limitation of the proposed trial is that none of the participants is blinded to group allocation, as the nature of the intervention precludes blinding of players, paramedics or coaches. To reduce potential confounding, the teams of the intervention and control group are clustered by district and these districts are geographically separated to prevent contamination. We hope to minimize potential bias in the control group by informing the control group as described above. Another study limitation is that we do not know the exact content of all practice sessions, since constant observation is not possible. We attempt to examine the content of the practice sessions in both research groups by regular, systematic, random and unannounced visits to monitor the practice sessions. In addition, the study is expected to yield data on the compliance of the intervention group with The11. Since previous research has shown that compliance with comparable injury prevention programmes tends to be low, this is also a special concern in the present study.[122,177] Although a study with "The11+", a revised version of The11, found that compliance was higher than with the original programme, we preferred to use the original The11.[175] The present study tries to improve compliance by monitoring the practice sessions, providing incentives (as described above in the 'compliance' section) and organizing meetings with coaches and paramedics of the participating teams.

4

Effectiveness of an injury prevention programme for adult male amateur soccer players: a cluster-randomized controlled trial

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Abstract

Background: The incidence rate of soccer injuries is among the highest in sports, particularly for adult male soccer players.

Purpose: To investigate the effect of the "The11" injury prevention programme on injury incidence and injury severity in adult male amateur soccer players.

Study design: Cluster-randomized controlled trial.

Methods: Teams from two high-level amateur soccer competitions were randomly assigned to an intervention (n=11 teams, 223 players) or control group (n=12 teams, 233 players). The intervention group was instructed to perform The11 in each practice session during one soccer season. The11 focuses on core stability, eccentric training of thigh muscles, proprioceptive training, dynamic stabilization, and plyometrics with straight leg alignment. All participants of the control group continued their practice sessions as usual.

Results: In total, 427 injuries were recorded, affecting 274 of 456 players (60.1%). Compliance with the intervention programme was good (team compliance 73%, player compliance 71%). Contrary to the hypothesis, injury incidences were almost equal between the two study groups: 9.6 per 1,000 sports hours (8.4–11.0) for the intervention group and 9.7 (8.5–11.1) for the control group. No significant differences were found in injury severity, but a significant difference was observed in the location of the injuries: players in the intervention group sustained significantly less knee injuries.

Conclusion: This study did not find significant differences in the overall injury incidence or injury severity between the intervention and control groups of adult male soccer players. More research is recommended, focusing on injury aetiology and risk factors in adult male amateur soccer players.

Introduction

Participating in sports on a regular basis is considered a vital component of an active and healthy lifestyle to reduce the risk of various diseases and to contribute to better social and physical performance. To some extent, however, sports injuries are inevitable. The incidence rate of outdoor soccer injuries is among the highest of all sports, particularly for adult male soccer players.[112,170] In the Netherlands, outdoor soccer causes the largest number of injuries each year (18% of all sports injuries), totalling approximately 620,000 injuries.[31]

Soccer is a high intensity sport characterized by continuous changes of direction and high-load unipodal actions. Participating in soccer imposes high demands on neuromuscular control, agility, and eccentric/concentric strength. Most soccer injuries are related to the lower extremities, in which muscle injuries are among the major problems.[51,52,61]

Significant reductions of lower extremity injury risk have been reported to be achieved by intervention programmes focusing on intrinsic risk factors.[1,60,116] Eccentric strength training reduced the risk of hamstring injury in heterogeneous populations of soccer players.[9,14,159] In addition, plyometric training and agility drills, the main components of a preventive programme developed by Heidt et al.[101], were found to be effective in lowering the incidence of injuries in soccer. It has also been shown that neuromuscular training can significantly reduce the risk of anterior cruciate ligament (ACL) injury in both male and female soccer players.[4,86] Finally, balance training proved to be effective in reducing non-contact ACL injuries in soccer players, especially in female athletes.[4]

An exercise programme called The11, developed with the support of the World Football Association FIFA, also focuses on injury prevention.[42] The effects of The11 on injury rates have been investigated previously. One study found that the programme reduced injury rates (21% fewer injuries) in male Swiss junior soccer players.[122] However, this injury prevention effect was not observed in female Norwegian junior soccer players.[177]

The preventive effect of The11 has not been studied in male adult soccer players, who represent the largest group of active participants in soccer worldwide with high injury incidence rates.[68,170] Therefore, our research on injury prevention focuses specifically on male adult soccer players. As proposed by Van Mechelen et al.[188] our study addressed steps three and four of the prevention sequence model: introducing preventive activities to reduce future risk and/or severity of sports injuries, and assessing their effectiveness. The aim of the present study was therefore to investigate the effectiveness of The11 in this high-risk population of adult male amateur soccer players. We hypothesized that these exercises, when integrated in the warm-up of each practice session, would have a preventive effect on injury incidence and/or injury severity compared to usual practice sessions without The11.

Methods

Trial design and randomization

In accordance with the principles of intention to treat, the effectiveness of the The11 injury prevention programme was evaluated in a two-armed cluster-randomized controlled trial (RCT). To minimize contamination, randomization took place at cluster level, namely that of regional competitions. The trial was approved by the medical ethics committee of the University Medical Centre Utrecht and was registered in the Dutch trial register (NTR2416). For more detailed information regarding the methods, the reader is referred to the study protocol published elsewhere.[185]

Participants

Teams from two geographically separated districts in Dutch high-level amateur soccer were invited to participate in the study. Male players from these teams, who were aged between 18 and 40 years, were eligible for inclusion. They generally had two or three practice sessions and one match each week. Players who left the team during the season were included in the study, taking the time they spent on the team into account. All players provided a written informed consent at the start of the trial.

Intervention

The The11 injury prevention programme has been developed with the support of the World Football Association FIFA. It includes ten exercises focusing on core stability, eccentric training of thigh muscles, proprioceptive training, dynamic stabilization, and plyometrics with straight leg alignment.[42] The 11th component, fair play advice, was not included in the present trial. The11 included the following exercises: the bench, sideways bench, hamstrings, cross-country skiing, chest passing in single-leg stance, forward bend in single-leg stance, figures-of-eight in single-leg stance, jumps over a line, zigzag shuffle, and bounding.

During the 2009/2010 soccer season (September–May), coaches of the teams in the intervention group were instructed to integrate The11 in the warm-up of each practice session (at least twice a week). Coaches were trained in applying The11 by the research staff at the end of the 2008/2009 season. In addition, coaches received a detailed information package (DVD, poster, and reader) presenting the basic elements of the injury prevention programme. Coaches and players in the intervention group familiarized themselves with the programme during the five weeks pre-ceding the start of the season (July–August), after which the programme was fully implemented in practice sessions at the start of the season. For players who are familiar with the exercises, the programme takes about 10-15 minutes. Coaches in the control group were invited to participate in a study of injury incidence and the characteristics of practice sessions. All participants in the control group continued their practice sessions as usual.

During the season, practice sessions of each team were visited by observers and members of the research staff each month. The purpose of these visits was to monitor the actual use of implementation of the The11 injury prevention programme in the intervention group. Random visits to the control group were scheduled to observe and record possible self-initiated preventive measures in their warm-up, specifically those of The11.

Data collection procedure

During the pre-season, all players were asked to fill out a questionnaire to record baseline characteristics. During the 2009/2010 season, individual information about each participant's exposure to soccer (numbers of practice sessions and matches) was reported weekly by the coaches, using a computer-based recording form. When a player was not present at a regular practice session or game, the reason for his absence was reported on the exposure form as 'injured' or 'other'.

The team paramedic or sports trainer, who was present at every practice session and soccer match of the team, was responsible for recording the soccer injuries in both study groups. Therefore, he/she used the Web-Based Injury System (BIS) developed by the Netherlands Organization for Applied Scientific Research (TNO Quality of Life).[178,185] BIS uses the basic guidelines of the consensus statement on injury definitions and data collection procedures in soccer.[78] The system captures epidemiological information on sports injuries (location, duration, and type), aetiology (intrinsic and extrinsic risk factors), consequences of injuries (e.g. work/school/sports absenteeism), and the volume and type of medical treatment, using so-called injury and recovery forms.

Outcomes

Player characteristics recorded were age, height, weight, years of experience as a soccer player, and soccer injuries sustained during the previous year (number and location).

The primary outcome of the study was the injury incidence per 1,000 hours of soccer participation (I). This was calculated according to the formula $I=(n/e)*1{,}000$, where n is the number of soccer injuries and e the total exposure time expressed as total hours of soccer participation. The Poisson model was used to obtain 95% confidence intervals (95% CI).

Exposure and all soccer injuries were recorded during the 2009/2010 competitive season, from the first competition match until the last regular competition match of the season. Table 4.1 shows the used definitions. These are in accordance with the consensus statement by Fuller et al.[78]. In addition, team and player compliance was recorded by all coaches in the intervention group using the exposure form.

Secondary outcomes were the absolute number of injuries, the proportion of injured players, as well as soccer injury characteristics (absenteeism, injury mechanism, recurrence, body part). Severity of injuries is reported as absenteeism in days.[78]

Table 4.1: Used definitions in data collection.[78]

Injury	Any physical complaint sustained by a player that results from a soccer match or soccer practice session, irrespective of the need for medical attention or time loss from soccer activities.
Recurrent injury	An injury of the same type and at the same site as a previous injury and which occurs after a player's return to full participation from the index injury.
Match exposure	Play between teams from different clubs.
Training exposure	Team based and individual physical activities under the control or guidance of the team's coaching or fitness staff that are aimed at maintaining or improving players' soccer skills or physical condition.

Sample size

Approximately 70% of all soccer players aged between 18 and 40 years (mainly males) get injured.[169] Based on the results reported by Junge et al.[122] and Heidt et al.[101] we estimated that the The11 programme would result in a 25% reduction of soccer injuries in our study. With a power of 0.80 and alpha of 0.05, this meant that 90 players in each group had to take part in the study during an entire soccer season. Given an estimated inflation factor for cluster randomization effects of 1.8[177], and assuming a drop-out rate of 26%[122], the research staff aimed to include a minimum of 219 players in each group at the start of the season. Assuming 19 players per team, twelve teams were included in each group.

Statistical methods

The statistical procedures were performed with SPSS 17 (SPSS Inc., Chicago, IL) and R (V2.13.2). Baseline characteristics, measured as continuous variables were expressed as mean and standard deviation (SD). Ordinal or categorical variables such as injury history were expressed as percentages. The following outcome parameters were analyzed: injury incidence, proportion of injured players, and injury profile. Because of their skewed distribution, exposure and absenteeism were presented as median and interquartile range. The categorical parameters representing injury profile were expressed as percentages.

The outcome parameters of the intervention and control groups were compared using a univariate t-test and Mann-Whitney U-test for the continuous parameters, and Chi-square (χ^2) analysis for categorical parameters. Significant differences between the two study groups at baseline were included as covariates (ANCOVA) to test the intervention effect.

To evaluate any effect of the programme during the season, survival curves (based on Cox regression) for both study groups were compared.[18] Additionally, Cox regression for recurrent events was used to compare the two groups, enabling both first time and recurrent injuries (adjusted for the time periods during each player had been on the team) to be used in the analysis.[184] Two-tailed p-values less than 0.05 were considered significant.

Results

The initial study population consisted of 24 soccer teams; one team declined to participate. The two clusters with 23 teams were randomized, resulting in 11 teams in the intervention group and 12 teams in the control group. Shortly after randomization, the coach of one team from the intervention group refused to use The11 during the practice sessions. Data of 456 players were analysed, 223 in the intervention group and 233 in the control group (Figure 4.1). During the intervention season, 29 players (6.4%) were lost to follow-up, mainly because they ended their soccer career or because they changed team or club. All their available data were included in the analysis of the effects of the intervention programme. No significant difference in dropout rate was found between the intervention group (n=11, 4.9%) and the control group (n=18, 7.7%). Baseline characteristics of the players in the two study groups were similar, except for height and weight (Table 4.2). Baseline data from dropouts and players with complete follow-up were not significantly different.

Exposure and injury characteristics

During the season, the players were involved in a total of 31,518 hours of practice time and 12,734 hours of match time, resulting in a total exposure time of 44,252 hours. The mean practice and match times per player were 69.1 and 27.9 hours, respectively, during the 33 weeks of the competition season.

In all, 427 injuries were recorded, affecting 274 of the 456 players (60.1%). The most commonly injured body parts (n=408) were ankle (19.1%), posterior upper leg (15.9%), knee (15.7%), anterior upper leg (10.5%), and groin (10.5%). The overall injury incidence for both groups was 9.6 (8.8–10.6) injuries per 1,000 player hours; 3.4 (2.8–4.1) in practice sessions and 21.9 (19.5–24.6) in matches.

Table 4.2: Baseline characteristics of the soccer players (n=456).

	Intervention group (mean ± SD)	**Control group (mean ± SD)**
Age (years)	24.4 ± 4.1	25.1 ± 4.3
Height (m) *	1.85 ± 0.1	1.82 ± 0.1
Weight (kg) *	79.1 ± 7.4	77.4 ± 7.4
BMI (kg/m^2)	23.2 ± 1.8	23.3 ± 1.8
Soccer experience (years)	17.2 ± 4.3	17.7 ± 4.6
Injury history (%)		
Injured in previous year	73.4 (n=214)	64.7 (n=221)
Injured at start of season	11.7 (n=223)	11.6 (n=233)

** Significantly different between the intervention and control groups.*

Compliance

Teams in the intervention group completed the intervention programme in 73% of all practice sessions (median 47, range 0-63), corresponding to performing The11 an average of 1.3 times per week. Players completed the exercises in 71% of the practice sessions they attended. Player absence meant that The11 was performed an average of 31 times per season (median 35, range 0-63). None of the teams in the control group regularly performed a structured prevention programme comparable to the intervention programme.

Effects of the intervention programme

As Table 4.3 shows, overall injury incidences were almost equal for both groups: 9.6 per 1,000 sports hours (8.4–11.0) for the intervention group and 9.7 (8.5–11.1) for the control group, as well as incidences of match and practice injuries. Nor were significant differences found in injury severity. None of the other outcomes showed significant differences between the two groups, apart from the percentage of knee injuries. However, after a Šidák correction for multiple testing (n=6) this result should be interpreted with care. In addition, when exposure is taken into account the difference in knee injuries was no longer significant. Results were corrected for baseline group differences in height and weight (Table 4.3).

Cox regression was used to further analyse the effects of the intervention programme. Survival curves for the injuries (without re-injuries) throughout the season showed no significant difference between the two groups (Figure 4.2). The analysis including all injuries that occurred during the season (i.e. both first-time and recurrent injuries) yielded the same result.

Figure 4.1: Flow diagram of the study population.

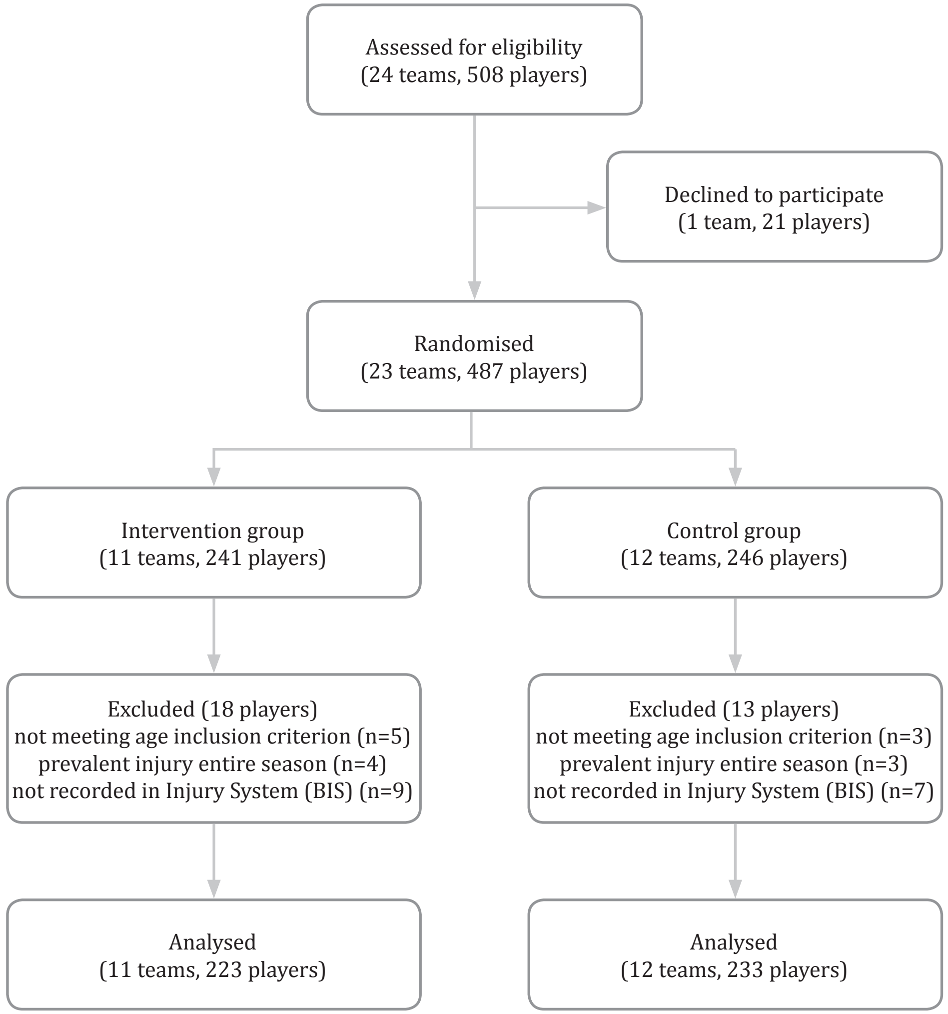
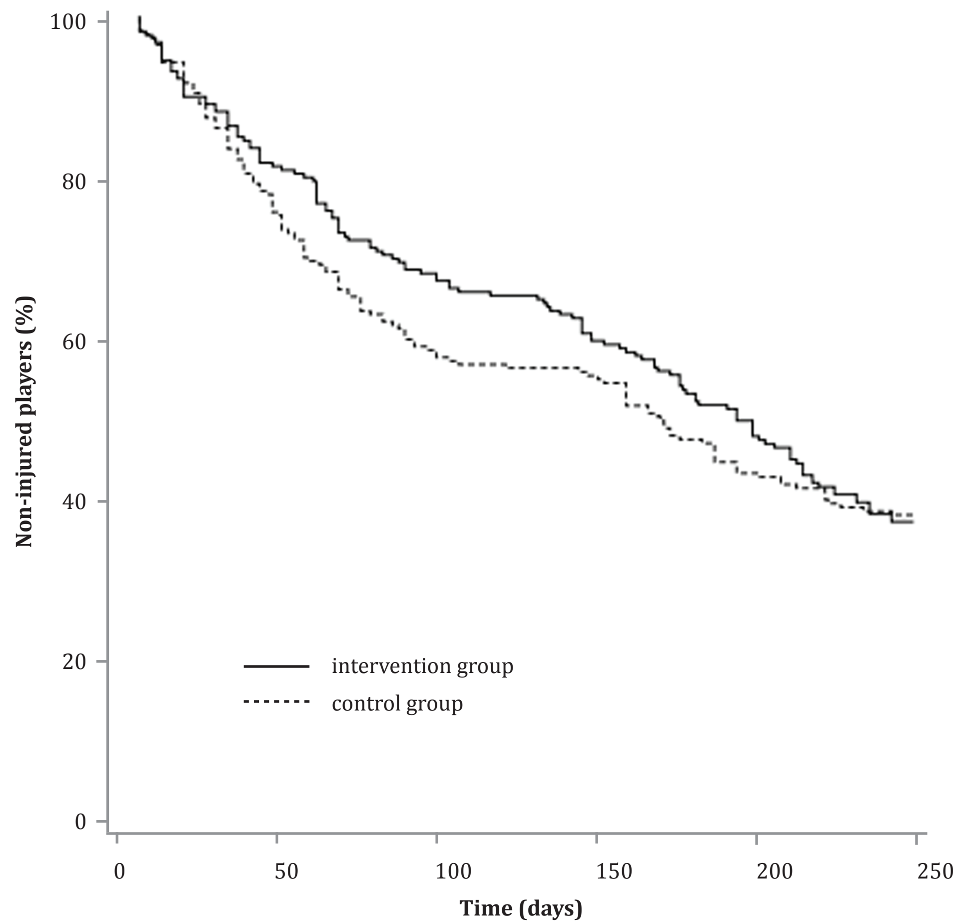


Table 4.3: Comparison of the intervention and control group.

	Intervention group	Control group
Injuries	207	220
Injured players (%)	60.5	59.7
Injury occurrence: match / training (%)	65.4 / 34.6 (n=191)	69.6 / 30.4 (n=194)
Hours of exposure (median, IQR)	103.4, 31.4	104.3, 35.0
Total injury incidence (95% CI)	9.6 (8.4–11.0)	9.7 (8.5-11.1)
Match injury incidence (95% CI)	21.1 (17.8–25.0)	22.7 (19.3–26.7)
Practice injury incidence (95% CI)	3.7 (2.8–4.8)	3.1 (2.3–4.0)
Days of sports absenteeism (median, IQR)	14, 28.5 (n=204)	17, 30 (n=211)
Injury severity (%):	(n=205)	(n=214)
slight (0 days)	0	0.5
minimal (1-3 days)	5.9	5.1
mild (4-7 days)	18.5	21.5
moderate (8-28 days)	46.3	41.6
severe (>28 days)	28.8	29.9
career ending	0.5	1.4
Injury mechanism: acute / overuse (%)	78.9 / 21.1 (n=199)	82.7 / 17.3 (n=197)
Recurrent injury (%)	13.0 (n=193)	14.1 (n=193)
Injury location (%): top 5	Ankle: 21.8 Upper leg (posterior): 18.4 Knee: 11.7 * Groin: 9.7 Upper leg (anterior): 8.3 Other: 30.1 (n=206)	Knee: 19.8 * Ankle: 16.3 Upper leg (posterior): 13.4 Upper leg (anterior): 12.9 Groin: 11.4 Other: 26.2 (n=202)

IQR=interquartile range, CI=confidence interval.
** Significantly different between the intervention and control groups.*

Figure 4.2: Survival curves based on Cox regression for first soccer injuries during the 2009/2010 season.



4

Discussion

Contrary to our hypothesis, we found no preventive effect of The11 on injury incidence or injury severity among male adult amateur soccer players during one season.

Whereas we found no preventive effect of The11 in our study population, consisting of adult males playing at a high amateur level, Junge et al.[122] found preventive effects of the programme among male youth soccer players. It is conceivable that an exercise programme have greater physical effects in younger players, since they have not yet established their basic movement patterns.[175] This may explain why an effect was found in junior soccer players, but not in senior soccer players playing at the highest amateur levels.

A gender effect has been suggested, as The11 includes five exercises with a major focus on balance and knee alignment.[20] These exercises aim to improve core stability and neuromuscular control,[25,86] and it is well known that female players have a 2-3 times higher ACL injury risk than male players, related to impaired knee alignment and lack of muscular balance.[193,201] Hence, a preventive effect may be more likely in female soccer players than in male soccer players.[101,138] The findings of the present study among a male soccer population supports this. It is thus important that prevention programmes such as The11 sufficiently address the specific injury risk factors relating to gender, age and playing level.

A study by Steffen et al.[177], which included female youth soccer players, reported no effects of The11. They suggested that low compliance with the programme explained the lack of effects and this was one of the most important reasons to introduce a modified programme: The11+. The11+ includes a greater diversity of exercises, changing both the type and the intensity during the soccer season. Subsequently, Soligard et al.[175,176] reported a preventive effect of The11+ among female youth soccer players. Amongst others, they reported a reduction in the incidence of knee injuries, which is to a certain extent in line with our results. The success of the new programme was partially explained by increased compliance to very acceptable levels (77%). However, it seems unlikely that low compliance was a key factor in the lack of an effect achieved with the original The11 programme in our study, as compliance was almost as good as that reported by Soligard et al.[175,176].

The positive effect found by Soligard et al.[175,176] could also suggest that the intensity of The11 may not have been sufficient to achieve adequate preventive effects in our study population. For example, exercise 3 of The11 is the so-called ‘Nordic Hamstring’ exercise. It has been shown in male soccer players, that a gradual increase in the number of repetitions over four weeks –from two sets of five to three sets of eight to twelve repetitions–increases eccentric hamstring muscle strength and decreases the rate of hamstring strain injuries.[9,147,159] This graded protocol comes close to the one implemented in The11+. In contrast, the Nordic Hamstring exercise protocol in The11 contains only a single set of five repetitions, which does not vary through the season. This might suggest that the intensity of at least some of the exercises in The11 were not sufficient to decrease the injury rate in our adult male amateur soccer players.

Having found no positive effect of the prevention programme among male adult amateur soccer players, we need to return to step 2 of the model by Van Mechelen et al.[188]. This means at least that a better understanding is needed of the etiological factors and injury mechanisms as risk factors for soccer injuries in male adult soccer players.

This study was the first randomized controlled trial documenting the effects of The11 on male adult soccer players. Ideally, randomization in trials should take place at the level of the subjects (players). Given the settings and methods in this trial, both practical and theoretical reasons made it impossible for such a randomization to be applied. Alternatively, randomization at the level of teams would have been the preferred route. However, it would not have been acceptable if some teams could possibly profit from the programme, while others in the same competition could not. As a result, randomization had to take place at district level, which led to a higher number of players being included in the trial.

In view of the expected large number of injuries in this study, verification of the injury diagnosis by an independent medical doctor was impossible to implement. However, the recording of injuries as well as the diagnosis was assumed to be very reliable. Using the definitions in the consensus statement on injury definitions and data collection in soccer, injuries were recorded primarily by local, well-trained paramedics.[78] Any injury that may have been missed was likely to be recorded in the weekly exposure form by the coaches. In case of any inconsistencies between the two recordings about the absence of a player due to injury, a member of the research staff contacted the coach and/or paramedic to verify the absence. Given these procedures, reporting bias and underreporting should have been minimal. If any underreporting exists, it will be restricted to minor injuries because more than 70% of the injuries reported resulted in absence of more than one week.

In conclusion, there are serious doubts that a general, multi-component training programme such as The11 is effective in this particular population of adult male amateur soccer players. The non-specific content of the programme, an ineffective intensity, and possibly also the limited number of two training sessions per week available to perform the programme may have caused the programme to become ineffective. Unfortunately, the programme was tested as a single intervention, making it impossible to determine which exercises failed to have an impact on the injury risk. New research should focus on the correct type and dose-response relationship of exercises, specifically addressing risk factors for injuries in adult male amateur soccer players. Such research should at least cover the most frequently reported injuries being ankle, knee, upper leg and groin injuries.

5

Preventive exercises reduced injury-related costs among adult male amateur soccer players: a cluster-randomized trial

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Abstract

Question: Is an injury prevention programme consisting of 10 exercises designed to improve stability, muscle strength, coordination and flexibility of the trunk, hip and leg muscles (known as "The11") cost effective in adult male amateur soccer players?

Design: Cost-effectiveness analysis of a cluster-randomized controlled trial.

Participants: 479 adult male amateur soccer players aged 18 to 40 years.

Intervention: The intervention group was instructed to perform The11 at each training session (2 to 3 sessions per week) during one soccer season. The exercises focus on core stability, eccentric training of thigh muscles, proprioceptive training, dynamic stabilisation and plyometrics with straight leg alignment. The control group continued their usual warm-up.

Outcome measures: All injuries and costs associated with these injuries were compared between groups after bootstrapping (5000 replications).

Results: No significant differences in the proportion of injured players and injury rate were found between the two groups. Mean overall costs in the intervention group were €161 (SD 447) per athlete and €256 (SD 555) per injured athlete. Mean overall costs in the control group were €361 (SD 1529) per athlete and €606 (SD 1944) per injured athlete. Statistically significant cost differences in favour of the intervention group were found per player (mean difference €201, 95% CI 15-426) and per injured player (mean difference €350, 95% CI 51-733).

Conclusions: The exercises failed to significantly reduce the number of injuries in male amateur soccer players within one season, but did significantly reduce injury-related costs. The cost savings might be the result of a preventive effect on knee injuries, which often have substantial costs due to lengthy rehabilitation and lost productivity.

Introduction

The beneficial health effect of a physically active lifestyle, e.g. engaging in sports, is offset by the accompanying high risk of sports injuries. Sports injuries impose a high economic burden on society, and with about 265 million active players worldwide in 2006, soccer makes a significant contribution to the sports injury problem.[68] The financial loss due to soccer injuries in the professional English soccer leagues during the 1999/2000 season was roughly estimated at €118 million.[204] In Switzerland, with 42,262 soccer injuries in 2003, the annual costs were estimated at €95 million augmented by the loss of more than 500,000 working days.[120] In the Netherlands, with a population of 16 million, there are 3.7 million sports injuries each year, with the greatest proportion (620,000 injuries) occurring in outdoor soccer.[31] The largest share (75-85%) of all soccer injuries consists of those affecting the lower extremities.[31]

To prevent soccer injuries, training programmes have been designed to improve strength, balance and muscle control of the lower extremities. One of these is a structured injury prevention programme called The11, developed by the FIFA Medical and Research Centre (F-MARC) to reduce both injury risk and injury severity in soccer. The programme consists of 10 exercises designed to improve stability, muscle strength, coordination and flexibility of the trunk, hip and leg muscles, and to promote fair play.[122]

The training programme reduced the amount of injured adolescent male amateur soccer players, but did not reduce the incidence of injury in adolescent female soccer players.[122,177] One reason why no preventive effect was detected in the latter study may be the low compliance among the intervention teams.[177] A recent study investigating the preventive effect of The11 among Italian male adult amateur soccer players found only minor effects on injury rates, but the lack of significant effects in this study may have resulted from the small sample size, generally low injury rates and lack of randomization and blinding procedures.[81]

In view of the results of these studies, a randomized study with a large sample size was needed to assess the effectiveness of The11 among adult male soccer players, in order to provide more evidence. Since adult male soccer players are the largest active soccer population in the Netherlands, and considering their high injury incidence rates,[170] implementation of a compact and structured training programme such as The11 could be highly beneficial in reducing the incidence and severity of injuries in this population. Fewer injured players and less severe injuries might also reduce both healthcare costs and the costs of productivity losses associated with injuries. Therefore, the research question for this study was: Is an injury prevention programme consisting of 10 exercises designed to improve stability, muscle strength, coordination and flexibility of the trunk, hip and leg muscles, cost effective in adult male amateur soccer players?

Methods

Design

A two-armed cluster-randomized controlled trial with concealed allocation and intention-to-treat analysis was used to evaluate the cost-effectiveness of The11. To avoid contamination, two regional competitions from different regions of the Netherlands were randomized to either the intervention group or the control group. A detailed description of the study design and randomization procedure is available elsewhere.[185,186]

Participants

Twenty-four soccer teams from two first-class competitions (the second-highest Dutch amateur level) were invited to participate in this study. Male players aged between 18 and 40 years, who were part of the first team at the start of the season, were eligible for inclusion. Participants who changed teams or were withdrawn from the team during the season were included in the analyses for the time they had been part of the team. Players with a pre-existing injury were included in the analysis for the time after full recovery. All participants provided written informed consent.

During the pre-season of August 2009, all players were asked to fill in a questionnaire regarding their age, height, weight, education, current work or student status, number of working hours per week and injury history. During the season, individual participants' exposure to training sessions or matches (in minutes) was reported weekly by the coaches. If a player was absent, the coach indicated whether they were injured or not.

Intervention

The intervention group was asked to perform the The11 injury prevention programme during the warm-up for each training session. The teams had 2 to 3 training sessions per week. The11 contains 10 exercises (presented in Table 5.1) and advice regarding fair play. The eleventh component, fair play advice, was not included in intervention for this trial. Coaches attended a practical demonstration session and received a detailed information package including a course reader, DVD and poster. To comfortably perform the ground exercises in all weather conditions, each team received 18 fitness exercise mats. Mid-season, an evaluation meeting was arranged for the coaches of the intervention group to ensure optimal implementation. The use of the intervention programme was recorded by the coaches. Additionally, adherence with the preventive exercises and the quality of their implementation were monitored by means of monthly random visits by observers and members of the research team.

The control group continued their regular warm-up exercises, which usually consists of running exercises, dynamic and static stretching and sprinting. The control group was not informed about the injury prevention programme implemented in the intervention group and received no further instructions. The control teams were also randomly visited to observe and record possible self-initiated preventive measures in their warm-up, specifically those included in the intervention program.

Outcome measures

All injuries occurring during the competition season were recorded weekly in a web-based injury registration system by the paramedical staff of the team. An injury was defined as a physical complaint sustained by a player that resulted from a soccer training session or soccer match, irrespective of the need for medical attention or time lost from soccer activities.[78,186]

Information about the date of injury, diagnosis, origin, recurrence and possible contributing factors was collected. After full recovery, defined as participation for the entire duration of a soccer training session or match,[186] an online recovery form was completed. This recovery form recorded the healthcare use, work or school absenteeism and purchase of secondary preventive devices (e.g. tape and inlays) for the entire injury episode.

5

Economic analysis framework

The economic analysis was performed from the societal perspective, which means that all significant costs associated with the injury were considered, regardless of who pays them.[95] Mean costs per participant and mean costs per injured participant were calculated. The economic evaluation was designed as a cost-effectiveness analysis to determine the costs of preventing an injury by means of the intervention programme, compared to the control group. The incremental cost-effectiveness ratio presents the incremental costs of using the intervention programme to prevent one injury, in comparison with regular warm-up. Incremental cost-effectiveness ratios were calculated by dividing the difference in mean total costs per participant between the intervention group and control group by the difference in numbers of injuries between the two groups, corrected for the difference in the number of participants between the groups.

Costs

The cost analysis was performed according to the Dutch guidelines for cost calculations in healthcare.[95] Table 5.2 presents the standard costs (year 2009) that were used in the economic evaluation. The analysis included the intervention costs, direct healthcare costs and indirect non-healthcare costs resulting from loss of production due to work or school absenteeism.

The costs associated with the implementation of the preventive exercises were included as intervention costs (Table 5.2). The accumulated intervention costs were €287 per team, corresponding to €14 per participant.

Table 5.1: Instructions and repetitions for the exercises of The11.

Exercise	Instructions	Repetitions/ duration
1. The bench	Head, shoulders, back and hips in a straight line, parallel to the ground. Elbows directly under the shoulders. Lift one leg a few centimetres off the ground.	Hold the position for 15 seconds. Repeat twice for each leg.
2. Sideways bench	Upper shoulder, hip and upper leg in a straight line parallel to the ground. Elbow directly under the shoulders. From above, shoulders, elbow, hips and both knees are in a straight line. Don't drop the hips.	Hold the position for 15 seconds. Repeat twice for each side.
3. Hamstrings	Ankles pinned firmly to the ground by a partner. Slowly lean forward keeping upper body and hips straight. Keep thighs, hips and upper body in a straight line. Try to hold this straight body alignment, using the hamstrings, for as long as possible, then control your fall.	Repeat 5 times.
4. Cross country skiing	Flex and extend the knee of the supporting leg and swing the arms in opposite directions in the same rhythm. On extension, never lock the knee, and don't let it buckle inwards. Keep pelvis and upper body stable and facing forwards. Keep pelvis horizontal and don't let it tilt to the side. Flex and extend each leg.	15 times on each leg.
5. Chest-passing in single-leg stance	Keep knees and hips slightly bent. Keep weight only on the ball of the foot, or lift heel from the ground. From the front, hip, knee and foot of the supporting leg should be in a straight line. Throw a ball back and forth with a partner.	10 times on each leg.
6. Forward bend in single-leg stance	As for Exercise 5, but before throwing it back, touch the ball to the ground without putting weight on it. Always keep knee slightly bent and don't let it buckle inwards.	10 throws on each leg.
7. Figures-of-eight in single-leg stance	As for Exercise 5 but before throwing it back, swing the ball in a figure-of-eight through and around both legs: first around the supporting leg with the upper body leaning forward, and then around the other leg standing as upright as possible. Always keep knee slightly bent and don't let it buckle inwards.	10 throws on each leg.
8. Jumps over a line	Jump with both feet, sideways over a line and back, as quickly as possible. Land softly on the balls of both feet with slightly bent knees. Don't let knees buckle inwards.	Repeat side-to-side 10 times and then forwards-backwards 10 times.

Table 5.1, continued: Instructions and repetitions for the exercises of The11.

Exercise	Instructions	Repetitions/ duration
9. Zigzag shuffle	Bend knees and hips so upper body leans substantially forward. One shoulder should always point in the direction of movement. Shuffle sideways through the Zigzag course as fast as possible. Always take off and land on the balls of the feet. Don't let knees buckle inwards.	Complete course twice.
10. Bounding	Bring the knee of the trailing leg up as high as possible and bend the opposite arm in front of the body when bounding. Land softly on the ball of the foot with a slightly bent knee. Don't let knee buckle inwards during take-off or landing.	Cover 30 metres twice.

Use of healthcare facilities as a result of injuries sustained was included as direct healthcare costs.[95] This included the costs of consulting a general practitioner, physiotherapist or medical specialist (e.g. orthopaedist, surgeon), hospital stay and injury-related costs of supplementary diagnostics (e.g. ultrasound, CT-scan), medical devices (e.g. crutches, braces), medication and secondary preventive devices (e.g. tape, braces, inlays, groin pants) as presented in Table 5.2.

Costs of productivity losses due to absence from work were included and valued using the friction cost method, according to Dutch standards for health economic evaluations.[95,125] At present, the Dutch friction period, that is, the time needed to replace a ill or injured employee, is 23 weeks on average.[95] All costs due to productivity losses were also corrected for an elasticity of 0.8, as the reduction in productivity is non-linearly related to the reduction in working time.[95] Based on the age range of 18 to 40 year and male gender, the mean cost price for one hour of work absenteeism was estimated at €26.41 (Table 5.2). The costs of school absenteeism were calculated using the net minimum youth wage for the age of 21 (the average age of students in our sample), which was €5.85 per hour.

Data analysis

An intention-to-treat procedure was adopted for the analysis of differences in effects and costs between the two groups. The differences in the proportion of injured players between the groups were analysed using Chi-square analysis, controlled for baseline differences between the groups. The difference in injury risk between the two groups, calculated as the number of injuries divided by the total number of players in each group, was analysed using the 95% confidence intervals based on the Poisson model.

Table 5.2: Standard costs (year 2009) used in the economic evaluation.

Costs	Amount (€)
Intervention costs	
Demonstration session	1.48
Evaluation session	1.12
Information package	2.57
Exercise mats	8.97
Total costs per player	14.14
Direct healthcare costs	
General practitioner (per visit) [a]	28.00
Physiotherapist (per visit) [a]	36.00
Manual therapist (per visit) [a]	36.00
Sports physician (per visit) [b]	73.00
Medical specialist (per visit) [a]	129.00
Accidents and Emergency (per visit) [a]	151.00
Supplementary diagnostics [a]	
Ultrasound	48.30
Radiograph	42.70
MRI-scan (upper/lower extremity) [d]	184.50
CT-scan	150.50
Laboratory research (blood tests) [d]	Individualized
Hospital stay per day [a]	251.00
Surgery [c]	Individualized
Medical devices (i.e. tape, salve, massage-oil) [e]	Individualized
Medication [f]	Individualized
Prevention devices [e]	Individualized
Indirect non-healthcare costs [g]	
Absenteeism from paid work (per hour)	26.41
Absenteeism from school (per hour)	5.85

[a] *Cost prices according to Dutch guidelines for healthcare costs.*[95]
[b] *Cost price according to rates of University Medical Centre Utrecht.*
[c] *Cost price according to the Dutch Healthcare Authority.*
[d] *Cost prices were individually evaluated from the nature of the laboratory examination/surgery according to the Dutch Healthcare Authority.*
[e] *Cost prices were individually determined from the type of medical device (i.e. crutches, braces, tape, massage oil) and preventive devices (i.e. tape, groin pants, inlays).*
[f] *Drug prices according to the Royal Dutch Society of Pharmacy.*
[g] *Indirect costs for paid work were calculated from mean age and sex-specific income of the Dutch population.*[95]

Data collected from the recovery form were used to derive the costs of injuries. Due to the skewed distribution of the cost data, confidence intervals around the cost differences were calculated using non-parametric bootstrapping with 5,000 replications.[46] Cost-effectiveness pairs were also obtained by bootstrapping with 5,000 replications. Cost-effectiveness planes were obtained by plotting the incremental costs (horizontal axis) against the incremental effects (vertical axis) of each single bootstrap.[24] A sensitivity analysis was performed for all injury data, including injuries for which the healthcare utilization data was not available (i.e. completely missing recovery forms). Costs relating to missing injury data were imputed using the mean costs per injury in each group. Multiple imputation was not possible because the missing-at-random assumption was violated.[136] All tests were two-tailed and p<0.05 was considered significant.

Results

Flow of participants through the study
Before the randomization procedure, one soccer team decided not to participate in the study. Randomization allocated 11 teams (236 eligible players) to the intervention group and 12 teams (243 eligible players) to the control group, as presented in Figure 5.1. After the intervention period of one competition season, 13 participants in the intervention group and 10 players in the control group were unable to be included in the analyses. This included 3 participants in each group with a pre-existing injury that did not resolve during the whole season. No players changed between teams during the season. There were 29 players that withdrew from a team and these were analysed for their period of participation. The baseline characteristics of each group are presented in Table 5.3.

Figure 5.1: Design and flow of participants through the trial.

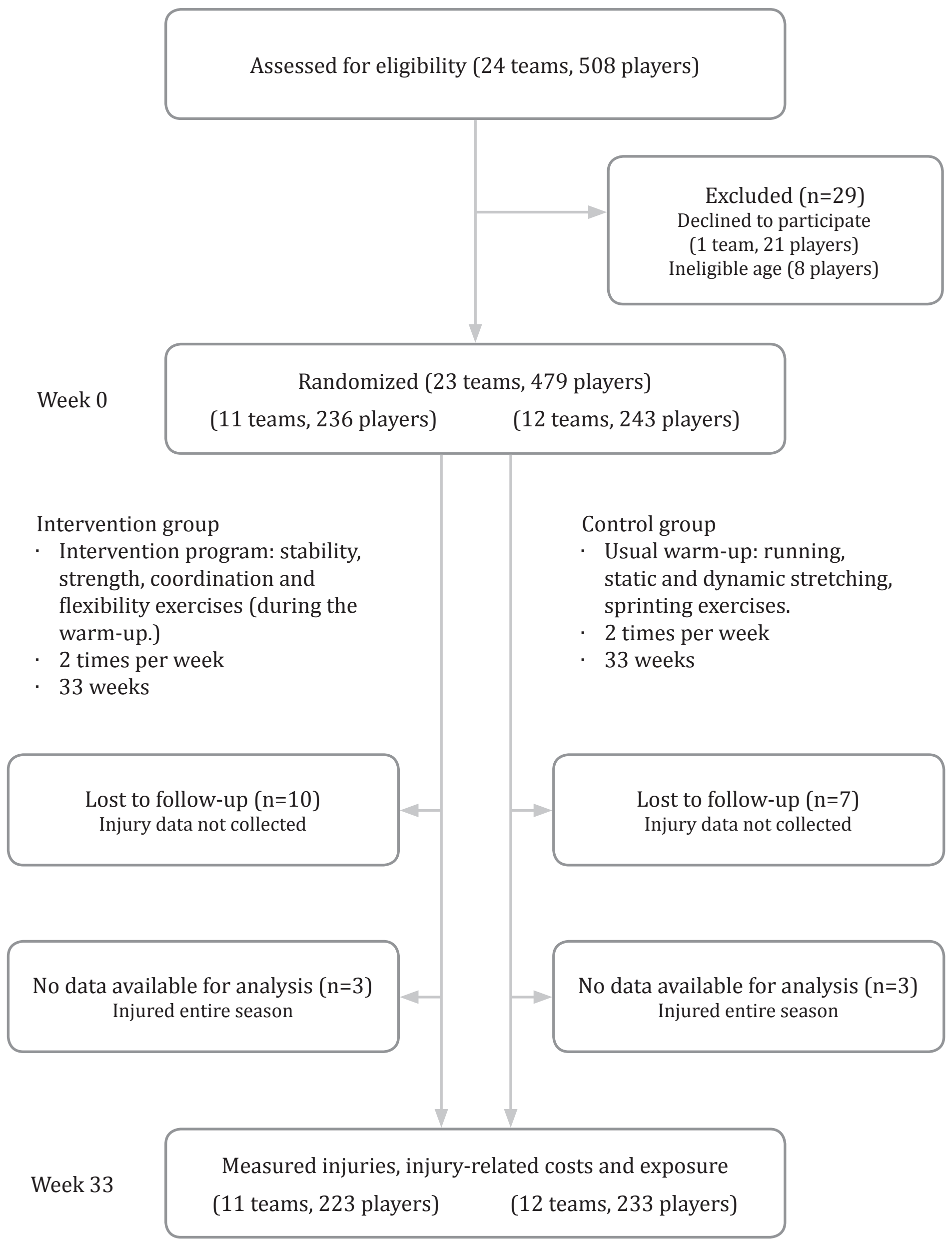


Table 5.3: Baseline characteristics of the participants.

	Intervention group	Control group
Age (yr), mean ± SD	24.4 ± 4.1	25.1 ± 4.3
Height (m), mean ± SD [a]	1.85 ± 0.1	1.82 ± 0.1
Weight (kg), mean ± SD [a]	79.1 ± 7.4	77.4 ± 7.4
BMI (kg/m2), mean ± SD	23.2 ± 1.8	23.3 ± 1.8
Players with paid work, n (%) [b]	121 (56)	147 (68)
Paid work per week (hr), mean ± SD [c]	36.6 ± 8.0	38.5 ± 7.5
Students, n (%) [b]	89 (41)	68 (32)
Unemployed n (%) [b]	6 (3)	1 (1)
Soccer experience (yr)	17.2 ± 4.3	17.7 ± 4.6
Injury history		
Injured previous year, n (%) [d]	157 (73)	143 (65)
Injured at start of season, n (%)	26 (12)	27 (12)

[a] *Statistically significant difference.*
[b] *Data were unavailable for 7 participants of the intervention group and 17 participants of the control group.*
[c] *Data were unavailable for 5 participants of the intervention group and 1 participant of the control group.*
[d] *Data were unavailable for 9 participants of the intervention group and 12 participants of the control group.*

Compliance with the trial method

Complete recovery forms were returned for 178 injuries (86%) in the intervention group and for 168 injuries (76%) in the control group. Recovery forms were incomplete for 10 injuries in the intervention group and 15 in the control group. Recovery forms were not completed at all for 19 injuries in the intervention group and 37 in the control group.

Forms with incomplete recovery data only lacked the number of contacts with a physiotherapist and/or manual therapist. The injuries with incomplete recovery forms did not differ significantly from those with complete recovery forms in terms of recovery duration and diagnosis. These injuries were therefore regarded as missing at random. For both groups, missing numbers of therapeutic consultations were imputed using the mean number of consultations derived from the complete recovery forms. Because of the small fraction of missing data, mean imputation was considered an appropriate method for handling missing data.[75]

The injuries with completely missing recovery forms had a significantly longer mean period of sports absence than those with complete forms and could therefore not be regarded as missing at random. The completely missing recovery forms were therefore not imputed for the main analysis, but were included in the sensitivity analysis (see data analysis).

Effect of intervention

The proportion of injured players and the injury rate did not differ significantly between the intervention and control groups (Table 5.4). For a full overview of other effect outcomes, we refer to a previously published paper.[186]

Table 5.4: Injury outcomes for both groups.

Injuries, n	207	220
Injured players, n (%)	135 (60)	139 (60)
Injury rate (95% CI)	0.93 (0.81 to 1.06)	0.94 (-0.83 to 1.08)

Cost effectiveness

The mean total costs were €161 (SD 447) per player in the intervention group and €361 (SD 1,529) per player in the control group (Table 5.5). This difference was statistically significant, being €201 (95% CI 15 to 426) less expensive per player in the intervention group. Overall direct healthcare costs were not significantly different between the intervention and control groups, at €44 (95% CI -17 to 111) lower in the intervention group. The indirect non-healthcare costs per player were significantly lower in the intervention group, with a mean difference €172 (95% CI 28 to 352).

Table 5.5: Mean (SD) of costs per player in euro during one soccer competition season and mean difference (95% CI) [a] between the two groups.

Costs per player	**Intervention group (n=223)**	**Control group (n=233)**	**Difference (intervention group – control group)**
Intervention costs	14	0	14
Direct healthcare costs	114 (225)	157 (438)	-44 (-111 to 17)
Indirect non-healthcare costs	32 (304)	204 (1,238)	-172 [b] (-352 to -28)
Overall costs	161 (447)	361 (1,529)	-201 [b] (-426 to -15)

[a] *Obtained by calculating bootstrap confidence intervals.*
[b] *Statistically significant difference.*

The mean overall costs per injured player were €256 (SD €555) in the intervention group and €606 (SD 1,944) in the control group (Table 5.6). This difference was statistically significant, being €350 (95% CI 51 to 733) less expensive per injured player in the experimental group. Direct healthcare costs per injured player did not differ significantly between the groups, at €76 (95% CI -18 to 285) lower in the intervention group. The indirect non-healthcare costs per injured player were significantly lower in the intervention group, with a mean difference of €288 (95% CI 49 to 589).

Table 5.6: Mean (SD) of costs per injured player in euro during one soccer competition season and mean difference (95% CI) [a] between the two groups.

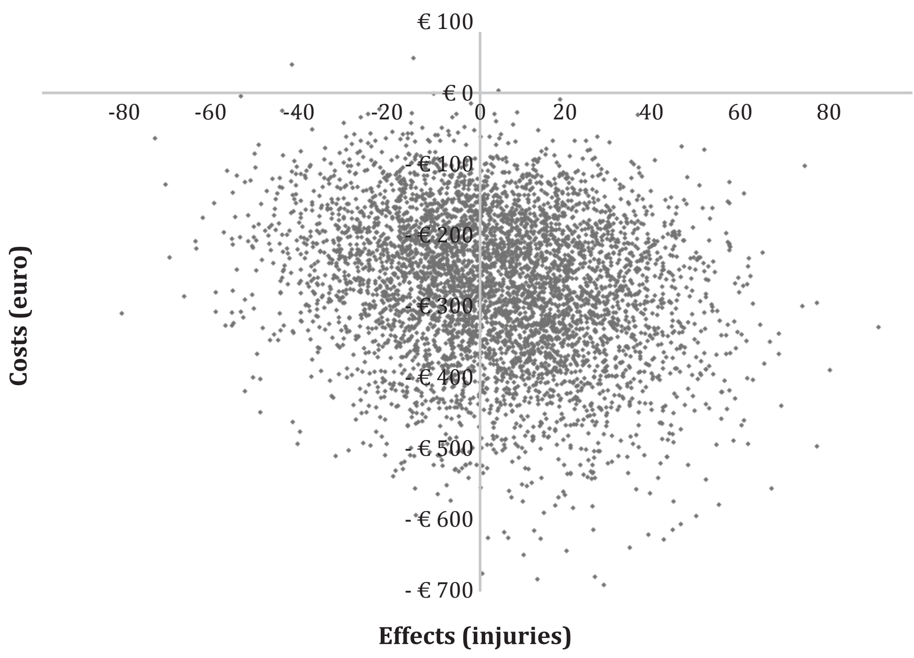
Costs per injured player	**Intervention group (n=135)**	**Control group (n=139)**	**Difference (intervention group – control group)**
Intervention costs	14	0	14
Direct healthcare costs	188 (247)	264 (542)	-76 (-285 to 18)
Indirect non-healthcare costs	53 (39)	342 (135)	-288 [b] (-589 to -49)
Overall costs	256 (555)	606 (1,944)	-350 [b] (-733 to -51)

[a] *Obtained by calculating bootstrap confidence intervals.*
[b] *Statistically significant difference.*

After bootstrapping, there was a difference in mean costs of €201 (95% CI 15 to 426) per player and a mean non-significant difference of 3.5 injuries per group (95% CI -40.3 to 46.8) in favour of the intervention group. From a cost perspective, the intervention programme was considered dominant compared to the regular warm-up. The cost-effectiveness plane with all incremental cost-effectiveness ratios (5000 samples) is presented in Figure 5.2. The bootstrap analyses showed that the intervention programme is cost-saving and more effective in 55% of the bootstrap replicates (SE quadrant) and cost-saving and less effective in 43% (SW quadrant).

After imputation of the mean costs per injury for the missing injury data, the cost difference of €272 (95% CI 94 to 501) per player in favour of the intervention group was statistically significant. This further supports the dominance of the intervention programme over the regular warm-up. In this sensitivity analysis, the intervention programme is cost-saving and more effective in 55% of the bootstrap replicates (SE quadrant) and cost-saving and less effective in 45% (SW quadrant).

Figure 5.2: Cost-effectiveness plane presenting costs and effect pairs after bootstrapping (5000 samples).



Discussion

This study showed that the injury prevention programme The11 (without fair play advice) reduced the costs associated with soccer injuries among Dutch adult male amateur soccer players, although it failed to significantly reduce the number of injuries in this group.[186] The intervention led to a significant reduction in mean overall costs, by €201 per player and €349 per injured player, compared to the control group.

Previous injury prevention studies using The11 in soccer populations differing in terms of age, gender or playing level have reported contradictory results.[81,122,177] Apart from compliance issues,[177] which seem to have been no major limitation in the present study,[186] discrepancy in the findings could be explained by differences in population characteristics. Gender,[67,89,156] age[29,94,161] and playing level[29,161] can account for differences in injury incidence, injury patterns and injury risk factors. It is plausible that The11 has a different impact in different soccer populations, since it is a multifaceted programme and addresses many injury risk factors. Another explanation could be that the The11 exercises lack sufficient intensity to achieve satisfactory preventive effects in male adult soccer players. For instance, it is debatable whether the 'Hamstrings' exercise in The11 provides a sufficient training load. Although a preventive effect of this eccentric hamstring exercise was found in amateur and professional soccer players, these studies involved significantly higher training loads than those used in The11.[9,159]

Because the non-significant injury reduction was accompanied by a significant cost saving, The11 can be considered superior to regular warm-up. After one season, soccer players in our intervention group had significantly lower total costs, primarily because of significantly lower non-healthcare costs per player. No significant between-group differences were found in the proportion of injured players and the injury rate, the cost saving effect in the intervention group could perhaps be explained by the variety in injury severity or type of injury. The former explanation seems unlikely, as no significant differences in injury severity, in terms of days of absence,[78] were found between the groups.[186] Another option is that the difference in costs might be explained by differences in injury location between the two groups. A significantly lower proportion of knee injuries was found in the intervention group compared to the control group,[186] the knee being the most frequent injury location in the control group. Knee injuries are often associated with lengthy and costly rehabilitation, resulting in high expenditure for medical care and substantial costs due to productivity losses.[34,38,82] The findings of the present study suggest that the intervention programme reduces the costliness of the injuries, which could be explained by the preventive effect on knee injuries'. From an economic perspective, country-wide implementation of The11 in soccer could be valuable. This is supported by the findings of Junge et al.[120], who found a reduction in the population-based insurance claims and healthcare costs among Swiss amateur players, after countrywide implementation of The11. In contrast to our findings, they found a preventive effect on injury incidence and injury severity (time loss), particularly for non-contact injuries.[120] It should be noted that their study aimed to evaluate the country-wide implementation of The11, so their design was less rigorous than the design chosen for the present study. The11 was implemented among male and female soccer players of different ages, with different injury patterns. The small sample sizes in their study meant that the Swiss authors were unable to draw conclusions about the effect of The11 on specific injuries or differences between different soccer populations. It remains unknown whether there were similar effects of The11 among senior soccer players compared to the other groups of soccer players.

Our study had some limitations, particularly in relation to our cost recording method. Healthcare use and productivity losses associated with injury were reported on the recovery form, which was completed after the player's full recovery. This may have led to some recall bias for injuries with a long and costly rehabilitation period. To minimize recall bias, the paramedical staff was advised to regularly ask players about their healthcare use and productivity loss, especially players with prolonged sports absenteeism.

Another limitation was missing cost data because of incomplete recovery forms (missing therapeutic consultations) and some completely missing recovery forms. The few missing therapeutic consultations (6% of the injuries) may be regarded as missing at random, as no differences were found with the complete recovery data. However, the problem of incomplete recovery forms could have been avoided if the injury registration system had also required the users to fill in the number of therapeutic consultations if more than one care provider had been consulted. We assume that imputation of these incomplete recovery data resulted in a more precise cost estimation of injuries in both groups, and did not affect the outcomes. As regards the completely missing recovery forms (13% of the injuries), missing injury costs were imputed using the average injury costs in each group. However, this strategy can severely distort the distribution of costs, causing the variation in these costs to be underestimated.[39] The outcomes of the sensitivity analysis should therefore be interpreted with some caution.

The study was performed from a societal perspective, but we did not include direct non-healthcare costs in this economic evaluation.[95] Direct non-healthcare costs consist of traveling expenses, cost for patient time or family members time and other costs. Incorporating these costs will increase the average costs per injury, but we do not expect (substantial) differences in these direct non-healthcare costs between both groups.

Our cost-effectiveness analysis, accompanying a cluster-randomized controlled trial, showed that although The11 failed to significantly reduce the injury incidence in male amateur soccer players, it did result in cost-savings compared to the non-intervention group. The cost-savings might be the result of a preventive effect on knee injuries in the intervention group. Future research should primarily focus on the preventive effect of specific exercises from The11 in relation to knee injuries, and the possible cost-savings. Despite the lack of a proven preventive effect, the potential of a structured prevention programme to reduce costs associated with injuries is of particular interest in view of the increasing healthcare costs worldwide.

6

Soccer injuries and recovery in Dutch male amateur soccer players: results of a prospective cohort study

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In revision

Abstract

Objective: To describe characteristics of outdoor soccer injury and recovery among Dutch soccer players.

Design: Prospective cohort study.

Setting & participants: During the 2009/2010 competitive season (33 weeks), 456 Dutch male soccer players of 23 amateur teams were prospectively followed.

Outcome measures: Coaches recorded individual exposure to all soccer activities. Paramedics or sports trainers collected information on the occurrence (e.g. location, type, circumstances) and consequences (e.g. absenteeism, medical treatment) of injuries.

Results & conclusions: In total 424 time-loss injuries were sustained by 60% (n=274) of the players, with 24% (n=108) having more than one injury. This corresponds to an overall incidence of 9.6 (8.7-10.5) injuries per 1,000 player hours; 3.9 (3.3-4.7) in training sessions and 20.4 (18.1-23.1) in soccer matches. Almost 30% (n=123) of the injuries lasted for more than one month, 14% (n=58) were re-injuries (causing longer absence than new injuries), and 54% (n=230) of the injuries were given medical treatment. The most common diagnoses were muscle/tendon (38%) or joint/ligament injuries (23%) of the lower extremities. After regaining the ability to fully take part in soccer training or matches, 27.4% of the players (n=116) still reported complaints. Therefore, players resuming soccer activities after an injury should be given special attention, to resolve the remaining complaints and to prevent re-injuries.

Introduction

Soccer is one of the most popular sports worldwide and the incidence rate of outdoor soccer injuries is among the highest of all sports, particularly for adult male soccer players.[112,119,170] Overall injury incidences reported for adult male amateur soccer players range from 4.3 to 29.6 injuries/1,000 soccer hours,[81,92,126] while specific injury risks for training and matches range from 2.0 to 11.2 and from 11.4 to 44.6, respectively.[2,81,116]

In 2011, there were more than 1.2 million licensed members of the Royal Netherlands Football Association (KNVB), 45% of whom were adult male soccer players (www.knvb.nl). Outdoor soccer, played by approximately 2,660 clubs in the Netherlands, causes the largest number of injuries each year (18% of all sports injuries), totalling approximately 620,000.[186]

One useful model in developing effective prevention strategies is the "sequence of prevention" model by Van Mechelen et al.[188]. Its first phase involves identifying the magnitude of the sports injury problem and describing in terms of incidence and severity. Secondly, the factors and mechanisms contributing to the occurrence of the sports injuries have to be identified.[188] In 2006, Fuller and colleagues published a consensus statement on injury definitions and data collection procedures in studies of soccer injuries.[78] To our knowledge, only a few previous studies on adult male amateur soccer players followed this standard.[16,62,81,92,126] Most studies on injury epidemiology were conducted with professional or youth players. There has been only one, outdated, study on injury risk in Dutch soccer, in which Inklaar et al.[114] followed 477 male (senior and junior) amateur soccer players during the second half of the 1986/1987 competition. The vast majority of the available epidemiological studies limit their information to the injury characteristics and circumstances at the moment the injury occurs and detailed information about injury recovery is lacking. In view of the negative consequences of injuries, like suffering of the injured players and their team, medical costs, sports and/or work absenteeism, and financial loss due to these injuries, it is important to collect and present data about injuries and the corresponding recovery period. The present prospective study aimed to provide insight into injury characteristics as well as the recovery period of the injuries, by examining outdoor soccer injuries sustained by Dutch adult male amateur soccer players during one competitive season.

Methods

The data for this prospective cohort study were obtained from a cluster-randomized controlled trial (RCT) comparing the injury incidences between an intervention group that used a special training programme (called "The11") during warm-up and a control group training as usual. The study protocol was approved by the Medical Ethics Committee of the University Medical Center Utrecht. The trial design, the intervention program, and the results of the trial have been described in detail elsewhere.[185,186] Teams from two geographically separated districts in the second highest Dutch amateur soccer league were invited to participate. Data on injuries and exposure were collected during the entire 2009/2010 competitive season, from the first competition match in September until the last regular competition match of the season in May (33 weeks).

Male soccer players, aged between 18 and 40 years, were eligible for inclusion. They generally had two or three practice sessions and one match each week. Players who were injured at the start of the season were included in the study, but that injury was not incorporated into the results. Also players who left the team during the season were included, based on the time they spent on the team. All players provided written informed consent at the start of the study.

During the pre-season period (August 2009), all players were asked to complete a questionnaire to record baseline characteristics. Data recorded were age, self-reported height and weight, player position, years of experience as a soccer player, and soccer injuries sustained during the previous year (number and location). All coaches reported individual player exposure to practice sessions and matches (in minutes) on a weekly basis, using a Microsoft Excel recording form. When a player was not present at a regular practice session or game, the reason for his absence was reported on the exposure form as "injured" or "other". Training exposure was defined as team-based and individual physical activities under the guidance of the team's staff. Match exposure was defined as play between teams from different clubs.[78] The team paramedic or sports trainer, who was present at every training session and match of his/her team, was responsible for recording all the injuries occurring during organized soccer activities, using the Web-Based Injury System (BIS) developed by the Netherlands Organization for Applied Scientific Research (TNO). BIS includes all categories needed to enter data according to the basic guidelines of the consensus statement on injury definitions and data collection procedures in soccer.[78] When a player sustained an injury he was asked to complete a questionnaire about the injury incurred. This so-called injury form comprised questions to collect epidemiological information on injuries (e.g. location, duration, severity, and type) and mechanisms (circumstances of the injury: contributing factors like contact, jumping, and weather conditions). Following the recovery period, a so-called recovery form had to be completed when the player was once again able to fully take part in soccer training or matches. This form was used to record information concerning the final diagnosis (in some cases after additional diagnostics); consequences of injuries, like work/school/sports absenteeism; and the amount and type of medical treatment (e.g. physical therapy, surgery). Injuries were recorded using the following time-loss definition, in accordance with the consensus statement: "any physical complaint sustained by a player resulting from a soccer match or soccer practice session, and leading to the player being unable to fully take part in a soccer activity on the day after the injury".[78] A recurrent injury was defined as: "an injury of the same type and at the same site as an index injury and which occurs after a player's return to full participation from the index injury" and a medical attention injury as: "an injury that results in a player receiving medical attention, i.e. an assessment of a player's medical condition by a qualified medical practitioner". Injuries were classified according to their severity, based on the number of days of absence from soccer: minimal (1-3 days); mild (4-7 days); moderate (8-28 days); severe (>28 days); or career ending.[78]

The statistical procedures were performed with SPSS 20 (SPSS Inc., Chicago, USA). Baseline characteristics measured as continuous variables were expressed as mean and standard deviation (SD). Ordinal or categorical variables, such as injury severity and injury history, were expressed as absolute numbers and percentages. The baseline data from dropouts and players with complete follow-up were compared using a univariate t-test for the continuous parameters, and χ^2 analysis for categorical parameters. Injury incidence per 1,000 hours of soccer participation (I) was calculated as $I=(n/e)*1{,}000$, where n is the number of soccer injuries and e the total exposure time expressed as total hours of soccer participation. The Poisson model was used to obtain 95% confidence intervals (95% CI). The following injury variables were analyzed: incidence, characteristics, circumstances, and consequences. Because of the skewed distribution, injury absenteeism is presented as median and interquartile range (IQR). The categorical parameters representing injury characteristics and injury circumstances are expressed as percentages. Since no effects of the intervention programme were found compared to the control group,[186] the analyses did not factor in group assignment, meaning that the intervention was not a covariate for injuries.

Results

The final sample consisted of 456 players from 23 teams. Baseline mean characteristics were: age 24.8±4.2 years; height 1.83±0.06 m; weight 78.2±7.5 kg; BMI 23.3±1.8 kg/m^2; soccer experience 17.5±4.5 years. Almost 70 percent of the players (n=300, 69.0%) reported a soccer injury in the year prior to the start of this study, and 52 players (11.4%) were injured at the start of the season. During the season, 29 players (6.4%) dropped out, mostly because they ended their soccer career or changed their team or club. Baseline characteristics did not differ significantly between dropouts and players with complete follow-up.

The total practice time during the season was 31,518 hours, and the total time spent in matches was 12,734 hours, resulting in a total exposure time of 44,252 hours. During the 33 weeks of the competition season, the mean numbers of hours of practice and match playing per player were 69.1±21.0 and 27.9±10.7, respectively.

A total of 424 time-loss injuries were recorded, affecting 274 of the 456 players (60.1%). This resulted in an overall injury incidence of 9.6 (8.7-10.5) injuries per 1,000 player hours; 3.9 (3.3-4.7) during training sessions and 20.4 (18.1-23.1) during matches. A team sustained an average of 0.7 injuries per match. More details regarding injury incidences are presented in Table 6.1.

Table 6.1: Injury and exposure characteristics of 456 amateur soccer players.

	Injuries (n)	**Exposure (hrs)**
Overall	424	44,252
During match *	260	12,734
During training *	123	31,518
	Injury incidence (/1,000 hrs)	**Exposure (hrs)**
Overall injuries	9.6	8.7 – 10.5
Match injuries	20.4	18.1 – 23.1
Training injuries	3.9	3.3 – 4.7
Medical-attention injuries	5.2	4.6 – 5.9
Recurrent injuries	1.3	1.0 – 1.7

** Time of occurrence for 41 injuries was not recorded.*

Of the injured players, 166 (36.4%) sustained one injury, and 108 (23.7%) sustained more than one injury: 77 players (16.9%) were injured twice, 23 players (5.0%) 3 times, 3 players 4 times, 4 players 5 times, and 1 player 6 times during the season. Fourteen percent (n=58) of the injuries were classified as recurrent injury, mostly affecting the posterior upper leg (n=14) and ankle (n=11). Fifty-three percent (n=31) of these injuries occurred within two months of a player's return to full participation ("early recurrence").

Most of the injuries were acute (n=318; 75.0%) and happened during a match (n=260; 61.3%). Possible contributing factors leading to an injury are listed in Table 6.2. The most commonly mentioned factors were: contact with other player (n=159; 40.2%), distortion (n=60; 15.2%), and turning/twisting (n=53; 13.4%). Injuries were most frequently located in the lower extremities (n=362; 85.4%). The most commonly injured body parts (n=406) were the ankle (n=77; 18.2%), posterior upper leg (n=65; 15.3%), knee (n=64; 15.1%), groin (n=43; 10.1%), and anterior upper leg (n=42; 9.9%). Affected body parts with corresponding injury types are listed in Table 6.3; locations and types are cross-tabulated in Table 6.4. The most common diagnoses were lower limb muscle/tendon injuries (n=154; 37.9%) and lower limb joint/ligament injuries (n=95; 23.4%), especially ankle sprains and posterior thigh strains.

Table 6.2: Circumstance(s) leading to a soccer injury.*

Contributing factor	**Number (%)** **396 (100) ****
Contact with other player	159 (40.2)
Distortion	60 (15.2)
Turning/twisting	53 (13.4)
Contact with ball	44 (11.1)
Fatigue	44 (11.1)
Jumping	43 (10.9)
Playing field conditions	42 (10.6)
Other (including warm-up, cool-down, inappropriate shoes)	42 (10.6)
Artificial turf	40 (10.1)
Sprinting	40 (10.1)
Reaching (for ball)	39 (9.8)
Shooting	30 (7.6)
Fall	27 (6.8)
Weather conditions	21 (5.3)

** More than one answer allowed.*
*** Possible contributing factors for 28 injuries were not recorded.*

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Injury time loss ranged from 2 to 407 days, with a median of 16 days and a interquartile range of 30. Recurrent injuries caused longer average absence (median=24 days, IQR= 35) than first-time injuries (median=16, IQR=30). Knee injuries had the most serious consequences in terms of days of absence from soccer play: the rehabilitation of a knee injury took an average of 53 days (median=25, IQR=51.5). Almost 30% of the injuries (n=123; 29.0%) lasted for more than one month. Injury severity is specified in Table 6.3. Four players (0.9%) had to end their soccer career because of an injury; three of them had sustained an anterior cruciate ligament (ACL) injury. One out of 20 injuries (n=19, 4.5%) caused the player to be absent from school or work. After regaining the ability to fully take part in soccer training or matches, 27.4% of the players (n=116) still reported complaints (mostly pain, but also swelling, strength reduction, or instability).

The most common treatments after sustaining an injury included ice/cooling, physical therapy, and adjusted training/ exercises (Table 6.5). Fifty-four percent of the injuries (n=230) were given medical treatment. Additional diagnostics (like ultrasound, radiographs, MRI-scans, CT-scans) were performed in 10.1% of all injuries (n=43). Several care providers treated the players during their recovery phase. Different treatments and care providers are specified in Table 6.5. Three percent of the injuries (n=14) were followed by hospitalization.

Table 6.4: Cross-tabulation of location and type of all soccer injuries.

	Injury location, number (%)					
Injury type	**Head/ neck**	**Upper limb**	**Trunk**	**Lower limb**	**Un-known ***	**Total**
Fractures and bone stress	1 (0.2)	2 (0.5)	0	10 (2.4)	0	13 (3.1)
Joint and ligament	0	2 (0.5)	3 (0.7)	95 (22.4)	0	100 (23.6)
Muscle and tendon	1 (0.2)	1 (0.2)	9 (2.1)	154 (36.3)	0	165 (38.9)
Contusions, skin lesions and laceration	4 (0.9)	1 (0.2)	5 (1.2)	24 (5.7)	0	34 (8.0)
Nervous system	2 (0.5)	0	0	0	0	2 (0.5)
Muscle and tendon + contusions etc.	0	3 (0.7)	2 (0.5)	38 (9.0)	0	43 (10.1)
Other combinations	0	1 (0.1)	1 (0.1)	13 (3.1)	0	15 (3.7)
Other injuries	0	0	5 (1.2)	8 (9.3)	0	13 (3.1)
Unknown *	1 (0.2)	0	3 (0.7)	17 (4.0)	18 (4.2)	39 (9.2)
Total	9 (2.1)	10 (2.4)	28 (6.6)	359 (84.7)	18 (4.2)	424 (100)

** Unknown, because injury location or diagnosis was not recorded.*

Table 6.3: Injury characteristics (location, type, severity) of match, training, and overall injuries.

	Match injuries Number (%) 260 (100) *	**Training injuries Number (%) 123 (100) ***	**Overall injuries Number (%) 424 (100)**
Injury location			
All head/neck injuries	8 (3.1)	1 (0.8)	9 (2.1)
Head/face	7 (2.7)	1 (0.8)	8 (1.9)
Neck/cervical spine	1 (0.4)	0	1 (0.2)
All upper limb injuries	4 (1.5)	6 (4.9)	10 (2.4)
Shoulder/clavicula	4 (1.5)	2 (1.6)	6 (1.4)
Wrist	0	1 (0.8)	1 (0.2)
Hand/finger/thumb	0	3 (2.4)	3 (0.7)
All trunk injuries	15 (5.8)	9 (7.3)	28 (6.6)
Sternum/ribs/upper back	3 (1.2)	2 (1.6)	7 (1.7)
Lower back	10 (3.8)	6 (4.9)	18 (4.3)
Pelvis/sacrum	2 (0.8)	1 (0.8)	3 (0.7)
All lower limb injuries	226 (86.9)	105 (85.4)	361 (85.1)
Hip/groin	25 (9.6)	16 (13.0)	47 (11.1)
Thigh (posterior)	46 (17.7)	15 (12.2)	65 (15.3)
Thigh (anterior)	29 (11.2)	11 (8.9)	42 (9.9)
Knee	37 (14.2)	18 (14.6)	64 (15.1)
Lower leg/Achilles tendon	22 (8.5)	13 (10.6)	37 (8.7)
Ankle	51 (19.6)	24 (19.5)	77 (18.2)
Foot/toe	16 (6.2)	6 (4.9)	27 (6.4)
Unknown **	7 (2.7)	4 (3.3)	18 (4.2)
Injury type			
Fractures and bone stress	8 (3.1)	4 (3.3)	13 (3.1)
Joint and ligament	60 (23.1)	35 (28.5)	100 (23.6)
Muscle and tendon	93 (35.4)	57 (46.3)	165 (38.9)
Contusions, skin lesions and laceration	26 (10.0)	7 (5.7)	34 (8.0)
Nervous system	2 (0.8)	0	2 (0.5)
Muscle and tendon + contusions etc.	35 (13.5)	8 (6.5)	43 (10.1)
Other combinations	12 (4.6)	2 (1.6)	15 (3.5)
Other injuries (not specified)	5 (1.9)	3 (2.4)	13 (3.1)
Unknown **	20 (7.7)	9 (7.3)	39 (9.2)
Injury severity			
Minimal (1-3 days)	9 (3.5)	4 (3.3)	21 (5.0)
Mild (4-7 days)	44 (16.9)	29 (23.6)	84 (19.7)
Moderate (8-28days)	122 (46.9)	56 (45.5)	184 (43.1)
Severe (>28 days)	79 (30.4)	32 (26.0)	123 (28.8)
Career ending	3 (1.2)	1 (0.8)	4 (0.9)
Unknown **	3 (1.2)	1 (0.8)	8 (1.9)

** Time of occurrence for 41 injuries was not recorded.*
*** Unknown, because injury location, diagnosis, or recovery date was not recorded.*

Table 6.5: Treatment and care provider after sustaining a soccer injury.

Treatment	Number (%) 369 (100) *
Ice/cooling	230 (62.3)
Physical therapy	163 (44.2)
Adjusted training/exercises	123 (33.3)
Manual therapy	18 (4.9)
Surgery	13 (3.5)
Medication/drugs	12 (3.3)
Care provider	**Number (%) 352 (100) ****
Sports masseur/sports trainer	304 (86.4)
Physical therapist	183 (52.0)
Sports physician	26 (7.4)
Medical specialist	21 (5.9)
Manual therapist	20 (5.7)
Emergency department	19 (5.4)
General practitioner	15 (4.3)

** Treatment for 55 injuries was not recorded.*
*** Care provider for 72 injuries was not recorded.*

Discussion

The main findings of this study were that almost 60% of Dutch amateur soccer players sustained at least one injury during one competitive soccer season, and approximately one third of these injuries resulted in absence from soccer play for at least one month.

The injury incidences in training sessions and matches in our study are consistent with data reported from other adult male amateur soccer cohorts.[2,81,92] Other outcomes are also comparable to those of previous prospective studies in male amateur and professional soccer, which found an approximately 5 times higher injury incidence in matches than in training sessions[116] and a longer absence from soccer play for re-injuries than for new injuries.[51,52] Because 3 (out of 4) players in our study who had to end their career had sustained an ACL injury, it is evident that prevention of ACL injuries is important, as has also been reported for other cohorts.[89] Such injuries, as well as other serious knee injuries, result in long rehabilitation periods. The absence of an injured player may have an adverse influence on the player himself, on the team, and also on society, in view of the associated health care costs.[47,120]

Compared to previous studies,[52,116] we found a lower re-injury rate (14%, n=58). Junge & Dvorak[116] reported a re-injury rate of 20-25% for male players in their review, and several Scandinavian studies in professional soccer found early re-injury rates between 12% and 30%. Ekstrand et al.[52] stated that the low rate of 12% (observed in European professional teams) could be due to better medical support in these clubs, providing more personalized rehabilitation to injured players. Although, this was not the case for the present study population, it is conceivable that the paramedics in our study were more aware of rehabilitation and/or prevention of (recurrent) injuries, owing to their participation in the trial.

In terms of phase two of the prevention sequence model,[188] the most important contributing factors for male amateur soccer players (Table 6.2) were contact with another player, distortion, and turning/twisting. Reducing the number of contact injuries might be achieved by changing the rules of the soccer game.[2,5,67] Unfortunately, we did not collect information about foul play, or yellow and red cards during/after the eliciting event. This information could be valuable to specify the contact situations leading to injuries and indicate the possibility of reducing them by changing rules. The frequency of the other contributing factors (distorting/turning/twisting) might be reduced by means of appropriate exercises to improve the stability of ankles and knees, and/or core stability.

In view of the expected large number of injuries in this study, it was impossible to have the injury diagnosis verified by an independent medical doctor. However, the recording and diagnosing of injuries were assumed to be highly reliable. Using the definitions in the consensus statement by Fuller et al.[78], injuries were recorded primarily by well-trained paramedics. Any injury that may have been missed was likely to be recorded in the weekly exposure form by the coaches. In case of any inconsistencies between the two recordings on the absence of a player due to injury, a member of the research staff contacted the coach and/or paramedic to verify the absence. Given these procedures, reporting bias and underreporting should have been minimal.

In line with the above, a strength of this study is that we followed the injured players until return to play. This enabled us to collect data about the recovery period. An additional advantage of this extensive follow-up period was that the final diagnosis in the recovery form was more precise than the first diagnosis in the injury form. In view of the amateur status of our study sample medical support for the teams was generally limited, which may have caused delays in diagnosis. It should be noted that the injury form was collected immediately after an injury was sustained, while the recovery form was collected at the end of the recovery period, after possible additional diagnostics and/or consultations with a therapist/specialist. Nevertheless, several injured players (10%) were lost to follow-up before their return to play, so the supplementary information from the recovery form was missing. We used the first diagnosis from the injury form to report the injury characteristics. Another strength of our study is that we gathered information prospectively, according to the international consensus statement by Fuller et al.[78], in a homogeneous subpopulation (high-level amateurs) of more than 450 players within the largest group of active participants in soccer worldwide, viz. male adult soccer players.

Conclusions

The main findings of this study were that almost 60% of the Dutch adult amateur players in our study became injured during one season, with muscle/tendon (38%) or joint/ligament injuries (23%) of the lower extremities as the most prominent injuries. Consequently, prevention should primarily focus on these most common diagnoses. In addition, 14% of the injuries were re-injuries and these caused longer absence than new injuries. And more than 1 in 4 players (27%) still reported complaints after regaining the ability to fully take part in soccer activities. Therefore, players resuming soccer activities after an injury should be given special attention, to resolve the remaining complaints and to prevent re-injuries. Furthermore, numerous soccer injuries had substantial consequences, as almost 30% lasted for more than one month, and 54% were given medical treatment. Finally, it would be interesting to compare research findings on contributing factors for different ages, genders and skill levels. Such comparisons could be useful to determine what prevention strategies are effective for specific study populations.

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Injuries in professional male soccer players in the Netherlands: a prospective cohort study

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Abstract

The aim of this study was to investigate the incidence and characteristics of injuries in the Dutch premier soccer league. During the 2009/2010 soccer season, a total of 217 professional players from 8 teams were prospectively followed. The medical staff recorded time-loss injuries, including information on injuries (e.g. type, location, and duration) and exposure data for training sessions and matches. A total of 286 injuries were recorded, affecting 62.7% of the players. The overall injury incidence was 6.2 injuries per 1,000 player hours; 2.8 in training sessions and 32.8 in matches. Most of the recorded injuries were acute (68.5%). Eight percent of the injuries were classified as a recurrent injury. Injuries were most likely to be located in the lower extremities (82.9%). Injury time loss ranged from 1 to 752 days, with a median of 8 days. Knee injuries had the greatest consequences in terms of days of absence from soccer play (on average 45 days). The most common diagnosis was muscle/tendon injury of the lower extremities (32.9%). We conclude that injury risk in the Dutch premier soccer league is high, especially during matches. Preventive measures should focus on the most common diagnosis, namely muscle/tendon injuries of the lower extremities.

Introduction

Soccer is the type of sport with the highest participation globally.[45] Over 200 million people from 203 nations are members of the Fédération Internationale de Football Association (FIFA), while the Union of European Football Associations (UEFA) has 23 million members in 51 countries.[195] Outdoor soccer was played by 2,635 clubs and approximately 60,500 teams in the Netherlands during the 2011/2012 season. There are currently more than 1.2 million licenced members of the Royal Netherlands Football Association (KNVB), 45% of whom are adult males.[167]

To obtain a good ranking in competition, soccer players have to be talented, well-trained and healthy, and injuries are a major adverse event in a soccer player's career. Medical and/or surgical treatment and rehabilitation interrupt the player's activity for a period ranging from a few weeks to several months.[195] If many injuries are sustained, team results can suffer.[26] Reducing injury incidence and increasing player safety requires a thorough knowledge of the epidemiology of soccer injuries.[8] One major problem in the epidemiological assessment of soccer injuries, however, is the methodological inconsistencies between studies. For example, injury definitions and methods for data collection and recording often differ considerably between studies.[23,153]

Studies that describe injury risk and injury patterns in professional soccer have typically been conducted during tournaments,[117,118,197] or only involved teams at the highest European level,[52,200] covered only part of a season,[90] or related to only one team.[27,36] Few published studies have included data on injuries within one national professional male soccer competition, involving multiple teams. Hence, little is known about the differences between countries in injury risk and injury patterns in professional male soccer. During the last ten years, acute and overuse injuries during matches and training sessions within national professional male soccer competitions have been recorded in Denmark[90] and Sweden.[90,91,199] In view of differences in performance level, medical support, match frequencies, and climate, it is plausible that the incidence and severity of soccer injuries may differ between the Scandinavian and other European soccer leagues.[199] The present study therefore aimed to prospectively record injuries in the Dutch premier soccer league to investigate the incidence and characteristics of injuries in male professional soccer players during one entire soccer season.

Methods

Male soccer players participating in the Dutch premier soccer league were prospectively followed during the entire 2009/2010 competitive season from July 31 until May 2 (39 weeks). Players who were injured at the start of the season, as well as players who left the team during the season were included in the study, taking the time into account they spent on the team. Players who were still injured after May 2 were prospectively followed until they were recovered, to collect information about the duration of their injury. Players who were injured at the start of the season, as well as players who left the team during the season, were included in the analysis, taking account of the time they spent on the team. The players were informed about the study and agreed to participate by signing an informed consent form. Study design and procedures are in accordance with the Declaration of Helsinki as well as the ethical standards of the International Journal of Sports Medicine.[97] The study protocol was approved by the ethics committee of TNO, and the entire study design was approved by the Science Committee of the EMGO Institute for Health and Care Research of VU Medical Center.

Within each club, one person was responsible for entering the data. This contact person was a member of the club's medical staff (physical therapist or team physician). At the start of the study, baseline characteristics of all players were recorded by the contact person, including information regarding age, height and body weight, playing position, years of experience as an professional soccer player, and soccer injuries lasting more than one week sustained during the previous year (number and location). Individual training session exposure was recorded by the contact person on a daily basis using an Excel sheet. Match exposure data was provided by the "Infostrada Sports" company (www.infostradasports.com), a worldwide provider of comprehensive and reliable sports statistics and sports information services.

During the entire 2009/2010 season, all clubs participating in the Dutch premier soccer league were requested to systematically record the injuries sustained by their first team, using TNO's Web Based Injury System (BIS).[186] BIS has been set up under the authority of the Dutch Ministry of Health, Welfare, and Sports to record information on injuries and recovery in 18 different types of sport. The data collection followed the international consensus statement on procedures for epidemiological studies of soccer injuries recommended by FIFA and UEFA.[78,87] In agreement with the consensus statement by Fuller and colleagues,[78] a time-loss injury was defined as "any physical complaint sustained by a player resulting from a soccer match or soccer training session, and leading to the player being unable to fully take part in a soccer activity on the day after the injury". Recovery was defined as follows: "according to the medical staff the player is capable to fully take part in the regular training sessions or to play matches". The player has not been recovered fully if any adjustment has to be made in the training programme as a consequence of an injury".[78] The contact person also recorded epidemiological information on injuries (e.g. type, location, and duration) and factors related to an injury, like contact with another player and/or weather conditions. For recurrent injuries we used the following definition: "an injury of the same type and at the same site as an index injury and which occurs after a player's return to full participation from the index injury". Based on the number of days of absence, injuries were categorized according to their severity: minimal (1-3 days); mild (4-7 days); moderate (8-28 days); severe (>28 days); career ending.[78]

All statistical procedures were conducted using SPSS 20 (SPSS Inc., Chicago, USA). Baseline characteristics, measured as continuous variables, are presented as mean values with corresponding standard deviation (SD). Ordinal or categorical variables, such as injury severity and injury history, are presented as absolute numbers and percentages. Separate injury incidence rates are presented for training and match exposure. The incidences were calculated as the number of injuries per 1,000 exposure hours, according to the formula $I=(n/e)*1,000$, where n is the number of soccer injuries sustained during the soccer season and e the total exposure time expressed as total hours of soccer participation. Corresponding 95% confidence intervals (95% CI) were obtained using the Poisson model. We also calculated the percentage of acute injuries, percentage of recurrent injuries, location, diagnosis, and duration. In view of the skewed distribution, absenteeism is presented as median and interquartile range. In the Discussion section, we compare the incidences in the Dutch soccer league with those in the Danish and Swedish leagues. This comparison is based on the 95% CIs.

Results

All 18 Dutch premier league soccer clubs were invited to participate in the present study. Six clubs declined to participate (n=149 players). Furthermore, four clubs had to be excluded due to missing exposure data (n=129 players). The final sample consisted of 217 players from 8 teams. Mean ranking of the included teams at the end of the season was 7.8. The mean team size was 27 (±3), ranging from 22 to 31 players per team. Baseline characteristics of the included players were: age 24.6±4.3 years; height 1.83±0.07 m; body weight 78.4±7.5 kg; BMI 23.5±1.6 kg/m^2; experience in professional soccer 6.3±4.2 years. Almost 40% of the soccer players (n=85, 39.2%) reported at least one soccer injury that had lasted more than one week in the year prior to the start of this study, and 14 players (6.5%) were injured at the start of the study.

During the season, the total exposure time was 46,194 hours (41,012 training session hours and 5,182 match hours). The mean training session exposure and match exposure per player were 189.0 (±71.5) hours and 23.9 (±21.6) hours, respectively, during the 39 weeks of the competition season.

In total, 286 time-loss injuries were sustained by 62.7% (n=136) of the players. The overall injury incidence was 6.2 (5.5-7.0) injuries per 1,000 player hours, with training incidence 2.8 (2.3-3.3) and match incidence 32.8 (28.2-38.1). The incidence of recurrent injuries was 0.5 (0.3-0.7). A team sustained an average of 1.1 injuries per match. A total of 60 players (27.6%) sustained one injury, and 76 players (35.0%) sustained multiple injuries. Of the players sustaining multiple injuries, 40 players (18.4%) were injured twice during the season, 16 players (7.4%) three times, 11 players (5.1%) four times and 9 players (4.0%) five times or more. Eight percent (n=22) of the injuries were classified as a recurrent injury. Sixty-four percent (n=14) of these injuries occurred within two months of a player's return to full participation ("early recurrence").

Most of the recorded injuries were acute (n=196; 68.5%) and occurred during a match (n=170; 59.4%). Factors most frequently mentioned as being related to an injury are stated in Table 7.1. The most commonly mentioned factors were contact with another player (n=92; 32.9%), jumping (n=33; 11.8%), and fatigue (n=32; 11.4%).

Table 7.1: Factors most frequently mentioned as being related to an a soccer injury.*

Contributing factor	Number (%) 280 (100) **
Contact with player	92 (32.9)
Jumping	33 (11.8)
Fatigue	32 (11.4)
Distorting	24 (7.1)
Turning/twisting	22 (7.9)
Contact with ball	18 (6.4)
Reaching (for ball)	17 (6.1)
Shooting	16 (5.7)
Other	16 (5.7)
Playing field conditions	16 (5.7)
Fall	8 (2.9)
Artificial turf	6 (2.1)
Weather conditions	6 (2.1)
Unknown	55 (19.6)
None	3 (1.1)

** More answers could be given.*
*** Factors are missing for 6 injuries.*

Injuries were most likely to be located in the lower extremities (n=237; 82.9%). The most commonly injured body parts (n=285) were: knee (n=61; 21.3%), thigh (posterior) (n=44; 15.4%), lower leg/Achilles tendon (n=34; 11.9%), ankle, and groin (both n=30; 10.5%). Affected body parts with corresponding injury types are listed in Table 7.2, and locations and types are cross-tabulated in Table 7.3. The most common diagnosis was lower limb muscle/tendon injury (n=94; 32.9%), especially hamstrings (n=38; 13.3%) and groin (n=25; 8.3%).

Injury time loss ranged from 1 to 752 days, with a median of 8 days and an interquartile range (IQR) of 12. Recurrent injuries caused longer absence (median=10.5 days, IQR=12) than first-time injuries (median=7 days, IQR=12.5). Knee injuries had the greatest consequences in terms of days of absence from soccer play: the rehabilitation of a knee injury took an average of 45 days (median=10 days, IQR=30). Fifteen percent of the injuries (n=44) lasted more than one month. Injury severity is specified in Table 7.2. No players had to end their soccer career because of an injury. After being able to fully take part in soccer training sessions or match play again, 12.2% of the players (n=35) still suffered from complaints (mostly pain (n=21) and swelling (n=8)).

Table 7.3: Cross-tabulation of locations and types of all soccer injuries.

	Injury location, number (%)					
Injury type	Head/ neck	Upper limb	Trunk	Lower limb	Un-known *	Total
Fractures and bone stress	2 (0.7)	3 (1.0)	0	4 (1.4)	0	9 (3.1)
Joints and ligaments	0	2 (0.7)	1 (0.3)	50 (17.5)	0	53 (18.5)
Muscle and tendon	0	0	9 (3.1)	94 (32.9)	1 (0.3)	104 (36.4)
Contusions, skin lesions, and lacerations	1 (0.3)	0	6 (2.1)	44 (15.4)	0	51 (17.8)
Nervous system	5 (1.7)	0	0	0	0	5 (1.7)
Muscle and tendon + contusions, skin lesions, and lacerations	0	0	0	3 (1.0)	0	3 (1.0)
Other combinations	0	2 (0.7)	2 (0.7)	16 (5.6)	0	20 (7.0)
Other injuries	3 (1.0)	0	6 (2.1)	10 (3.5)	0	19 (6.6)
Overuse	0	0	6 (2.1)	16 (5.6)	0	22 (7.7)
Total	11 (3.8)	7 (2.4)	30 (10.5)	237 (82.9)	1 (0.3)	286 (100)

** Unknown, because injury location was not recorded.*

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Table 7.2: Injury characteristics (location, type, severity) of match, training, and overall injuries.

	Match injuries Number (%) 170 (100) *	Training injuries Number (%) 114 (100) *	Overall injuries Number (%) 286 (100)
Injury location			
All head/neck injuries	6 (3.5)	5 (4.4)	11 (3.8)
Head/face	6 (3.5)	4 (3.5)	10 (3.5)
Neck/cervical spine	0	1 (0.9)	1 (0.3)
All upper limb injuries	3 (1.8)	4 (3.5)	7 (2.3)
Shoulder/clavicula	2 (1.2)	2 (1.8)	4 (1.4)
Elbow	1 (0.6)	0	1 (0.3)
Hand/finger/thumb	0	2 (1.8)	2 (0.6)
All trunk injuries	18 (10.6)	12 (10.5)	30 (10.4)
Sternum/ribs/upper back	4 (2.4)	3 (2.6)	7 (2.4)
Lower back	7 (4.1)	7 (6.1)	14 (4.9)
Pelvis/hip	7 (4.1)	2 (1.8)	9 (3.1)
All lower limb injuries	143 (84.1)	92 (80.7)	237 (82.9)
Groin	15 (8.8)	15 (13.2)	30 (10.5)
Thigh (posterior)	29 (17.1)	15 (13.2)	44 (15.4)
Thigh (anterior)	11 (6.5)	10 (8.8)	22 (7.7)
Knee	38 (22.4)	23 (20.2)	61 (21.3)
Lower leg/Achilles tendon	19 (11.2)	15 (13.2)	34 (11.9)
Ankle	20 (11.8)	10 (8.8)	30 (10.5)
Foot/toe	11 (6.5)	4 (3.5)	16 (5.6)
Unknown **	0	1 (0.9)	1 (0.3)
Injury type			
Fractures and bone stress	4 (2.4)	5 (4.4)	9 (3.1)
Joint and ligament	40 (23.5)	13 (11.4)	53 (18.5)
Muscle and tendon	56 (32.9)	48 (42.1)	104 (36.4)
Contusions, skin lesions, and laceration	42 (24.7)	9 (7.9)	51 (17.8)
Nervous system	3 (1.8)	2 (1.8)	5 (1.7)
Muscle and tendon + contusions, skin lesions, and laceration	2 (1.2)	1 (0.9)	3 (1.0)
Other combinations	11 (6.5)	8 (7.0)	20 (7.0)
Other injuries	2 (1.2)	17 (14.9)	19 (6.6)
Overuse	10 (5.9)	11 (9.6)	22 (7.7)
Injury severity			
Minimal (1-3 days)	28 (16.5)	21 (18.4)	50 (17.5)
Mild (4-7 days)	53 (31.2)	38 (33.3)	91 (31.8)
Moderate (8-28 days)	56 (32.9)	41 (36.0)	98 (34.3)
Severe (>28 days)	30 (17.6)	14 (12.3)	44 (15.4)
Career ending	0 (0)	0 (0)	0 (0)
Unknown **	3 (1.8)	0	3 (1.0)

** Time of occurence for 2 injuries was not recorded.*
*** Unknown, because injury location or recovery date was not recorded.*

Discussion

It is plausible that incidences and severity of soccer injuries differ between European soccer leagues.[200] The aim of the present study was to investigate the incidence and characteristics of injuries in male soccer players in the Dutch premier soccer league.

We found an overall incidence of 6.2 injuries per 1,000 player hours (95% CI 5.5–7.0), which is significantly lower than the overall incidence of 7.6 (95% CI 7.0–8.8) found in the Swedish competition[91] and the 14.2 (95% CI 9.l–19.9) incidence in the Danish competition.[90] The training incidence of 2.8 (95% CI 2.3–3.3) found in our study was also significantly lower than that in the Swedish (5.3; 95% CI 4.7–5.8) and Danish competitions (11.8; 95% CI 6.7–16.9). These differences cannot be explained by the use of different methodology, as all three studies followed the international consensus agreements on procedures for data collection in epidemiological studies of soccer injuries recommended by FIFA and UEFA.[78,87] In agreement with our finding of differences between these countries in the incidence of soccer injuries, a recent study found that teams from the northern parts of Europe had higher overall injury incidences than teams from more southern parts of Europe.[198] The northern group consisted of clubs from Scotland (n=1), England (n=5), France (n=4), the Netherlands (n=2), Belgium (n=2), Germany (n=3), and Italy (northern part: n=3), while the southern group included teams from Italy (southern part: n=1), Portugal (n=2), and Spain (n=2). The study confirmed our hypothesis that there are regional differences in injury incidence within European professional soccer.

In agreement with the findings of several studies, most of the injuries in our study affected the lower extremities (84.1%).[91,198,200] Furthermore, 8% of the injuries were recurrent injuries. This is in agreement with the findings of a UEFA injury study 52 and in disagreement with studies in Scandinavian professional soccer, in which recurrent injury rates varied between 22% and 30%.[88,90,91,199] According to Ekstrand and colleagues, one possible explanation for the difference might be that top-level clubs in Europe have more medical support, providing more personalized rehabilitation for injured players.[52] Furthermore, Bjørneboe and colleagues reported a difference in the league system in Norway and Sweden compared to that of most European leagues.[23] Due to climatic conditions, the Norwegian and Swedish league seasons runs from April to October/November, with a 3-months preseason period starting in January. In most other European leagues, the soccer season starts in July and ends in May.

The reliability of injury recording is always a concern in epidemiological studies.[52] The current study used the consensus statement on injury definitions and data collection procedures for studies of injuries in soccer, which emphasizes that injury registration should be carried out prospectively and conducted by a member of the medical staff.[78] Research has shown that more injuries are recorded by prospective injury registration

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systems compared with retrospective interviews.[115,169] However, a recent study concluded that a prospective injury registration system is not always complete.[23] Bjørneboe and colleagues studied the accuracy of a prospective injury registration system based on medical staff reporting, by comparing it with retrospective interviews with players. Of the 123 acute injuries, 19% were only recorded through the player interviews, 54% by both methods and 28% through the medical staff registration, indicating that medical staff reports underestimated the incidence of time-loss injuries by at least one-fifth compared with player interviews. We would like to emphasize that the teams in our study were professional level teams with full access to medical staff, which might reduce the risk of missing injuries during the registration period. Therefore, we do not think we greatly underestimated the injury risk in the Dutch premier soccer league in our study.

This study had some further limitations that need to be addressed. Firstly, we only collected data on one soccer season. An advantage of a one-season prospective study design is that there are few dropouts due to in-season transfers, but there is a certain risk that the findings may represent a chance occurrence for that particular season.[124] However, several prospective studies based on data on a number of seasons demonstrated no significant changes in injury incidence over time.[27,36,52,91] The findings of these studies indicated that a study covering one full season can provide a sufficient assessment of the injury incidence among soccer players. Secondly, a study by Waldén and colleagues showed that half of the players belonging to teams participating in the Champions League had national team obligations. A total of 4% of all injuries occurred during matches played in the national team.[200] Our study did not take account of match exposure time and injuries sustained by players with national team obligations, which may have led to a slight underestimation of the injury risk in the Dutch premier league soccer players.

Despite these limitations, the strength of the current study is that we collected and analyzed data on multiple soccer clubs within one national competition. Although we included only 8 of the 18 premier league teams, we argue that this is a representative sample of professional soccer players in the Netherlands. This argument is based on the mean ranking of the included teams at the end of the season (mean ranking=7.8). Furthermore, we followed the international consensus agreements on procedures for epidemiological studies of soccer injuries recommended by FIFA and UEFA,[78,87] allowing us to compare the results with those of current and future studies into soccer injuries.

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Differences in injury risk and characteristics between Dutch amateur and professional soccer players

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Submitted

Abstract

Aim: To compare the incidence and characteristics of injuries between Dutch amateur and professional male soccer players during one entire competition season.

Methods: During the 2009/2010 season, 456 Dutch male amateur soccer players of 23 amateur teams and 217 players of 8 professional teams were prospectively followed. Information on injuries (e.g. type, location, absenteeism) and individual exposure to all soccer activities were recorded in both cohorts. Injuries were recorded using the time-loss definition.

Results: In total, 424 injuries were recorded among 274 of the amateur players (60.1%) and 286 injuries were sustained by 136 (62.7%) of the professional players (p=0.52). The overall injury incidence was significantly higher in the amateur cohort (9.6; 95% CI 8.7-10.5 vs. 6.2; 95% CI 5.5-7.0) as was the incidence during training sessions (3.9; 95% CI 3.3-4.7 vs. 2.1; 95% CI 1.7-2.6). In contrast, the injury incidence during matches was significantly higher for professional players (20.4; 95% CI 18.1-23.1 vs. 31.8; 95% CI 27.3-37.1). Moreover, professional players had a significantly higher incidence of minimal injuries, whereas the incidence of moderate and severe injuries was significantly higher for amateurs. Lastly, professional players sustained significantly more overuse injuries whereas, amateurs reported significantly more recurrent injuries.

Conclusions: The abovementioned differences in injury rates between amateur and professional players in the Netherlands can be explained by the difference in the level at which they play, since factors like the availability of medical support and/or the team size may influence the injury risk and characteristics.

Introduction

Soccer is one of the most popular sports worldwide. In the Netherlands, there are more than 1.2 million licensed members of the Royal Netherlands Football Association (KNVB) and 900 of them have been contracted by a professional soccer club (www.knvb.nl). The incidence rate of outdoor injuries in soccer is among the highest of all sports, particularly for adult male players.[112,119,170]

Soccer injuries result from a complex interaction of multiple intrinsic and extrinsic risk factors.[19] There is general consensus that the incidence of injuries is higher during matches than in training sessions.[150] However, several studies describing soccer injuries in male players have produced contradictory results with regard to the relation between injuries and the skills levels. The majority of these results have been summarized in two reviews, but the studies included in them have considerable limitations, like small study populations, no exposure registration and only focusing on severe injuries.[41,150] In addition, since the studies were published before 2006, they did not follow the guidelines of the consensus statement for such studies by Fuller and colleagues.[78] The two reviews describe the results of six studies. One showed a higher overall injury incidence at higher levels of play.[114] Two other studies reported that players competing at higher levels have a higher injury rate during matches and a lower injury rate during training sessions, compared to players at a lower level.[55,152] One of these studies specifically stated that the total injury incidence was similar between different skills levels.[55] In contrast, the fourth study concluded that the total injury incidence was significantly different between low-skilled and high-skilled players with the former showing a higher overall injury rate. However, specific incidences for matches and training sessions were not different between the two groups.[163] The last two studies showed that low-skilled players run a higher risk of suffering (time-loss or severe) injuries than high-skilled players.[29,161]

In conclusion, comparing characteristics and risk of injury between soccer players participating at different levels has been difficult due to differences between studies in research populations and methodology. To our knowledge, there have been no studies comparing the epidemiology of soccer injuries in professional and amateur soccer during the same season and using the same study design. Therefore, the aim of this study was to compare the incidences and characteristics of injuries between Dutch amateur and professional male soccer players, using data obtained with one consistent method during an entire competition season.

Methods

Study design and setting

A prospective two-cohort design was used to study soccer injuries in Dutch male amateur soccer players and male professional soccer players. The data for the amateur cohort were obtained from a cluster-randomized controlled trial (RCT) comparing the injury incidences between an intervention group that used a training programme (called "The11") during warm-up and a control group training as usual. Teams from two districts in the second highest Dutch amateur soccer league were invited to participate (n=24). Although the sample size was sufficient to detect differences, this RCT found that the programme had no preventive effect on injury incidence or injury severity among these male amateur soccer players during one season. The trial design, the intervention programme, and the results of the trial have been described in detail elsewhere.[185,186] For the professional cohort, all teams participating in the Dutch premier league were invited to participate (n=18).

Data on injuries and exposure for both cohorts were collected during the 2009/2010 competition season, from the first to the last regular competition match of the season. The teams in the amateur cohort collected data for 33 weeks, and all teams in the professional cohort for 39 weeks.

Participants

The amateur cohort comprised male soccer players, aged between 18 and 40 years. They generally had two or three training sessions (on average 90 minutes each) and one match each week. For the professional cohort, all male soccer players participating in the Dutch premier league were eligible for inclusion (no age restriction). On average, they had training sessions on 4-5 days of the week and at least one competition match every week. The training sessions consisted of endurance, skills training (both on average 70 minutes per session), strength, rehabilitation training (both 60 minutes per session on average) or a combination of these elements.

Players who were already injured at the start of the season, as well as players who left the team during the season, were included in the study based on the time they spent on the team. All players provided written informed consent at the start of the study.

Variables, definitions and data sources

During the pre-season period, all amateur and professional players were asked to complete a questionnaire to record baseline characteristics, viz. age, self-reported body height and weight, field position and soccer injuries sustained during the previous year (number and location).

During the competition season, data collection included exposure and injury registration. One person within each team was responsible for recording all injuries that occurred during organized soccer activities. In the amateur cohort, this was done by a team paramedic or sports trainer. In the professional cohort, it was done by a member of the club's medical staff. In both cohorts, the responsible person was present at each of the team's training sessions and matches. All injuries sustained during organized soccer activities were recorded, using the Web-Based Injury System (BIS) developed by the Netherlands Organization for Applied Scientific Research (TNO).[185] BIS includes all the categories that are needed to enter data according to the basic guidelines of the consensus statement on injury definitions and data collection procedures in soccer.[78] When a player sustained an injury, he was asked to complete a questionnaire about this injury. This so-called injury form comprised questions to collect epidemiological information on injuries (e.g. type, location, and duration). Injuries were recorded using the following time-loss definition, in accordance with the consensus statement by Fuller et al.[78]: "any physical complaint sustained by a player resulting from a soccer match or soccer training session, and leading to the player being unable to fully take part in a soccer activity on the day after the injury". A recurrent injury was defined as: "an injury of the same type and at the same site as an index injury and which occurs after a player's return to full participation from the index injury". Injuries were classified according to their severity, based on the number of days of absence from soccer: minimal (1-3 days); mild (4-7 days); moderate (8-28 days); severe (>28 days) or career ending.[78] Individual player exposure (in minutes) was reported on a weekly basis.

The coaches in the amateur cohort recorded the individual exposure to training sessions and matches. The contact person of the professional team recorded the individual exposure to training sessions, while match exposure was provided by 'Infostrada Sports' which is a worldwide provider of comprehensive and reliable sports statistics and sports information services.

When a player was not present at a regular training session or match, the reason for his absence was reported on the exposure form as "injured" or "other". Training exposure was defined as team-based and individual physical activities under the guidance of the team's staff. Match exposure was defined as play between teams from different clubs.[78]

Statistical methods

The statistical tests were performed with Microsoft Excel and SPSS 20. Injury incidence per 1,000 hours of soccer participation (I) was calculated as I=(n/e)*1,000, where n is the number of soccer injuries sustained during the soccer season and e the total exposure time expressed as total hours of soccer participation. The Poisson model was used to obtain 95% confidence intervals (95% CI). Differences between amateur and professional players were assessed using rate ratios[85] and z-statistics for injury incidences,[85,134] a univariate t-test for the normally distributed continuous parameters (e.g. age and BMI), Mann Whitney U-test for the continuous variable absenteeism from soccer and χ^2 analysis for categorical parameters (e.g. field position and injury location). The two-sided significance level was set at $p<0.05$. For comparisons within the injury locations and injury types, a Bonferroni correction was used for multiple testing.

Results

Participants and descriptive data

The final amateur cohort consisted of 456 players from 23 teams (one team declined to participate). The mean team size was 20 (±2), ranging from 16 to 23 players per team. On average, the amateurs had played soccer for 17.5 (±4.5) years. Nearly seven out of ten amateur players (n=300, 69.0%) reported having sustained a soccer injury in the year prior to the start of this study, and 52 players (11.4%) were injured at the start of the season.

Six professional teams declined to participate and four teams had to be excluded from the analysis because exposure data were missing. The final professional cohort therefore consisted of 217 players from 8 teams. The mean team size was 27 (±3), ranging from 22 to 31 players per team. On average, the professionals had played professional soccer for 6.3 (±4.2) years. Nearly forty percent of the professional players (n=85, 39.2%) reported having sustained a soccer injury that lasted for more than one week in the year prior to the start of this study, and 14 players (6.5%) were injured at the start of the season.

Baseline characteristics of the players in the two cohorts were similar, except for nationality (Table 8.1). The team size was significantly different between the amateur and professional cohorts (20 vs. 27 players, respectively).

Exposure, injury incidence, and severity

Exposure times were significantly different between the two cohorts. The total exposure time during the season was 44,252 hours (31,518 for training; 12,734 for matches) in the amateur cohort and 46,194 hours (41,012 for training; 5,182 for matches) in the professional cohort ($p<0.001$ for overall, training and match exposure). During the season, the mean overall exposure time was 213 hours per professional player and 97 hours per amateur player ($p<0.001$). On average, the professional teams had 2.7 times more training hours per player than the amateur teams ($p<0.001$), while the amateurs had 17% more match exposure per player than the professional players ($p<0.01$).

During the season, 424 injuries were recorded among 274 of the amateur players (60.1%) and 286 injuries were sustained by 136 (62.7%) of the professional players (p=0.52). The overall injury incidence was higher in the amateur cohort, as was the incidence during training. In contrast, the injury incidence during matches was significantly higher for professional players. Separate analyses of the severity categories showed that professional players had a significantly higher incidence of minimal injuries, whereas the amateurs had a significantly higher incidence of moderate or severe injuries. More details regarding injury incidences are presented in Table 8.2.

Table 8.1: Baseline characteristics of Dutch amateur (n=456) and professional soccer players (n=217).

	Amateur cohort (mean ± SD)	**Professional cohort (mean ± SD)**	**p-value**
Age (years)	24.8 ± 4.2	24.6 ± 4.3	0.75
Body height (m)	1.83 ± 0.06	1.83 ± 0.07	0.14
Body weight (kg)	78.2 ± 7.5	78.4 ± 7.5	0.75
BMI (kg/m^2)	23.3 ± 1.8	23.5 ± 1.6	0.08
Field position (%)			0.74
Goal keeper	9.9	12.0	
Defender	32.2	32.3	
Midfielder	32.5	29.0	
Attacker	25.4	26.7	
Dutch nationality (%)	95.0	50.2	<0.001 *
Injured at start of season (%)	11.4	6.5	0.06

** Significantly different between the amateur and professional cohorts.*

Injury characteristics

The two cohorts showed no significant difference in match injuries for the four field positions (p=0.08). The proportion of overuse injuries was higher among professional players (26.9% vs. 19.3%; p=0.02);

The distribution of all injury locations was similar for amateur and professional players (p=0.19). The knee was the most common injury location in the professional cohort, whereas ankle injuries were most common among the amateurs. Professional players reported significantly more contusions, skin lesions and lacerations ($p<0.001$). See Table 8.3 for more details about injury location and type.

Compared to professional players, absenteeism from soccer due to injuries was higher among amateur players ($p<0.001$). Among the professional players, injury time loss ranged from 1 to 752 days, with a median of 8 days and an interquartile range (IQR) of 12. Among the amateurs, time loss ranged from 2 to 407 days, with a median of 16 days, and a IQR of 30 days. Moreover, significantly more amateur players still reported complaints after regaining the ability to fully take part in soccer training or matches (31.3% vs. 13.4%; p<0.001).

Table 8.2: Injury incidence in Dutch amateur (n=456) and professional soccer players (n=217).

Injuries	Amateur cohort (95% CI)	Professional cohort (95% CI)	Risk ratio (95% CI)	p-value (z-test)
Total	9.6 (8.7 – 10.5)	6.2 (5.5 – 7.0)	0.65 (0.56 – 0.75)	<0.001 *
Match	20.4 (18.1 – 23.1)	31.8 (27.3 – 37.1)	1.61 (1.32 – 1.95)	<0.001 *
Training	3.9 (3.3 – 4.7)	2.1 (1.7 – 2.6)	0.71 (0.55 – 0.92)	0.01 *
Recurrent injuries	1.3 (1.0- 1.7)	0.5 (0.3 – 0.7)	0.36 (0.22 – 0.59)	<0.001 *
Severity				
Minimal	0.5 (0.3 – 0.7)	1.1 (0.8 – 1.4)	2.28 (1.38 – 3.78)	<0.001 *
Mild	1.9 (1.5 – 2.4)	2.0 (1.6 – 2.4)	1.04 (0.77 – 1.39)	0.80
Moderate	4.2 (3.6 – 4.8)	2.1 (1.7 – 2.6)	0.51 (0.40 – 0.65)	<0.001 *
Severe	2.8 (2.3 – 3.3)	1.0 (0.7 – 1.3)	0.34 (0.24 – 0.48)	<0.001 *

** Significantly different between the amateur and professional cohorts.*

Table 8.3: Locations and types of injury in Dutch amateur (n=456) and professional soccer players (n=217).

	Amateur cohort number (%)	Professional cohort number (%)	p-value
Injury location			
All head/neck injuries	9 (2.1)	11 (3.8)	0.26
Head/face	8 (1.9)	10 (3.5)	
Neck/cervical spine	1 (0.2)	1 (0.3)	
All upper limb injuries	10 (2.4)	7 (2.3)	1.00
Shoulder/clavicle	6 (1.4)	4 (1.4)	
Wrist	1 (0.2)	1 (0.3)	
Hand/finger/thumb	3 (0.7)	2 (0.6)	
All trunk injuries	28 (6.6)	30 (10.4)	0.09
Sternum/ribs/upper back	7 (1.7)	7 (2.4)	
Lower back	18 (4.3)	14 (4.9)	
Pelvis/sacrum	3 (0.7)	9 (3.1)	
All lower limb injuries	361 (85.1)	237 (82.9)	0.59
Hip/groin	47 (11.1)	30 (10.5)	0.90
Thigh (posterior)	65 (15.3)	44 (15.4)	1.00
Thigh (anterior)	42 (9.9)	22 (7.7)	0.38
Knee	64 (15.1)	61 (21.3)	0.04 ^
Lower leg/Achilles tendon	37 (8.7)	34 (11.9)	0.21
Ankle	77 (18.2)	30 (10.5)	0.01 ^
Foot/toe	27 (6.4)	16 (5.6)	0.79
Unknown #	18 (4.2)	1 (0.3)	
Injury type			
Fractures and bone stress	13 (3.1)	9 (3.1)	1.0
Joint and ligament	100 (23.6)	53 (18.5)	0.13
Muscle and tendon	165 (38.9)	104 (36.4)	0.54
Contusions, skin lesions and laceration	34 (8.0)	51 (17.8)	<0.001 *
Nervous system	2 (0.5)	5 (1.7)	0.19
Combinations	58 (13.7)	23 (8.0)	0.03
Other injuries (not specified, including overuse)	13 (3.1)	41 (14.3)	<0.001 *
Unknown #	39 (9.2)	0	
Total	424 (100)	286 (100)	

^ Not significantly different between the amateur and professional cohorts, after Bonferroni correction.
 # Unknown, because injury location or diagnosis was not recorded.
** Significantly different between the amateur and professional cohorts, after Bonferroni correction.*

Discussion

The principal findings of this study were that the overall injury incidence was higher in the amateur cohort, as a result of a higher incidence during training sessions. In contrast, the injury incidence during matches was significantly higher for professional players. The injury incidences in training sessions and matches for the amateur cohort are consistent data from previous studies.[2,81,92] The overall incidence rate for the professional cohort is significantly lower than that found in the Swedish (7.6; 7.0–8.3) and Danish (14.4; 9.1–19.8) professional soccer competitions.[90,91] These differences are in agreement with a recent study reporting a higher general injury incidence among teams from northern Europe. This may be caused by the influence of regional circumstances, like field conditions and weather, on injury incidence.[198] Various suggestions have been made to explain the contradictory results regarding the influence of level of play on injuries. Depending on the methodology used, low-skilled groups may have the same number of injuries as groups at higher skills levels, but show a higher incidence rate based on less exposure.[150] Another explanation why less skilled players have a higher injury rate would be that more experienced players acquire skills relevant to avoiding injury-prone actions.[16] On the other hand, the intensity of training sessions and matches increases with the competition level, so skilled players run a greater injury risk than less skilled players.[108]

Significantly more severe injuries (>28 days) and more recurrent injuries were reported among the amateur players than among the professionals. These differences may be explained by several factors. Quantitatively, there is an absolute effect associated with the number of players per team. The smaller team size in amateur soccer leads to fewer options to substitute injured players as well as players who are more injury-prone. This is underlined by the fact that the amateurs had a 17% higher match exposure per player than the professionals. A relative effect may have been caused by underreporting of minor injuries in the amateur cohort, since the person recording the injuries was available only 2-3 times a week (during training sessions and matches). This contrasts with the (nearly) daily contact between medical staff and players in professional soccer. As a result, minor injuries of amateurs may have been missed, as players may have recovered from minor injuries in the meantime. Qualitatively, the medical support is less consistent secondary to economic constraints of amateur teams. This may lead to delayed diagnoses, but also to less optimal rehabilitation, incomplete healing of injuries and/or neglect of minor injuries. Moreover, the availability of medical staff in professional soccer may lead to more personalized rehabilitation of players sustaining more severe injuries.[53,54,93] This is confirmed by the fact that the amateur players in our study were more likely than the professional players to report remaining complaints after regaining the ability to fully take part in soccer training or matches.

Interestingly, the professional players reported more overuse injuries than the amateur players. As suggested by Ekstrand et al.[53], the increased intensity at the professional level may contribute to this higher number of overuse injuries. In addition, the risk of overuse injuries may be increased by the frequent use of nonsteroidal anti-inflammatory drugs (NSAIDs) in professional soccer.[181,183] On the other hand, the difference in overuse injuries should be interpreted with caution as the number of such injuries may have been underestimated in both cohorts of our study, due to the use of the time-loss injury definition. It is likely that some overuse injuries do not lead to time being lost from sport.[17,30]

The major strength of this study is the systematic collection of data on soccer injuries in professional and amateur soccer in the Netherlands during the same season using the same injury registration system (BIS). However, due to the different settings of these two cohorts, some minor differences were present in the data collection procedure. Since a Dutch company provided high-quality data on the match exposure of all professional players in the Netherlands, we decided to use these exposure data in our data analysis. In addition, some definitions in the BIS intake form were slightly different between the amateur and professional players. For instance, at baseline the amateurs were asked to specify all soccer injuries they had sustained in the previous year, whereas the professionals were asked to report only those injuries lasting for more than one week.

In this study, 8 of the 18 premier league teams provided usable injury and exposure data. This sample can be regarded as representative of professional soccer in the Netherlands, given the mean ranking (=7.8) of these teams at the end of the season (median=7; IQR=8.3), suggesting that the whole range of professional soccer was represented.

It is probably not possible to translate our results into a more generalized conclusion about the influence of the level of play on the risk and characteristics of injuries among all soccer players. Level of play as a risk factor for injuries is influenced by several aspects, such as the duration of a competition season, the availability of medical support and the skills levels of the players and such factors will be country-specific. Therefore, our results, which showed a higher training incidence and more severe and recurrent injuries among amateurs and higher match incidence and more overuse injuries among professionals, only apply to soccer injuries in the Netherlands.

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Risk factors for hamstring injuries in male soccer players: a systematic review of prospective studies

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Abstract

Hamstring injuries are common injuries in soccer players. In view of the high incidence and the serious consequences, identifying risk factors related to hamstring injuries is essential. The aim of this systematic review was therefore to identify risk factors for hamstring injuries in male adult soccer players. PubMed, Embase/Medline, Cumulative Index to Nursing and Allied Health Literature, and SPORTDiscus were systematically searched, and prospective studies investigating risk factors for hamstring injuries in adult male soccer players were included. The methodological quality of the included articles was assessed using a standardized set of predefined criteria. Seven of the eleven studies identified, involving a total of 1,775 players and 344 hamstring injuries, met the inclusion criteria. All but one of the included studies met at least five of nine methodological criteria, causing them to be qualified as 'high quality'. The included studies used univariate as well as multivariate analyses to identify risk factors for hamstring injury. The results from the multivariate analyses suggest that previous hamstring injury is most strongly related to hamstring injury. Conflicting evidence is found for hamstring length or flexibility and strength imbalances as risk factors for the occurrence of hamstring injuries.

Introduction

Soccer is one of the most popular sports worldwide, with more than 260 million players.[116] Participants include both males and females of every age and at all levels. Hamstring injuries are common injuries in soccer players and account for 12 to 16% of all soccer-related injuries.[9,36,72,84,89,205] A hamstring injury is usually a muscle strain, which is an overstretch of the musculotendinous unit.[84] Of all muscle strains sustained by soccer players, 47% affect the hamstring muscles, mostly the biceps femoris.[14,72,84,100,110,158] Hamstring injuries are characterized by a high re-injury rate (12-31%) and can lead to inability to play soccer for up to 90 days.[84,91,100,110,158,205]

Musculotendinous injuries usually result from non-contact mechanisms.[205] A hamstring injury typically occurs during rapid acceleration or deceleration, a quick change of direction during sprinting at maximum speed or during jumping, and frequently at the end stage of the swing phase of gait.[84,98] During the deceleration of knee extension, there is a quick and intensive change from maximum eccentric to concentric contraction. It's during this rapid changeover that the hamstrings are most vulnerable to injury.[9,72,100,110,158,192] Soccer players perform the above described actions very frequently and are therefore highly vulnerable.

The causes of hamstring injuries are complicated and multifactorial.[144,145] The general potential risk factors that have been proposed can be divided into intrinsic, player-related factors and extrinsic, environment-related factors.[41,113,150,188] Examples of intrinsic factors are muscle weakness, instability, fatigue, poor flexibility, poor technique, and psychosocial factors. Examples of extrinsic factors are insufficient warm-up, training parameters, and playing surfaces.[3,9,84,110,192]

Some risk factors, like age, sex and ethnic origin, are not modifiable.[18] A further distinction can be made between local and non-local risk factors.[109,110] Of all hamstring injuries that occur, 14-19% are without muscle damage suggesting non-local muscle pathology, e.g. restricted range of motion and instability of the lower back.[109] Such non-local muscle pathology can result in additional stress on the hamstring muscles.[9,109,110]

A systematic review covering sports in general by Foreman et al.[72] found that no single risk factor was significantly associated with hamstring injuries. They included seven prospective studies, but only one described hamstring injuries in soccer players; the other six were related to Australian football or rugby players. In view of the high incidence, the adverse consequences and the fact that risk factors for sustaining an injury might depend on specific sports activities, identifying factors related to hamstring injuries specifically in soccer players is essential to reduce the incidence of these injuries.[100,109,110,158] Therefore, the aim of this systematic review was to identify risk factors for hamstring injuries in male adult soccer players.

Methods

Search strategy

The databases PubMed, Embase/Medline, CINAHL, and SPORTDiscus were systematically searched for potentially relevant articles, from inception until November 9, 2011. The PubMed search used combinations of Medical Subject Headings and free text words. Synonym lists were created on the following three aspects: (1) risk factor, (2) hamstring injury, and (3) soccer. The following combination of keywords was used: (risk factor OR factor OR caus* OR etiolog* OR determinant OR predict* OR prospective OR cohort study) AND [(hamstring AND injur*) OR (hamstring AND strain)] AND (soccer OR football) NOT (rugby OR Australian football). This search strategy was adapted for Embase/Medline, CINAHL, and SPORTDiscus. The searches in CINAHL and SPORTDiscus were restricted to peer-reviewed articles. One author (AV) created the key words and search strategy for each database. Subsequently, the databases were searched independently by two authors (AV, IP). The results of these searches were combined and duplicates were removed. The full search strategy is available on request from the corresponding author (AB).

Selection criteria

The relevant citations were first screened on title and abstract. Articles were considered relevant, as decided independently by two authors (AB, AV), if the study met the following inclusion criteria: (1) prospective design involving risk factors for hamstring injuries in soccer players, (2) statistical analysis include injured and non-injured players (e.g. logistic regression analysis), (3) study sample consisting of males over 18 years of age, and (4) acute or overuse muscle injury in the region of the posterior thigh, sustained during a soccer training or match.[78,165] Articles were excluded if the study: (1) was limited to reporting incidence rates for injuries, (2) was limited to recurrent hamstring injuries, (3) investigated an intervention or treatment effect (e.g. randomized controlled trial), (4) was not available as full text, or (5) was not published in English, German, or Dutch. Disagreements between the two authors regarding a study's eligibility were resolved by discussion until consensus was reached or, where necessary, a third author (IP) made the final decision. References in the full-text articles were tracked to ensure that no relevant articles were missed.

Methodological quality

Two authors (AB, IP) scored the methodological quality of each included article independently, using a standardized list of predefined criteria.[164] The list consists of fifteen items, distinguishing between informativeness (six items) and validity/precision (nine items). Each quality criterion was rated as positive (+), negative (-), or unknown (?). The scores given by the two authors were compared, and differences were discussed until consensus was reached. Each study was assigned a total quality score by counting the number of items with positive scores on the validity/precision criteria (methodological score). A study was considered of high quality if this methodological score was at least five out of nine.[164]

Results

Study identification

The literature search of the four databases resulted in 249 hits. After duplicates had been removed, 157 articles were screened on the basis of title and abstract. This led to eleven articles being assessed for eligibility,[13,33,35,51,64,73,91,102,159,202,205] and seven of them were included independently by two authors (Figure 9.1).[13,33,64,73,91,102,202] Reference lists in the articles were searched further for additional relevant publications, but this reference tracking did not result in further inclusions. Studies were predominantly excluded because the injuries concerned were not hamstring injuries, because the article offered a global description of injuries in soccer, or because the study was not designed as a prospective study.

All included studies (n=7) were prospective cohort studies with a follow-up period of one or two soccer seasons.[13,33,64,73,91,102,202] The populations consisted of male, professional and amateur, outdoor soccer players (1755 in total) in European or Brazilian leagues. Study samples ranged from 36[102] to a maximum of 508 participants.[64] The number of recorded hamstring injuries varied from 14[102] to 76 per study.[64] The related risk factors were evaluated unifactorially[13,33,64,91,102,202] and/or multifactorially.[13,64,73,91,102,202] Table 9.1 shows the main characteristics of the included studies.

Methodological quality

The methodological scores ranged from four to seven points, with a mean and median of 6 points. The results of the quality assessment after consensus are presented in Table 9.2 Six of the seven included studies demonstrated high methodological quality.[13,64,73,91,102,202] None of the included studies had a negative score on the three criteria about data collection.[13,33,64,73,91,102,202]

Table 9.1: Characteristics and results of the included articles.

Author (year)	Population and follow-up period	RESULTS Hamstring injuries	RESULTS Significant * (Risk factor)	Non-significant (Risk factor)
Árnason et al.[9] (2004)	n=306 17 teams from the two highest divisions in Iceland Age 24, range 16–38 Injured players (mean±SEM): 24.8±0.4; uninjured players (mean ±SEM): 23.4±0.3 Follow-up during the competition season, lasting 4 months	n=31 A player was defined as injured if he was unable to participate in a match or a training session because of an injury that occurred in a football match or during training. 0.9 injuries ± 0.2/1,000 playing hours 0.5 injuries ± 0.1/1,000 training hours 3.0 injuries ± 0.7/1,000 match hours	Univariate analysis: - Age - Previous hamstring injury Multivariate analysis : - Age (OR 1.4 [1-year increase]; 95% CI 1.2–0.4) - Previous hamstring strain (OR 11.6; 95% CI 3.5–39.0) NB Risk factors with p≤0.2 were included in the multivariate analysis.	Univariate analysis: height, weight, body composition (% fat), BMI, hamstring flexibility, maximal average power, counter movement jump, counter movement jump one leg, standing jump, peak O2 uptake, player exposure (training and match), training/match ratio Multivariate analysis: weight, body composition (% fat)
Croisier et al.[33] (2008)	n=462 Belgian, Brazilian and French professional soccer players of 29 teams Age 26 (± 6) Follow-up during the competition season, lasting 9 months	n=35 Definition: the following criteria had to be simultaneously met: 1) physical examination showing pain on palpation, passive stretch, and active contraction of the muscle involved; 2) diagnosis supported by ultrasonography or magnetic resonance imaging; 3) a period of 4 weeks of missed playing time for the player concerned.	Logistic regression: Increased rate of hamstring injuries in subjects with untreated pre-season strength imbalances compared with players with a normal strength profile (RR 4.66; 95% CI 2.01–10.8, p<0.05).	
Engebretsen et al.[64] (2010)	n=508 31 amateur teams from the Norwegian 1st, 2nd or 3rd division Age 24.0±4.2 Injured players (mean±SEM): 23.9±0.2; uninjured players (mean±SEM): 24.8±0.6 Follow-up during one soccer season	n=76 (51 acute, 25 overuse) Definition: any physical complaint by a player that made him seek medical assistance and that resulted from a soccer match or soccer training, forcing him to miss or be unable to take full part in future soccer training or match play. 0.7 injuries/1,000 playing hours (95% CI 0.5–0.9) 0.3 injuries/1,000 training hours (95% CI 0.2–0.4) 1.8 injuries/1,000 match hours (95% CI 1.2–2.5)	Univariate analysis: - Previous acute hamstring injury (OR 2.62; 95% CI 1.54–4.45) - Hamstring function, based on Hamstring Outcome Score [HaOS] (OR 1.29 [10-point reduction]; 95% CI 1.08–1.54) Multivariate analysis : - Previous acute hamstring injury (adjusted OR 2.19; 95% CI 1.19–4.03, p=0.01) NB Risk factors with p<0.1 were included in the multivariate analysis.	Univariate analysis: age, player position, hamstring length, counter movement jump test, Nordic hamstring strength test, 40m sprint test, level of play (last season), junior/senior national team matches, height, weight, BMI Multivariate analysis: age, player position, hamstring function (based on Hamstring Outcome Score [HaOS] total score)
Fousekis et al.[73] (2011)	n=100 4 professional teams from the Greek 3rd National Soccer League division Age 22.99, range 19.4 – 27.8 Injured players: 22.94 (±4.11), uninjured players: 23.00 (±3.27) Follow-up during the competition season, lasting 10 months	n=16 Definition: non-contact muscle strains forcing players to miss at least one scheduled practice session or game. 42% of the total reported lower extremity muscle strain injuries 57% of the total reported non-contact muscle strain injuries	Multivariate analysis : - Eccentric isokinetic hamstrings strength asymmetries (OR=3.88; 95% CI 1.13–13.23) - Functional leg length asymmetries (OR=3.80; 95% CI 1.08–13.33) - Previous hamstring injury (OR=0.15; 95% CI 0.029–0.79) NB Risk factors with p≤0.1 were included in the multivariate analysis.	Multivariate analysis: age, weight, height, hamstring isokinetic strength, knee functional strength ratio, hamstring flexibility, proprioception, anthropometrics (mid-thigh girth, lower-leg functional length), anterior knee laxity

Table 9.1, continued: Characteristics and results of the included articles.

Author (year)	Population and follow-up period	RESULTS Hamstring injuries	RESULTS Significant * (Risk factor)	RESULTS Non-significant (Risk factor)
Hägglund et al.[91] (2006)	n=263 (season 1) and 262 (season 2) (only players who participated in both seasons were included in the risk factor analysis, n=197 players/394 limbs) 12 teams from the highest Swedish soccer division Age 25 (±5), range 17–38 Follow-up during two full consecutive seasons (2001 and 2002)	n=66 (season 1) and 75 (season 2) Definition: any injury occurring during a scheduled training session or match causing the player miss the next training session or match. 2001: 0.8 injuries / 1,000 playing hours (95% CI 0.7 – 1.1) 2002: 1.0 injuries / 1,000 playing hours (95% CI 0.8 – 1.2)	Univariate analysis: - previous hamstring injury (hazard ratio=3.2; 95% CI 1.8-6.0) - age (hazard ratio=1.1; 95% CI 1.0–1.2) Multivariate analysis : - previous hamstring injury (hazard ratio=3.5; 95% CI 1.9–6.5) - age (hazard ratio=1.1; 95% CI 1.0–1.2) NB Risk factors with p<0.2 were included in the multivariate analysis.	Univariate analysis: height, weight, BMI Multivariate analysis: ---
Henderson et al.[102] (2010)	n=36 Elite professional soccer players from an English Premier League soccer club Age 22.6 (±5.2) Injured players: 26.7 (±6.5), uninjured players: 21.4 (±3.4) Follow-up during the competition season, lasting 45 weeks	n=14 Definition: an injury that would result in a player being unable to participate in general training for a period of 48h or more and requiring medical attention. All injuries were diagnosed clinically by the doctor, physiotherapists and sport therapists employed at the club, and subsequently confirmed by MRI scan. 13.5% of all injuries were disruptions to the hamstring musculature. NB Only data of hamstring injuries (no recurrence) to the dominant limb (n=10) were modeled.	Univariate analysis: - Age (injured players: 26.7±6.5; non-injured players: 21.4 ± 3.4) Multivariate analysis: - Age (OR = 1.78; 95% CI 1.17–2.72) - Active hip flexion ROM for the dominant limb (OR = 0.77; (95% CI 0.62–0.97) - non-counter movement jump (OR = 1.47; 95% CI 1.02–2.12)	Univariate analysis: prior injury, hip flexion ROM (passive ROM, active ROM and active/passive ROM), peak torque, HQ strength ratio, agility run, counter movement jump, non-counter movement jump, YIET (YoYo Intermittent Endurance Test, level 2) Multivariate analysis: lean mass
Witvrouw et al.[202] (2003)	n=146 Professional Belgian soccer players from 14 teams Age not specified Follow-up during one competition season	n=31 Definition: any tissue damage caused by soccer participation that kept a player out of practice or a game. 46% of the total of lower extremity muscle injuries reported	Univariate analysis: - Hamstring muscle flexibility [less than 90°] (p=0.02) Multivariate analysis: - Hamstring muscle flexibility [less than 90°] (p=0.02)	Univariate analysis: time in training and games, number of injuries between the dominant and non-dominant leg, height and weight (for all lower extremity injuries) Multivariate analysis: number of injuries between the dominant and non-dominant leg, quadriceps muscle flexibility, gastrocnemius muscle flexibility, adductor muscle flexibility NB These factors were included in a model of all musculoskeletal injuries in this study. It remains unclear which factors were used for the analysis of hamstring injuries.

Age presented as mean years (±SD).
** p<0.05.*

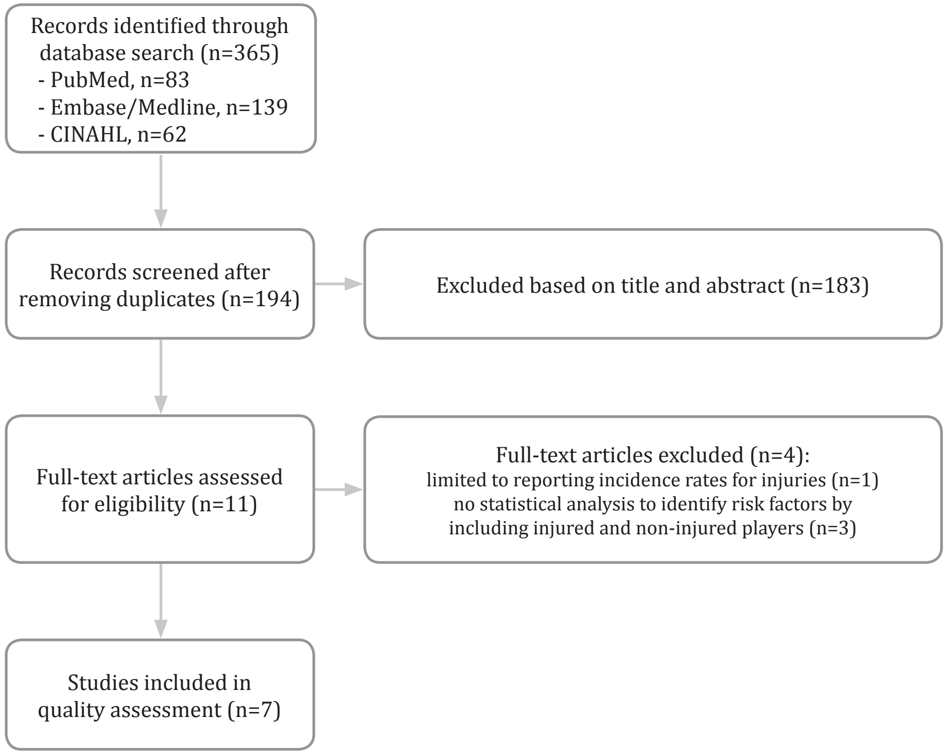
SD=standard deviation, BMI=body mass index, CI=confidence interval, OR=odds ratio, ROM=range of motion, RR=relative risk, HQ=hamstring to quadriceps, SEM=standard error of the mean, MRI=magnetic resonance imaging.

Table 9.2: Criteria list for assessment of the methodological quality of prospective studies.[164]

Item/ Study (by first author)	Árnason et al.[9] (2004)	Croisier et al.[33] (2008)	Engebretsen et al.[64] (2010)	Fousekis et al.[73] (2011)	Hägglund et al.[91] (2006)	Henderson et al.[102] (2010)	Witvrouw et al.[202] (2003)
1. Adequate description of source population[a]	+	+	+	-	+	?	?
2. Adequate description of sampling frame, recruitment methods, period of recruitment, and place of recruitment (setting and geographic location)[b]	+	-	+	-	+	-	-
3. Participation rate at baseline at least 80%, or if the nonresponse was not selective (show that baseline study sample does not significantly differ from population of eligible subjects)	+	-	-	+	+	?	-
4. Adequate description of baseline study sample (i.e., individuals entering the study) for key characteristics (n, age, gender, level)[c]	+	-	-	+	+	+	-
5. Provision of the exact n at the follow-up measurement	+	+	+	+	+	+	+
6. Provision of exact information on follow-up duration	+	+	-	+	+	+	-
7. Response at follow-up was at least 80% of the n at baseline	+	-	+	+	-	+	+
8. Information on not selective nonresponse during follow-up measurement(s)[d]	n.a.	-	-	n.a.	-	n.a.	n.a.
9. Adequate measurement of determinants: done by objective measures (e.g., performance test) and not by self-report (selfreport = –; no/insufficient information = ?)	+	+	+	+	+	+	+
10. Determinants were assessed at a time prior to the measurement of the health outcome (injuries)	+	+	+	+	?	+	+
11. Adequate measurement of the health outcome (injuries): done by medical expert (i.e., physician, physical therapists) and not by self-report (selfreport = –; no/insufficient information = ?)	+	+	+	+	+	+	+
12. The statistical model used was appropriate[e]	+	-	+	+	+	+	+
13. The number of cases/events was at least 10 times the number of the independent variables	-	n.a.	+	-	+	-	-
14. Presentation of point estimates and measures of variability (CI or SE) >> model	+	+	+	+	+	+	-
15. No selective reporting of results	+	+	+	+	?	+	+
Methodological score *	7	4	7	7	6	6	6

** This score is assigned by counting the positively scored items on the validity/precision criteria: 3, 7-13, 15. A study was considered of high quality if this score was at least 5 of 9.*
[a] Rating of criteria: + = yes; – = no; ? = unknown, n/a = not applicable. [b] Adequate = sufficient information to be able to repeat the study. [c] + is given only if adequate information is given on all items. [d] + is given only if nonselective dropout on key characteristics is reported in the paper. [e] + is given if a multivariate regression model was used.

Figure 9.1: Flow chart literature search and selection.



The included studies in this review used univariate as well as multivariate analyses to identify risk factors for sustaining a hamstring injury. The results of these analyses can be found in Table 9.3 and are illustrated in the following paragraphs.

Univariate analysis

Six studies used univariate analysis to identify risk factors for a hamstring injury.[13,33,64,91,102,202] The following risk factors were studied.

Age

Three articles reported that players who sustained a hamstring injury were significantly older.[9,91,102] One other article did not find this significant age difference between injured and uninjured players. However, age was identified as a potential predictor of increased injury risk (p=0.09) in this study.[64]

Hamstring function

One study identified hamstring function to be significantly associated with injury.[64] Players completed the Hamstring Outcome Score (HaOS), which includes five major components (symptoms and stiffness, pain, soreness, function in sports, and quality of life) that may determine hamstring function.

Hamstring length or hamstring flexibility

Witvrouw et al.[202] showed that players with a hamstring muscle injury had significantly lower hamstring flexibility before the injury compared with the uninjured group. Three articles reported that hamstring length or hamstring flexibility was not significantly different between injured and uninjured players.[9,64,102]

Previous injury

Three studies reported that a previous hamstring injury was a significant risk factor for a new hamstring injury.[9,64,91]

Strength imbalances

Croisier et al.[33] used concentric and eccentric isokinetic assessments of the hamstring and quadriceps muscles to identify soccer players with strength imbalances. They found a significantly increased rate of hamstring muscle injury in subjects having strength imbalance compared with players showing no imbalance in preseason. Henderson et al.[102] reported no significant differences between injured and non-injured players with various isokinetic measures of leg strength.

Other possible risk factors

None of the following factors were identified as significant risk factors in the articles included in this review: 40 meter sprint test,[64] agility run,[102] body composition (% fat),[9] body mass index,[9,64,91] height,[9,64,91,202] jump tests (counter movement jump (CMJ),[9,64,102] CMJ one leg,[9] non-CMJ,[102] standing jump[9]) junior/senior national team matches,[64] level of play in previous season,[64] maximal average power,[9] Nordic hamstring test,[64] number of injuries between the dominant and non-dominant leg,[202] peak O_2 uptake,[9] peak torque,[102] player position,[64] player training and match exposure,[9,202] training/match ratio,[9] weight,[9,64,91,202] and YoYo Intermittent Endurance Test (YIET, level 2).[102]

Multivariate analysis

Six of the included studies had used a multivariate analysis.[9,64,73,91,102,202] All available information from these analyses is presented below.

The multivariate logistic regression analysis by Árnason et al.[9] revealed age and previous hamstring injuries to be significant predictor variables for sustaining a hamstring injury.

The regression coefficient for age was 0.20±0.05 in the univariate analysis and 0.33±0.09 in the multivariate analysis. The regression coefficient for previous injury was 2.48±0.49 in the univariate analysis and 2.45±0.62 in the multivariate analysis, indicating that previous injury is a confounding factor for age, but not vice versa. Weight and body fat were also included in the multivariate analysis, but were not found to be significant.

Table 9.3: Examined risk factors in the included studies.

	Univariate analysis	Multivariate analysis
Significant	Age * 1, 5, 6 Hamstring function 3 Hamstring length/flexibility * 7 Previous injury 1, 3, 5 Strength imbalances (untreated) * 2	Age * 1, 5, 6 Eccentric isokinetic strength asymmetries 4 Functional leg length asymmetries 4 Hamstring length/flexibility * 6, 7 Non-counter movement jump 6 Previous injury 1, 3, 4, 5
Non-significant	40m sprint test 3 Age * 3 Agility run 6 Body Mass Index (BMI) 1, 3, 5 Body composition 1 Counter movement jump 1, 3, 6 Counter movement jump one leg 1 Hamstring length/flexibility * 1, 3, 6 Height 1, 3, 5, 7 Level of play 3 Maximal average power 1 National matches 3 Non-counter movement jump 6 Nordic hamstring test 3 Number of injuries between the dominant and non-dominant leg 7 Peak O2 uptake 1 Peak torque 6 Player exposure 1, 7 Player position 3 Standing jump 1 Strength imbalance (HQ ratio) * 6 Training/match ratio 1 Weight 1, 3, 5, 7 YoYo Intermittent Endurance Test (YIET, level 2) 6	Adductor muscle flexibility 7 Age * 3, 4 Anterior knee laxity 4 Anthropometrics 4 Body composition 1 Gastrocnemius muscle flexibility 7 Hamstring length/flexibility * 4 Hamstring function 3 Hamstring isokinetic strength 4 Height 4 Knee functional strength ratio 4 Lean mass 6 Number of injuries between the dominant and non-dominant leg 7 Player position 3 Proprioception 4 Quadriceps muscle flexibility 7 Weight 1, 4

** Contradictory evidence is reported for this risk factor. HQ=hamstrings to quadriceps.*
1, Árnason et al.[9]; 2, Croisier et al.[33]; 3, Engebretsen et al.[64]; 4, Fousekis et al.[73]; 5, Hägglund et al.[91]; 6, Henderson et al.[102]; 7, Witvrouw et al.[202].

The multivariate analysis by Engebretsen et al.[64] showed that previous acute hamstring injury was the only significant risk factor. Age, player position and hamstring function (based on the Hamstring Outcome Score [HaOS] total score) were considered as other factors to predict which players would be more prone to sustaining a hamstring injury, but were not significantly related.

Previous hamstring injury and increasing age were significantly associated with hamstring injury in the multivariate analysis by Hägglund et al.[91]. No other factors were included in the model.

The analysis by Fousekis et al.[73] revealed three significant predictors of hamstring strain occurrence: eccentric hamstring strength asymmetries, functional leg length asymmetries and previous hamstring injuries. The first two increased the odds ratio (OR) of injury, while the third decreased it. According to Fousekis et al.[73] players with an eccentric isokinetic strength asymmetry of >15%, a functional leg length asymmetry of >1.8 cm and no previous injury (OR<1) were at greater risk of suffering a non-contact hamstring injury than those with less pronounced or no asymmetries and hamstring strain injury. The article did not state whether other risk factors were included in the multivariate analysis.

Henderson et al.[102] showed that a model containing age, lean mass, non-counter movement jump and active range of hip flexion of the dominant limb was significantly associated with increased risk for hamstring injury in the dominant limb. This model successfully discriminated between subjects with a higher propensity for hamstring injury and those with a lower propensity, correctly classifying 88.6% of cases. Of the four variables in the model, only lean mass did not make a unique significant contribution (p=0.068).

Among all of the variables for musculoskeletal injuries measured and described by Witvrouw et al.[202] only decreased flexibility of the hamstrings was identified as a significant risk factor for the occurrence of hamstring injury. The articles did not state exactly which other risk factors were included in the multivariate analysis.

Discussion

This review has provided more insight into risk factors associated with hamstring injuries among male adult soccer players. Several risk factors were investigated in univariate and/or multivariate analyses.

A look at the univariate analyses shows that no significant risk factor has been identified by all relevant studies. However, older age and previous injury were identified as significant factors in three out of four studies.[9,64,91,102] Conflicting evidence was reported for hamstring flexibility[9,64,202] and strength imbalances.[33,102] Due to the multifactorial nature of hamstring injuries, the use of multivariate analyses is preferable because this investigates the associations with a number of factors acting together.[18] Apart from the player's weight (which was not identified as a significant risk factor[9,73]) only two other possible risk factors, viz. previous injury and age, have been tested in multivariate analyses in more than one study.[9,64,73,91,102] Previous injury was identified as a significant risk factor in all of these studies,[9,64,73,91] age in three out of four.[9,91,102] This is consistent with the outcome of the univariate analyses.

Previous hamstring injury is the most commonly recognized risk factor for new hamstring injuries,[9,72,109,110,150] although it is still unclear whether re-injury is due to slow healing, inadequate rehabilitation, or premature return to play, or is due to an active risk factor that caused the first injury and has remained unknown.[51,72,100,110,160] The results of the present review confirm the importance of a previous injury in relation to hamstring injuries in soccer players. However, the results of the multivariate analyses are conflicting, since Hägglund et al.[91], Engebretsen et al.[64] and Árnason et al.[9] reported that players with a previous hamstring injury are at greater risk for an injury in this muscle group, while according to Fousekis et al.[73] previous hamstring injury actually decreases the odds of a new injury. These contradictory results might be explained by the differences in injury history, determined at baseline. Of the articles reviewed here, two reported on study samples consisting of players who had no injury history over a specified period.[73,202] Witvrouw et al.[202] described that none of the players had a history of muscle injury in the lower extremities in the previous two years. Of the 249 players who had preseason testing, 103 players were excluded because their injury history or were cut, traded, or sent to another team before or during the season. Hence, this study could not identify the impact of a previous injury on a recurrent hamstring injury, but monitored an unbiased population to identify possible risk factors. While Fousekis et al.[73] reported that all players in their study had been free of injury for at least 6 months prior to testing at baseline and their study found that players having no previous injury were at greater risk of sustaining a hamstring injury than players with a previous injury.[73] As stated before, three articles show that players with a previous hamstring injury are at greater risk for sustaining another hamstring injury. It is important to know when the previous injuries occurred: within the previous year, ever, etcetera. However, two articles did not describe the time period in which the previous injury was sustained.[9,64] The other article recorded previous injuries during the preceding season, so within ten months.[91] For future research it is recommended to define the time period which was used to record previous injuries.

Age has also been identified as a common predictive factor for sustaining hamstring injuries, but this was not evaluated or established in all studies included in this review.[9,91,102] The mean age of the injured players differs in the included studies and ranged from almost 23 to 26 years. Besides the fact that one study[202] did not specify the age of the players, the difference in findings could be due to differences between studies in terms of the age profile of the participants. The age profile could be related to the level of play of the participants. Since this varies in the different studies, also the age of the players differs. Although one included study in this review showed that the risk factor age is independent from previous injury, an explanation of the common finding that players with a hamstring injury were significantly older than uninjured players could be that the likelihood of older soccer players having suffered a previous hamstring injury could be greater than that of younger soccer players.[102]

Apart from age and previous injury, hamstring flexibility has been investigated as a potential risk factor for hamstring injuries. Findings by Witvrouw et al.[202] and Henderson et al.[102] suggested that preseason testing of the flexibility of the hamstrings can identify players at risk of developing muscle injuries. These two studies using multivariate analyses, found that players with reduced hamstring muscle flexibility are at significantly higher risk for injuries.[102,202] Other studies, however, reported contradictory findings.[9,64,73,155] Differences in conclusions regarding flexibility may be explained by the measuring methods. Several tests are available to assess hamstring muscle flexibility: active and passive straight leg raise test, active and passive knee extension test and a number of differing sit-and-reach tests.[15] Two of the studies in which reduced flexibility was not found to be a significant risk factor had measured the flexibility of the hamstring muscles with passive knee extension,[9,64] whereas two other studies, in which reduced flexibility was found to be a significant risk factor had measured the supine straight leg raise test.[102,202] The discussion of how to measure hamstring flexibility is ongoing since 1982.[56] Nevertheless, a "gold standard" has not been clearly established.[37] Therefore, it is difficult to interpret the different conclusions regarding hamstring flexibility.

Some considerations need to be taken into account when interpreting the results of the studies included in our review. A potential weakness of the included articles is that all six articles which used a multivariate analysis had methodological limitations, in that their sample sizes were too small to detect slight to moderate associations. As discussed by Bahr & Holme[18] this needs to be carefully considered when using a multivariate statistical approach. Detecting moderate to strong associations requires 20-50 injury cases, while small to moderate associations would need about 200 injured subjects.[18] Four out of six studies reported enough injured cases to detect moderate to strong associations.[9,64,91,202] Larger studies using multivariate analysis are needed to detect small to moderate associations. A second limitation is that not all possible risk factors were investigated in the included studies. Some factors, e.g. the surface of the soccer field, could conceivably play a role in causing a hamstring injury, but non-local risk factors were not examined in the studies. Posterior thigh symptoms may be local, but also referred. For example, referred symptoms may be due to the lumbar spine or the sacroiliacal joint.[109,110] Finally, there were no pre-defined criteria for what constitutes a hamstring injury: as shown in Table 9.1 the definition of a (hamstring) injury differs between the studies. Croisier et al.[33] defined a player as being injured when the physical complaint caused four weeks of missed playing time. While in the other studies players had to miss at least one training/match and/or receive medical treatment to be defined as injured. Therefore, it is possible that the paper of Croisier et al.[33] only included players with more severe injuries. In addition, there may have been a wide variety in reported diagnoses, due to the use of different criteria. The injuries were reported by a range of professionals, e.g. medical staff and/or team personnel, and different types of diagnostic tools, for example physical examination, MRI scanning and/or ultrasound examination may have been used. Despite the fact that all injuries described in the included studies met our selection criteria, using well-defined outcomes contributes to the quality of a study and the interpretation of the results.

A limitation of our review is the assessment of the methodological quality of the included studies. Several quality assessment tools are available, and the assessment used in the present study distinguished between methodological quality and the quality of the report. Although the methodological quality items are relevant, judging methodological quality remains subjective and difficult in some cases. This is why we had two reviewers scoring the items; consensus was always reached after discussion.

It is particularly the modifiable risk factors which can be used in the creation of adequate prevention strategies. Although studies to identify risk factors have yielded conflicting evidence, studies investigating interventions based on modifiable risk factors are available. However, Goldman & Jones[84] reported in a systematic review that there is insufficient evidence and not enough confirmation from randomized controlled trials (RCTs) to draw conclusions on the effectiveness of interventions used to prevent hamstring injuries. One of their recommendations was that rigorously conducted and sufficiently powered randomized controlled trials are warranted to determine the effects of, for instance, eccentric hamstring muscle strengthening on the rate of acute hamstring injuries.[84] Petersen et al.[159] designed a 'good quality RCT' to study whether eccentric hamstring strength training could lower the incidence of hamstring injuries. Their training programme was able to reduce the injury rate of new and recurrent injuries.

Perspective

This systematic review is the first to focus on potential risk factors for hamstring injuries in male adult soccer players. More knowledge about risk factors would make it possible to identify players at risk in outdoor soccer and to design adequate prevention strategies. The evidence from the high-quality studies with multivariate analysis shows that previous hamstring injury is most strongly related to hamstring injury. Conflicting evidence is found for age and hamstring length or hamstring flexibility. Certain factors have been investigated in several included studies and have never been identified as a significant risk factor. Therefore, it is likely that these factors, e.g. BMI, counter movement jump, height, player exposure and weight, do not play an important role in causing a hamstring injury. Prospective studies with larger populations and multivariate analysis are needed to better determine local and non-local risk factors related to the occurrence of hamstring injuries in male adult soccer players. Studies using similar methods and/or identical populations are recommended to better interpret the findings of these studies.

10

General discussion

In 2007, the Royal Netherlands Football Association (KNVB) asked us to investigate the preventive effect of a new injury prevention programme, called "The11", in the largest group of active participants in soccer, namely adult male soccer players. This final chapter discusses the main conclusions of this research project. Based on the findings presented in this dissertation, it also discusses practical implications and offers some recommendations for future research.

Previous research included two studies (both included in the review in chapter 2) investigating the effect of The11. One study with Swiss male junior soccer players showed significantly fewer injured players in the intervention group.[122] In contrast, the other study reported no injury prevention effect in Norwegian female junior soccer players, most likely because compliance with the programme was low (the injury prevention programme was used in 52% of all training sessions).[177] The aim of our study was to investigate the effectiveness of The11 in adult male amateur soccer players. We hypothesized that its ten exercises, when integrated in the warm-up of each training session during an entire season, would have a preventive effect on injury incidence and/or injury severity compared to usual training sessions without The11.

Contrary to our hypothesis, we did not find significant differences in the overall injury incidence or injury severity between the intervention and control groups, although the study did result in a cost-saving effect. The cost savings might be caused by a preventive effect on the (generally long-lasting and expensive) knee injuries in the intervention group. Unfortunately, the additional cost-effectiveness analysis offered no added value since the intervention programme had no preventive effect on soccer injuries in one season. In conclusion, there are doubts that The11 is an effective intervention to prevent soccer injuries in this particular population of adult male amateur soccer players. Possible reasons why the programme did not have a significant effect on injuries in our study, included the limited number of two training sessions per week that were available to perform the programme, as well as an ineffective intensity and the limited specificity of the programme.

Optimizing soccer injury prevention programmes

Based on the results described in this dissertation, there is a need to further optimize injury prevention programmes for adult male soccer players. The Fédération Internationale de Football Association (FIFA) revised the original The11 programme to The11+ a few years later (after we had received the grant to perform our RCT). This revised version includes key exercises of The11, as well as additional exercises to provide variation and progression. It also includes a new set of structured running exercises. These changes are intended to improve both the preventive effect of the programme and the compliance by coaches and players. Finally, the revised programme is expected to be better suited as a complete warm-up programme for training and matches.[175] However, we believe further improvements are needed to reduce injury rates in adult male soccer players.

One suggestion to optimize soccer injury prevention programmes is to modify the dosage of the exercises. Both frequency and intensity of exercises are very influential. In our RCT, players performed The11 an average of 1.3 times a week. It is plausible to assume that this frequency is not sufficient to ensure the effectiveness of the intervention programme for these players, since physiological adaptations can be expected in soccer players training at least 2-3 times a week (e.g. strength training, 4-5 repetitions in 4 series, 85-90% of one repetition maximum) for 8 weeks.[107] Nevertheless, a study by Soligard et al. showed that the revised version The11+ could prevent injuries in young female soccer players who performed the intervention programme at exactly the same average frequency as in our study (i.e. 1.3 times per week).[175] However, the exposure time in their study was three times longer in teams with high compliance than those with low compliance (1.5 vs. 0.2 injury prevention sessions per player per week).[176] Since compliance was highly correlated with total exposure time in their study, and since exposure increases with skill levels, these results suggested that high compliance teams played at higher competitive levels than low compliance teams. This implies that The11+ is effective for young female soccer players, especially at higher levels (implying more exposure to soccer). One modification in The11+ relative to The11 is the progression in number of repetitions of exercises during the season. The positive effect found by Soligard et al. could also suggest that the intensity of the The11 exercises in our study may not have been sufficient to achieve adequate preventive effects in this population.[175,176] For example, exercise 3 of The11 is the so-called 'Nordic Hamstring' exercise. It has been shown in male soccer players that a gradual increase in the number of repetitions over a period of 4 weeks (from two sets of 5 to three sets of 8–12 repetitions) increases eccentric hamstring muscle strength and decreases the rate of hamstring strain injuries.[9,147,159] This graded protocol comes close to that implemented in The11+. In contrast, the Nordic Hamstring exercise protocol in The11 involves only a single set of five repetitions, which does not vary through the season. This is in contrast with the common method of progressive overload, which prescribes that muscles need to be overloaded to stimulate adaptive processes of the body in order to increase or maintain physical strength.[139] The lack of gradual increase in The11 might mean that the intensity of at least some of the The11 exercises was not sufficient to reduce the injury rate in our adult male amateur soccer players.

An associated issue in the potential effect of an intervention programme is compliance.[179] Before we started our RCT, previous research had shown that compliance with The11 tends to be low.[177] We therefore, tried to improve compliance by monitoring the training sessions, providing incentives and organizing meetings with the coaches and

paramedics of the participating teams (see chapter 3). Despite previous suggestions that compliance might be an important cause of not finding positive effects of prevention programmes, the compliance in our study was good. The exposure data revealed that teams completed The11 in 73% of all training sessions and players did so in 71% of the sessions they attended. These results were achieved by ten teams of the intervention group, while the coach of one team declined to perform The11 during the training sessions of his team. But an per-protocol analysis of the effects of the intervention programme (so without the non-compliant team) yielded similar, not significantly different, results were found. In the two Norwegian studies with The11 and the The11+, team compliance rates were 52% and 77%, respectively.[175,177] Although latter study explained the improved compliance from the increased variation and progression of exercises in The11+, our study resulted in similar compliance rates with the original version of the programme. It is therefore questionable whether the modifications made to the content of the programme have influenced compliance. In addition, a recently published meta-analysis revealed that the estimated preventive effects were relatively stronger in studies with better compliance (i.e. 64%) with the intervention.[80] This view is confirmed by Soligard et al.[175,176], since they showed that the risk of overall and acute injuries was reduced by more than a third among players with high compliance compared to players with intermediate compliance. Finally, it is important, however, to see the above-mentioned percentages in perspective. Even if compliance in our study was close to 100%, players performed the intervention programme (only) twice a week, which still may not be sufficient to prevent soccer injuries.

One of the other key factors that need reconsideration is the content of the soccer injury prevention programmes. Establishing which specific exercises have favourable effects on injury incidence and/or injury severity requires more knowledge about the risk factors and injury mechanisms of soccer injuries. Preventive measures should then focus on the modifiable risk factors. The aetiology of sports injuries is known to be multifactorial.[144] According to step 2 of the 4-step model of injury prevention proposed by Van Mechelen et al.[188] –"establishing the aetiology and mechanisms of sports injuries"– studies on the aetiology of those injuries require a dynamic model that accounts for the multifactorial nature of these injuries. In addition, a complete description of the mechanisms of a particular injury type in a given sport needs to account for the events leading to the injury situation (playing situation, player and/or opponent behaviour).[128] We have to keep in mind that it is impossible to prevent all soccer injuries by performing injury prevention exercises. Some actions (e.g. foul tackles) will frequently lead to injuries, regardless of preventive measures. Unfortunately, the data from our RCT were not very suitable to use to identify risk factors and/or mechanisms of soccer injuries. Although we did collect some baseline characteristics of the participating players before the start of the intervention season (predominantly anthropometric variables like BMI and sports-related variables such as exposure and playing position), we did not collect more specific physical data. Performance tests could provide valuable information on potential risk factors.[58,63,74,151] For instance, it seems reasonable to hypothesize that explosive athletes with a dominant fast-twitch muscle fibre type would be more prone to strain injuries. This hypothesis has been tested by Engebretsen et al.[63], but they concluded that neither the 40-m sprint test nor the counter-movement jump test result was associated with injury risk in male soccer players. We conducted a literature review to study risk factors for hamstring injuries in male adult soccer players (chapter 9), since many risk factors for this type of injury are mentioned in the literature, but the findings are contradictory. We choose this specific injury because hamstring strains represent one of the most prevalent injury types in both amateur and professional soccer and a significant proportion of these injuries are recurrent injuries.[111] Based on the results of our literature review we concluded that previous hamstring injury is the strongest predictive factor for hamstring injury. Conflicting evidence has been reported for age and hamstring length or flexibility as risk factors for the occurrence of hamstring injuries. Since unambiguous evidence about modifiable risk factors for hamstring injuries is lacking, it remains difficult to incorporate this information into preventive measures. In conclusion, obtaining further knowledge about risk factors and injury mechanisms will result in a clearer understanding of the way a particular exercise modifies a risk factor. This can then be used to specify which exercises needs to be included in a soccer injury prevention programme.

Implementing injury prevention programmes

The findings reported in this dissertation enable several practical implications to be formulated. Firstly, we can conclude that injury prevention for soccer players remains very important, not only in view of the high incidence rates found in the epidemiological studies presented in this dissertation (chapters 6 to 8) but also based on the opinions of players and coaches participating in our studies. At the end of the intervention season, we asked the players and coaches of the intervention group to fill in a questionnaire to assess their attitudes towards The11 and injury prevention in general, as recommended by Finch in her TRIPP stage 5 –"understand the intervention implementation context including personal, environmental, societal and sports delivery factors that may enhance or be barriers".[69] Unpublished results from our study showed that 110 players (53%) returned the questionnaire. Although the players estimated that injury risk is low during training sessions (69%) and matches (46%), almost three quarters of them believed that it is important to pay attention to injury prevention during training sessions. All coaches (n=11) indicated that including injury prevention in training sessions is important. These findings underline the importance of preventing soccer injuries and the potential role of coaches.

The second implication concerns the start of implementing injury prevention. It may be more beneficial to implement preventive measures in activities with junior players from age 14 years onwards, as their compliance may be better than that of a population of senior players, and physical exercises (focusing on e.g. core stability, neuromuscular control and agility) have more effect in young players, since they have not yet developed their basic movement pattern.[175]

Finally, our study has yielded several practical experiences. The replies to the aforementioned questionnaire allowed us to conclude that 55% of the players in the intervention group of our study were moderately to highly motivated to perform The11 during each training. An average one third of the players reported each exercise to be "boring". Coaches and players believed that "Bench", "Sideways bench" and "Hamstrings" are the most important exercises of The11 to prevent soccer injuries. These three exercises are ground exercises. The experiences of players and coaches showed that teams did not like to perform these exercises on the training field, especially if the training took place on artificial turf or if the natural grass field was in poor condition and/or the weather condition was autumnal or wintry. The participating teams avoided these situations, which resulted in two alternatives. All teams appreciated our gift of exercise mats, and most teams used the mats in the abovementioned situations. Other teams preferred to do the ground exercises indoors before the start of the training session. We realize that monitoring the performance quality, i.e. whether the The11 exercises are performed correctly, is also crucial. FIFA emphasizes this in their recommendation: "For all exercises, correct performance is of great importance. Therefore, the coach should supervise the programme and correct the players if necessary." (www.f-marc.com). We examined the content of the training sessions of all participating teams by regular, random and unannounced visits. The purpose of these visits for teams in the intervention group was to monitor the actual use and implementation of the The11 intervention programme. While the visits to the control group were scheduled to observe their actual warm-up and to record possible self-initiated preventive measures in their warm-up, specifically those that also are part of The11. A standardized form was used to score and evaluate the training sessions, at least twice a month during the entire season, in terms of injury-prevention activities (duration and type of exercises) for both research groups. These observations led us to conclude that the quality of performance of The11 exercises varied between teams and also within the programme (some exercises are easier to perform than others). We also concluded that none of the teams in the control group systematically performed exercises of The11.

Future research

Various aspects need further investigation in order to reduce injuries among adult male soccer players. According to step 2 of the Van Mechelen et al.[188] model –"establishing the causes of an injury"– research should focus on identifying risk factors for specific injuries. The occurrence of injuries is influenced by the players' age, gender, type of sport, and skills level. Knowledge about these causes can subsequently help to identify players at increased risk of injury. The literature shows that the effectiveness of a particular injury prevention measure could be different in different populations.[103] For instance, The11 includes five exercises with a major focus on balance and knee alignment. It is well-known that female players have a 2-3 times higher ACL injury risk than male players.[193,201] Therefore, a positive effect of The11 on injuries may be more likely in female soccer players than in male soccer players, which might be supported by the findings of our RCT among a male soccer population. In addition, most studies have focused on intrinsic risk factors, but improving extrinsic factors or reducing or eliminating inciting events could also be beneficial in preventing injuries. Fair play and/or rule compliance could help to decrease injury risk as well.[5,79] However, it is still unclear whether this is true, as a few recent studies on long-term injury surveillance among soccer players reported conflicting findings.[7,22,27,52] In conclusion, more knowledge about the risk factors and mechanisms of soccer injuries would also make it possible to optimize injury prevention measures.

The next step will be to introduce preventive measures focusing on the risk factors identified (step 3 of the Van Mechelen et al.[188] model). When it becomes possible to identify players at increased risk in different populations, prevention programmes should target only those players at risk. This "tailor-made" prevention approach is especially relevant in professional soccer, since it is easier to incorporate individual or extended training sessions in the professional setting compared to the amateur setting. The structure of a generic programme like The11 (focusing on multiple joints and/or muscle groups) is more suitable for amateur teams with (only) 2-3 training session per week. Nevertheless, amateur players could also do specific exercises at home or before/after a training session, possibly together with their team, to increase the frequency of the exercises for better injury prevention results. FIFA also advises doing the exercises of The11+ regularly, i.e. at least twice a week (www.f-marc.com). In addition, future research should look into the effect of specific exercises to prevent soccer injuries. Such research should at least cover the most frequently reported soccer injuries, viz. ankle, knee, hamstring and groin injuries. Future studies should also elucidate which exercise intensity, frequency, type and durations leads to preventive effects on injury incidence and/or injury severity.

Finally, it is vitally important for researchers to pay attention to stages 5 and 6 of the TRIPP model, after a preventive measure has proved to be effective. It is necessary to understand the implementation context to ensure that researchers know what works in the "real world".[70,71] For this purpose, regular and unannounced visits to all participants (as we did in our RCT) are essential to monitor the implementation of the intervention in practice. This relates to the advice that research findings should be widely disseminate to the persons involved, and researchers should interact with medical and paramedical practitioners, players and coaches. More advanced communicating tools, like social media or mobile phone apps, could play a role in these implementation stages to improve the dissemination of research evidence, and also increase compliance with the preventive measure by the target populations.[171]

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Summary & Samenvatting

Sport is considered a vital element of an active and healthy life-style that reduces the risk of various diseases. Soccer is one of the most popular sports worldwide and challenges physical fitness by requiring a variety of skills at different intensities. However, it also causes the largest number of injuries each year (18% of all sports injuries) in the Netherlands.

The aim of this dissertation is to contribute to the body of evidence on injury prevention for adult male soccer players. It reports on the effectiveness and cost-effectiveness of an injury prevention programme in terms of injury incidence and injury severity in this population. It also presents information about the epidemiology and aetiology of soccer injuries.

Chapter 1 is a general introduction and presents the "sequence of prevention" model proposed by Van Mechelen et al. (1992). This four-step model describes how epidemiological sports injury research should ideally be performed. This chapter discusses all four steps and presents background information for each of them. The chapter also addresses some important procedures regarding injury prevention research.

Injury prevention for soccer players

The first part of this dissertation deals with injury prevention. From the review described in **chapter 2** we concluded that there is conflicting evidence for the effectiveness of exercise-based programmes to prevent soccer injuries. These generic (non-specific) preventive training programmes involve different exercises focusing on multiple joints and/or muscle groups and aim to prevent of the most common soccer injuries. Such multifaceted programmes are widely applicable, because there is no need to first determine which players are at risk. We believe that the general structure of such programs can be useful for numerous adult male soccer teams, because they are cost-free and can often be easily incorporated in regular training sessions.

Chapters 3 to 5 then describe the study design and results of our randomized controlled trial (RCT) investigating the effectiveness and cost-effectiveness of FIFA's "The11" programme for Dutch adult male amateur soccer players. After one season, we did not find significant differences in the overall injury incidence or injury severity between the intervention and control groups, although the intervention did result in a cost-saving effect. In conclusion, there are doubts that The11 is an effective programme to prevent soccer injuries in this particular population of adult male amateur soccer players. The lack of additional effect compared to the control group may have been caused by the limited number of training sessions per week that were available to perform the programme (two sessions), as well as the limited specificity of the programme, and possibly also the ineffective intensity.

Soccer injuries in adult male soccer players

Based on the model by Van Mechelen et al. and having found no preventive effect of The11 on injury incidence among male amateur players, we used the data we had collected to establish the extent of the injury problem for this particular group and to gain more insight into injury characteristics. **Chapter 6** presents the main findings of this study: almost 60% of Dutch amateur soccer players sustained at least one injury during one competitive soccer season, and approximately one third of these injuries resulted in absence from soccer play for at least one month. The most common diagnoses were muscle/tendon (38%) and joint/ligament injuries (23%) of the lower extremities. In addition, 14% of the injuries were recurrent injuries and these caused longer absence than new injuries. We also observed that more than 1 in 4 players (27%) still reported complaints after regaining the ability to fully take part in soccer activities. Hence, players resuming soccer activities after an injury should be given special attention, to resolve the remaining complaints and to prevent re-injuries.

Chapter 7 provides information on injuries in Dutch professional soccer players. The most common diagnosis among this population was also muscle/tendon injury of the lower extremities (33%). Their overall injury incidence was 6.2 (5.5-7.0) injuries per 1,000 player hours; 2.8 (2.3-3.3) in training sessions and 32.8 (28.2-38.1) in matches.

In **chapter 8**, the injury data from the professional and amateur cohorts are compared. The overall injury incidence was higher in the amateur cohort, as was the incidence during training. In contrast, the injury incidence during matches was higher among the professional players. Finally, professional players sustained more overuse injuries whereas the amateurs reported more severe injuries and more recurrent injuries.

Risk factors and injury mechanisms for soccer injuries

Soccer injuries result from a complex interaction of multiple risk factors and events. Many risk factors are mentioned in the literature, but the findings are contradictory. We therefore conducted a literature review to study risk factors for hamstring injuries in male adult soccer players (**chapter 9**). We concluded that previous hamstring injury is the strongest predictive factor for hamstring injury. Conflicting evidence was found for age and hamstring length or flexibility as risk factors for hamstring injuries.

Finally, **chapter 10** offers a general discussion, reflecting on the main findings of our studies. Two crucial themes in injury prevention research are discussed, namely optimizing injury prevention programmes and implementing such programmes. The chapter ends with several recommendations for future research.

Sport wordt beschouwd als een belangrijk element van een actieve en gezonde leefstijl, waardoor het risico op allerlei ziekten vermindert. Wereldwijd is voetbal één van de meest populaire sporten. Omdat in het voetbal diverse vaardigheden op verschillende intensiteiten uitgevoerd dienen te worden, is lichamelijk fitheid van de speler een vereiste. Desondanks veroorzaakt voetbal in Nederland de meeste blessures per jaar (18% van alle sportblessures).

Dit proefschrift bevat nieuwe kennis over blessurepreventie bij volwassen, mannelijke voetballers. De (kosten)effectiviteit van een blessurepreventief oefenprogramma op de incidentie en ernst van blessures bij deze doelgroep wordt beschreven. Daarnaast komen bevindingen over epidemiologie en etiologie van voetbalblessures aan bod.

Hoofdstuk 1 is een algemene inleiding waarin het "preventie-sequentie" model van Van Mechelen e.a. (1992) gepresenteerd wordt. Dit model beschrijft in vier fasen hoe epidemiologisch sportblessureonderzoek idealiter uitgevoerd zou moeten worden. In dit hoofdstuk worden alle fasen uitgebreid beschreven en toegelicht. Tot slot behandelt dit hoofdstuk enkele belangrijke procedures met betrekking tot het uitvoeren van blessurepreventie-onderzoek.

Blessurepreventie voor voetballers

Het eerste deel van dit proefschrift gaat over blessurepreventie. In het review beschreven in hoofdstuk 2 concludeerden we dat er tegenstrijdig bewijs is voor de effectiviteit van oefenprogramma's ter voorkoming van voetbalblessures. Deze generieke preventieve programma's bevatten verschillende oefeningen die focussen op diverse gewrichten en/of spiergroepen, met als doel dat ze de meest optredende voetbalblessures voorkomen. Zogenaamde multi-component programma's zijn breed inzetbaar, omdat het niet nodig is om vooraf te bepalen welke spelers een verhoogd blessurerisico hebben. De algemene structuur van dergelijke programma's kan zeer bruikbaar zijn voor talrijke voetbalteams, omdat de programma's zonder extra kosten toepasbaar zijn en vaak gemakkelijk in een reguliere training geïntegreerd kunnen worden.

Hoofdstuk 3 tot en met 5 bevatten vervolgens de studie-opzet en de resultaten van ons gerandomiseerd onderzoek, waarin de effectiviteit en kosteneffectiviteit van het FIFA-programma "De11" bij Nederlandse volwassen, mannelijke amateurvoetballers onderzocht werd. Na één seizoen vonden we geen significante verschillen in de blessure-incidentie of de ernst van blessures tussen de interventie- en de controlegroep. De interventie resulteerde echter wel in een kostenbesparend effect. We kunnen concluderen dat er twijfels zijn dat De11 een effectief programma is om blessures te voorkomen bij deze doelgroep van volwassen, mannelijke voetballers. Drie mogelijke redenen voor het ontbreken van een positief effect zijn: het beperkt aantal beschikbare trainingen per week (2) waarin het programma uitgevoerd werd, de beperkte specificiteit van het programma en mogelijk ook de te lage intensiteit van het programma.

Voetbalblessures bij volwassen, mannelijke voetballers

Gebaseerd op het model van Van Mechelen e.a. en het feit dat we geen preventief effect van De11 op blessure-incidentie bij volwassen, mannelijke amateurvoetballers vonden, hebben we de verzamelde data gebruikt om de omvang van het blessureprobleem en inzicht in de blessurekarakteristieken bij deze specifieke groep vast te stellen. In **hoofdstuk 6** worden de belangrijkste bevindingen van deze studie beschreven. Bijna 60% van de Nederlandse volwassen, mannelijke amateurvoetballers liep minstens één blessure op tijdens het competitieseizoen. Ongeveer een derde van deze blessures leidde tot sportverzuim van minimaal één maand. De meest voorkomende diagnoses waren spier/pees- (38%) en gewricht/band- (23%) blessures aan de onderste extremiteiten. Ook bleek dat 14% van de blessures een herhaling van een eerdere blessure was en dat deze blessures langer sportverzuim veroorzaakten dan nieuwe blessures. Daarnaast zagen we dat meer dan 1 op de 4 spelers nog restklachten had nadat ze hun voetbalactiviteiten weer volledig opgepakt hadden. Spelers zouden tijdens hun revalidatie dus speciale aandacht moeten krijgen voor een verantwoorde sportterugkeer. Indien hun klachten volledig verdwenen zijn, kunnen recidieven voorkomen worden.

Hoofdstuk 7 geeft informatie over blessures bij Nederlandse profvoetballers. De meest voorkomende diagnose bij deze populatie was ook spier/pees-blessures aan de onderste extremiteiten (33%). De blessure-incidentie was 6,2 (5,5–7,0) blessures per 1,000 voetbaluren; 2,8 (2,3–3,3) tijdens trainingen en 32,8 (28,2–38,1) tijdens wedstrijden.

In **hoofdstuk 8** worden de blessuredata van amateurs en professionals met elkaar vergeleken. De blessure-incidentie was hoger bij de amateurs, evenals de incidentie tijdens training. Echter, de blessure-incidentie tijdens wedstrijden was hoger bij de profs. Tot slot liepen profvoetballers meer geleidelijk ontstane blessures op dan amateurs, terwijl amateurs meer recidieven en ernstige blessures rapporteerden dan profs.

Risicofactoren en blessuremechanismen voor voetbalblessures

Voetbalblessures ontstaan door complexe interactie van verschillende risicofactoren en acties. Veel risicofactoren zijn beschreven in de literatuur, maar de bevindingen hierover zijn tegenstrijdig. Daarom hebben we een literatuurreview uitgevoerd, waarin we onderzochten wat de risicofactoren voor hamstringblessures voor volwassen, mannelijke voetballers zijn (**hoofdstuk 9**). We concludeerden dat een eerder opgelopen hamstringblessure de sterkst voorspellende factor voor een hamstringblessure is. Voor de risicofactoren leeftijd en hamstringlengte of –flexibiliteit vonden we tegenstrijdig bewijs.

Dit proefschrift wordt afgesloten met een algemene discussie in **hoofdstuk 10**. Hierin worden de belangrijkste bevindingen van onze studies besproken. Twee cruciale thema's in relatie tot ons onderzoek worden bediscussieerd, namelijk het optimaliseren van blessurepreventieve programma's en het implementeren van dergelijke programma's. Het hoofdstuk eindigt met diverse aanbevelingen voor vervolgonderzoek.

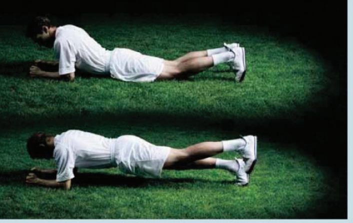
Appendix: poster The11

The 11

The Prevention Programme

1 The bench

Head, shoulders, back and hips in a straight line, parallel to the ground. Elbows directly under the shoulders. Lift one leg a few centimetres off the ground and hold this position for 15 seconds. Repeat 1-2 times for each leg.



2 Sideways bench

Upper shoulder, hip and upper leg in a straight line parallel to the ground. Elbow directly under the shoulders. From above, shoulders, elbow, hips and both knees are in a straight line. Hold this position for 15 seconds and don´t drop the hips. Repeat twice each side.

3 Hamstrings

Ankles pinned firmly to the ground by a partner. Slowly lean forward keeping upper body and hips straight. Keep thighs, hips and upper body in a straight line. Try to hold this straight body alignment, using the hamstrings, for as long as possible, then control your fall. Repeat 5 times.

4 Cross-country skiing

Flex and extend the knee of the supporting leg and swing the arms in opposite directions in the same rhythm. On extension, never lock the knee, and don't let it buckle inwards. Keep pelvis and upper body stable and facing forwards. Keep pelvis horizontal and don't let it tilt to the side. Flex and extend each leg 15 times.

5 Chest-passing in single-leg stance

Keep knees and hips slightly bent. Keep weight only on the ball of the foot, or lift heel from the ground. From the front, hip, knee and foot of the supporting leg should be in a straight line. Throw a ball back and forth with a partner. 10 times on each leg.

6 Forward bend in single-leg stance

As for Exercise 5, but before throwing it back, touch the ball to the ground without putting weight on it. Always keep knee slightly bent and don't let it buckle inwards. 10 throws on each leg.

7 Figures-of-eight in single-leg stance

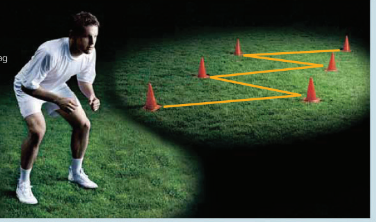
As for Exercise 5 but before throwing it back, swing the ball in a figure-of-eight through and around both legs: first around the supporting leg with the upper body leaning forward, and then around the other leg standing as upright as possible. Always keep knee slightly bent and don't let it buckle inwards. 10 throws on each leg.

8 Jumps over a line

Jump with both feet, sideways over a line and back, as quickly as possible. Land softly on the balls of both feet with slightly bent knees. Don't let knees buckle inwards. Repeat side-side 10 times and then forwards-backwards 10 times.

9 Zigzag shuffle

Bend knees and hips so upper body leans substantially forward. One shoulder should always point in the direction of movement. Shuffle sideways through the Zigzag course as fast as possible. Always take off and land on the balls of the feet. Don't let knees buckle inwards. Complete course twice.



10 Bounding

Bring the knee of the trailing leg up as high as possible and bend the opposite arm in front of the body when bounding. Land softly on the ball of the foot with a slightly bent knee. Don't let knee buckle inwards during take-off or landing. Cover 30 metres twice.

11 Fair Play

A substantial amount of football injuries are caused by foul play, so the observance of the Laws of the Game and especially Fair Play are essential for the prevention of football injuries. Play fair!

Dankwoord

Tijdens mijn promotietraject heb ik gemerkt dat onderzoek doen en een proefschrift schrijven diverse gelijkenissen heeft met het voetbalspel. Beide doe je in een team, het is allebei dynamisch en afwisselend, beide vereisen zowel fysieke als mentale fitheid en door vooraf bedachte tactieken verloopt het allebei soepel(er). Op deze manier terugkijkend, vond ik het afgelopen jaren in ieder geval erg leuk om deze 'sport' te beoefenen. Ik had daarbij een sterk team om me heen. Promoveren doe je namelijk niet alleen en heel graag bedank ik dan ook iedereen die een bijdrage geleverd heeft!

Deelnemers

Allereerst degenen die aan het SCORE-onderzoek deelgenomen hebben: trainers die wekelijks de speelminuten van hun team registreerden, verzorgers die de blessures van hun spelers rapporteerden en natuurlijk de amateurvoetballers zelf die het interventieprogramma tijdens de trainingen uitvoerden, vragenlijsten invulden en/of deelnamen aan de fysieke testen. Zonder jullie medewerking was het niet mogelijk geweest om zo'n mooie, uitgebreide dataset samen te stellen. Ook jullie praktijkervaringen heb ik als zeer waardevol ervaren. Alle mensen van de 1e klasse clubs uit district Zuid I en Noord (zaterdagafdeling, 2009-2010) die bijgedragen hebben aan het succesvol verlopen van het onderzoek, bedankt voor alles!

Hoofd- en assistenttrainers

Beste Frank, nogmaals hartelijk dank voor je vertrouwen als promotor, waardoor ik in november 2008 kon beginnen aan mijn promotieonderzoek. Ook bedankt dat je me in de daaropvolgende jaren met raad en daad bijgestaan hebt. Ik vond het prettig dat de drempel om bij je aan te kloppen nooit hoog was.

Beste Ingrid en Janine, in de loop van mijn promotietraject kregen jullie beiden een formele rol als co-promotor. De discussies die we gevoerd hebben waren leerzaam, jullie reacties op mijn vragen volgden vaak snel en tussendoor was het ook nog eens heel plezierig. Kortom, ik heb veel geleerd van jullie alledrie, bedankt voor de fijne samenwerking!

Medische en technische staf

Hier begin ik graag met mijn Sport-collega's Mark en Sandor. Mannen, ik heb prettig met jullie samengewerkt aan dit voetbalonderzoek. Jullie inhoudelijke kennis, maar zeker ook de praktijkervaringen uit de voetbalwereld, kwamen zeer goed van pas. Heel erg bedankt, ook voor jullie fijne omgang! Vervolgens de andere collega's uit de Q5-gang: Karin, Jaap J en Jaap T. Bedankt voor jullie gezelligheid op de werkvloer. En niet te vergeten Marrette, bedankt voor de ondersteuning afgelopen jaren.

Daarnaast wil ik alle sportartsen, fysiotherapeuten, onderzoekers, secretaressen en leiding van de afdeling Revalidatie, Verplegingswetenschap & Sport hartelijk danken.

Mede door jullie aanwezigheid vond ik het een hele verbetering om van het kille Q-gebouw naar de kantoortuin in bouwdeel W te verhuizen.

Ook de contacten met medepromovendi waren zowel leerzaam als gezellig. Anne, Christel, Lotte, Maureen en Matagne, door jullie aanwezigheid werden de RMI-activiteiten een stuk leuker. Ook de andere Hoogstraat-onderzoekers wil ik bedanken voor hun bijdrage aan de methodologiebijeenkomsten. Last but not least, Thomas, bedankt voor de ontspannen lunchwandelingen en –spelletjes met je kamergenoten.

Hoewel mijn proefschrift al vergevorderd was toen ik in Leiden kwam werken, wil ik mijn huidige TNO-collega's bedanken voor hun interesse afgelopen maanden.

Naast alle collega's hebben ook diverse KNVB-medewerkers een zeer belangrijke bijdrage geleverd aan het onderzoek. Zowel degenen werkzaam op de districtskantoren Noord en Zuid I als de mensen in Zeist: hartelijk dank voor jullie enthousiaste medewerking. Dit maakte het een stuk makkelijker om de deelnemers te (blijven) motiveren. Daarnaast heb ik zelf ook erg genoten van het voorrecht dat we tijdens het interventieseizoen met het onderzoeksteam (en afgevaardigden van de deelnemende clubs) diverse interlands en bekerwedstrijden bezochten. Bedankt allemaal!

Stagiaires

De dataverzameling was nooit zo compleet geweest zonder de inzet van verschillende stagiaires. Karin en Esther, jullie wil ik hartelijk danken voor de geweldige inzet tijdens de vele (koude) voetbaltrainingen en testavonden tijdens het seizoen 2009-2010. Daarnaast hebben enkele stagiaires hun (afstudeer)scriptie met behulp van SCORE-data geschreven. Dat leverde zinvolle input voor de data-analyse en uiteindelijke rapportage op. Ook hebben twee stagiaires een belangrijke basis gelegd voor de systematische reviews in dit proefschrift. Nick en Astrid, bedankt voor jullie enthousiaste inzet en de prettige samenwerking! Jullie eerste publicaties zijn binnen. En ik hoop dan ook dat ik in de toekomst bij jullie promoties aanwezig kan zijn.

Raad van Advies

De kwaliteit van het SCORE-onderzoek werd bewaakt door een stuurgroep met allerlei experts. Ardine, Han, Janet, Jasper, Kim, Michel, Peter, Ton en nogmaals Ton, bedankt voor jullie inzet tijdens de stuurgroepbijeenkomsten! Dit heeft het onderzoek naar een hoger niveau gebracht. Daarbij wil ik enkele stuurgroepleden bedanken voor hun waardevolle bijdrage als co-auteur.

Trainingskamp

Net als voetballers doen, ben ik ook op een internationaal trainingskamp gegaan. En wel in Noorwegen, bij het Oslo Sports Trauma Research Center (OSTRC). Dear Roald, thank you so much for giving me the opportunity to gain foreign working experience at

the OSTRC. Dear Kathrin, thank you for welcoming me into the OSTRC-research group. You have become one of the co-authors of the epidemiological paper about injuries in Dutch male amateur soccer players. It was a pleasure working with you. I really enjoyed my stay in Oslo and also the spring seminar in Kleivstua (climax of my exchange period). Dear Norwegian PhD-candidates and all other ones: takk NIH-kollegas. Being able to work with international colleagues is a joy. I hope we will stay in touch the coming years and will be able to start research together!

Vierde officials
Heren van de beoordelingscommissie, prof. dr. R.L. Diercks, prof. dr. B.W. Koes, prof. dr. L.P.H. Leenen, prof. dr. D.B.F. Saris, prof. dr. N.J. de Wit, bedankt voor het positief beoordelen van mijn manuscript. Ik zie er naar uit om 21 mei met jullie van gedachte te wisselen over mijn wetenschappelijke bevindingen.

Sponsoren
Zonder subsidies hadden de studies beschreven in dit proefschrift niet uitgevoerd kunnen worden. ZonMw en KNVB, hartelijk dank dus! Bovendien is dit proefschrift tot stand gekomen door financiële steun van Anna Fonds|NOREF, Coaches Betaald Voetbal, Nea International bv / Push braces & PSB Sportbraces, Nederlands Paramedisch Instituut, TNO, Universitair Centrum Sportgeneeskunde, Vereniging voor Sportgeneeskunde, waarvoor ik hen veel dank verschuldigd ben!

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Publiek en thuisfront
En dan als laatste, iedereen die tussendoor voor de broodnodige ontspanning heeft gezorgd. Na hard werken genoot ik altijd van de leuke (weekend)activiteiten en goede gesprekken met vrienden, familie en kennissen. Daar draait het om in het leven, bedankt dus voor alles! En ik hoop dat we in de toekomst nog veel leuke momenten samen mee maken.

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About the author

Curriculum Vitae

Anne-Marie van Beijsterveldt was born on 22 October 1981 in Tilburg, the Netherlands. In 1999, after completing secondary school at Cobbenhagencollege in Tilburg, she moved to Maastricht to study health sciences at Maastricht University. Four years later she obtained her Master of Science degree in movement sciences. The next year she started studying human movement technology at the The Hague University of Applied Sciences, obtaining her Bachelor of Engineering degree in 2006.

In the course of her studies, she developed a growing interest in sports research, which she put into practice when she started her PhD research project at the Sports Medicine department of the University Medical Centre Utrecht in 2008. Under the supervision of Prof. Frank Backx, she investigated the effectiveness of FIFA's injury prevention programme "The11" in terms of injury incidence and severity among adult male amateur soccer players, in close cooperation with the Royal Dutch Football Association (KNVB). During the spring of 2012, she worked for nine weeks at the Oslo Sports Trauma Research Centre in Norway. She completed her PhD project in December 2012.

Anne-Marie is currently continuing her applied research activities as a scientist at the Netherlands Organization for Applied Scientific Research (TNO) in Leiden, focusing on several sports-related projects.

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