SOCCER INJURY SURVEILLANCE AND IMPLEMENTATION OF AN INJURY PREVENTION PROGRAMME IN RWANDA

ASSUMAN NUHU

Thesis Presented for the Degree of
DOCTOR OF PHILOSOPHY
in the Department of Health and Rehabilitation Sciences
Faculty of Health Sciences
UNIVERSITY OF CAPE TOWN

Supervisors:
Dr Theresa Burgess
Professor Jennifer Jelsma

June 2018

DECLARATION

I, Assuman Nuhu, do hereby declare that the work on which this thesis is based is my original work, except where acknowledgements indicate otherwise. Neither the whole work nor any part of this thesis has been, is being, or is to be submitted for another degree in the University of Cape Town or any other university.

Assuman Nuhu

Signature: Signed by candidate

Date : 07 June 2018

DEDICATION

To my parents, for your support in every endeavour in my life, I appreciate in particular your struggle for our education that I appreciate more than you can imagine. "*My Lord, Have mercy on them both as they did care for me when I was little*" Qur'an, Surat 17: Verse 24.

To my wife, Uwase Fatuma and children Umutoniwase Nazneen and Hirwa Fahim. "Our Lord, grant me from my spouse and offspring the comfort of my eyes and make us the leaders of the pious" Qur'an, Surat 25: Verse 74.

ACKNOWLEDGEMENTS

I would like to thank Almighty God, for His blessings bestowed to me until completion of the research. Many thanks go to the University of Cape Town especially the Division of Physiotherapy for giving me the opportunity to learn from the globally renowned institution. I am grateful to the sponsor received from the Government of Rwanda though the Rwanda Education Board.

Deep and sincere gratitude go to my supervisor Dr Theresa Burgess for your guidance, encouragement and the source of inspiration to sincerity, perfection, autonomy, and excellence. I am also most grateful to my co-supervisor, Professor Jennifer Jelsma, for your motivation, dynamism, motherliness and high level of professionalism. I was privileged and honoured to study under your kind supervision and be assured that what I learnt from both of you will be cascaded down to the wider research community in Rwanda.

I would like to thank members of the Department of Physiotherapy at the University of Rwanda for being there for me professionally. More importantly, thanks to my PhD colleague Jean Baptiste Sagahutu for being there for me during challenging times.

I would like to sincerely thank my brothers, sisters, in-laws and friends for the countless spiritual and emotional support. Your support was of great value for me.

Finally, I would like to warmly thank all that helped me with data collection, FERWAFA staff, research assistants, coaches, medical personnel and all the players that participated in the study. The study would not be possible without your involvement, time and loyalty.

Many thanks to all that contributed to my study in one way or the other.

May God Bless you all.

ABSTRACT

Incidence, mechanism and risk factors for injuries in first division soccer players in Rwanda: a two-year prospective study

Background: There is growing participation in soccer at all levels of sport. Soccer increases the physical and psychological demands on players, which subsequently increase the risk of injuries. There are limited prospective epidemiological studies in Africa, and studies that have been conducted to date often fail to incorporate standardised injury definitions or reporting methods. Therefore, there is an urgent need to conduct epidemiological studies within the context of low to middle-income countries, where resources may be limited, and taking into consideration exposure times to design appropriate preventive measures.

Aim: The purpose of the study was to explore the nature and incidence of soccer-related injuries in first division players in Rwanda, and to establish intrinsic risk factors for injuries.

Methods: A prospective cohort study was conducted for two seasons. Eleven teams (326 players) and 13 teams (391 players) were followed for the seasons 2014-2015 and 2015-2016. Anthropometric and musculoskeletal screening composed of flexibility tests, strength and endurance, balance and proprioception tests, and lower limb function tests were conducted as well as training and match exposure were recorded. Team medical personnel recorded the location, type, duration and mechanism of time-loss injuries following the suggestion of the International Federation of Football Associations (FIFA). The primary outcome was the incidence of overall, training and match injury as well as body part, type, patterns and severity of injuries. Multivariate model using the Chi-squared Automatic Interaction Detection (CHAID) was used to assess intrinsic predictors of injury. Significance was accepted as $p<0.05$.

Results: There were 455 injuries and approximately 46% of the players were injured in each of the two seasons. The team weighted mean incidence of match injuries was significantly lower during season one (14.2 injuries/ 1000 hours) compared to season two (21.9 injuries/ 1000 hours) ($t(22)= -2.092$, $p=0.048$). No difference was observed in the team-weighted incidence for overall and training injuries between the two seasons. There was increased injury incidence with increased acute: chronic training and match workload ratios. Lower extremities were the most frequently affected over the two seasons (80% of all injuries), with the knee joint most commonly injured (28% off all injuries) followed by the ankle joint

(25% of all injuries). Ligament strains were the most common form of injury followed by muscle strains and contusions. The most common mechanisms of injury were collisions between players and receiving a tackle. About three quarters of the reported injuries were mild or moderate in severity and injuries to the Achilles tendon lead to the longest median lay-off time. The greatest incidence of injuries was sustained between the 46thand 60thminute of match play. A score of 11cm or less on the Sit and Reach test, more than one year in the current club and a timed hop of more than 2.5 seconds were all associated with injury.

Conclusions: The rate of injuries found in this study is lower compared to the studies that reported injuries in adult male at either professional or amateur level. The patterns of training and match injuries, location, type and severity of injuries are similar to previous studies. Flexibility and balance, and co-ordination emerged as being significant predictors of increased risk of injury. More studies with emphasis on intrinsic and extrinsic factors are needed to attain wider knowledge concerning injuries among soccer players in Africa. Prevention intervention is necessary to minimise the of lower limb injuries.

The impact of the FIFA 11+ programme: a randomised controlled trial

Background: The nature of soccer predisposes players to encounter an increased number of injuries over time, especially lower extremities injuries. Injured players may have therefore have limited opportunities to proceed to elite levels of play. The Medical Assessment and Research Centre (F-MARC) of the Federation of International Football Association (FIFA) developed the FIFA 11+ injury prevention warm up programme with the goal of reducing the incidence of injuries in soccer players. However, only a few studies have been conducted to study its effectiveness in soccer through randomised controlled trials (RCTs), with limited evaluation in African countries.

Aim: The purpose of the study was to assess the impact of a coach-led intervention on injury incidence and severity in second division soccer players in Rwanda.

Methods: A cluster randomized controlled trial with teams as unit of randomization was used among 24 teams (626 players) competing in the second division in Rwanda for the period of seven months. Twelve

teams (309 players) were randomised in the intervention group and 12 teams (317 players) formed the control group. During the preseason period, intervention group coaches received training in the FIFA 11+ soccer specific warm up, and were instructed to perform the FIFA 11+ for players at least three times a week during the training and matches. Control group coaches received training in first aid and were instructed to continue their usual warm up. Medical personnel recorded training and match time-loss injuries following the FIFA guidelines. Coaches' beliefs and injury prevention practice readiness were assessed though paper based questionnaires. Coaches recorded data pertaining to the compliance of the programme. Cluster-adjusted exposure, injury, and compliance data were used in the analysis. Descriptive statistics were used to analyse the demographic characteristics of the coaches and players. Independent t-test or Mann-Whitney U and Chi-Squared test were used for numerical and categorical data respectively. Odds ratios (OR) of the control/ intervention groups sustaining injuries was computed using the Epi-Info complex tables function. All ethical issues were considered.

Results: Other than increased levels of coaching experience, there were no differences between the demographic and licence level of the coaches. At the commencement of the study, very few coaches were in the preparation or higher stages of behaviour change regarding coaching practices. Within six months of receiving the training, several of the coaches in both the intervention and control groups had moved to the preparation phase and beyond. The only difference between the two groups was that each of the coaches in the intervention group were in the implementation of injury prevention phase at six months. Injuries were sustained by a total of 52% of all players, 63% in the control group and 40% in the intervention group. The overall, training and match incidence rates were all significantly lower in the intervention group ($p<0.001$). The odds and risk ratios for injuries were significantly higher in the control group for overall injuries but not for training and match injuries. The overall risk difference between the two groups was 10.65%, which was significantly higher in the control group. Team weighted incidence of lower limb injuries was significantly lower in the intervention group ($p<0.001$) as well as in thigh and groin ($p=0.002$), knee ($p=0.049$) and ankle ($p=0.005$) injury incidence. There was a 20% reduction in the risk of sustaining moderate and severe injuries in the intervention group. The teams carried out the injury prevention programme an average 3.6 times per week and at 77% of all training sessions and matches. Compliance levels did not have any impact on the incidence of any injury subtype.

Conclusion: The FIFA 11+ programme significantly decreased the incidence of overall, training, match injuries as well as lower limb injuries. The intervention increased coaches' awareness of their role in

injury prevention. There is a need to educate coaches and players regarding injury prevention strategies to be included their regular training taking into consideration context.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ACL	Anterior Cruciate Ligament
AT	Artificial Turf
ANOVA	Analysis of Variance
BMI	Body Mass Index
CAF	Confédération Africaine de Football
CHAID	Chi-squared Automatic Interaction Detection
CI	Confidence Intervals
ER	External rotation
FC	Football Club
FERWAFA	Fédération Rwandaise de Football Associations
FIFA	Fédération Internationale de Football Association
F-MARC	FIFA-Medical Assessment and Research Centre
HBM	Health Belief Model
HREC	Human Research Ethics Committee
ICC	Intra-class correlation coefficient
IQR	Interquartile Range
IR	Internal rotation
LEFT	Lower Extremity Function Test
MCL	Medial Collateral Ligament
MeSH	Medical Subject Heading
N	Number
NCAA	National Collegiate Athletic Associations
NISR	National Institute of Statistics Rwanda

OR	Odd Ratio
PACTR	Pan African Clinical Trial Registry
PCL	Posterior Collateral Ligament
PCMA	Pre-competition Medical Assessment
RCT	Randomised Controlled Trial
RICE	Rest Ice Compression Elevation
RR	Relative Risk
SD	Standard Deviation
SEBT	Star Excursion Balance Test
SPSS	Statistical Package for Social Sciences
TRIPP	Translating Research into Injury Prevention Practice
TTM	Trans-theoretical model
UEFA	Union Europeenne de Football Associations
USA	United States of America

GLOSSARY OF TERMS

Soccer or football: A game opposing two teams of 11 players played by kicking the round ball with the legs or heads aiming at entering it in the goal of the opposing side[1]. In the present study, the words soccer will be used.

Soccer Injury: "*Any physical complaint resulted for soccer participation"*[2].

- **Time loss injury**: "*Any injury causing the player to miss the next training session or match*"[3].
- **Traumatic injury**: "*Any injury suddenly occurring during soccer participation with known cause*"[3].
- **Overuse injury**: "*Any injury with gradual onset and no known trauma*"[3].
- **Recurrent injury**: "*Injury affecting the same body area and of the same type occurring after return to full soccer participation*"[4].
    - **Early recurrent**: "*Recurrent injury happening within 2 months of return to full participation*"[4].
    - **Late recurrent**: "*Recurrent injury happening 2-12 months after return to full participation*"[4].
    - **Delayed recurrent**: "*Recurrent injury happening more 12 month after return to full participation*"[4].
- **Injury severity**: "*Number of days of absence to full practice participation and match selection*"[4].

Injury prevention: The implementation of interventions to eliminate or reduce the likelihood and the severity of injuries caused by external or internal mechanisms before they occur[5].

CHAPTER 1. INTRODUCTION AND SCOPE OF THE THESIS

1.1 Background to the Study

Soccer is a highly practiced sport with 265 million players worldwide. Approximately 4% of the global population participate in soccer. Soccer is also popular in Africa, with more than 46 million players, which equates to 4.8% of the African population[6]. Participation in soccer has grown rapidly following the performance of African teams and players in the international arena. There has been a tremendous increase in the number of registered or unregistered teams with local soccer governing bodies; and therefore, many players and officials participate at all levels. The increased participation of young players in the game is an important sign of the growth of the game. It seems that soccer governing bodies at national and international levels are on the right track to make the game even more popular in the future[6].

Soccer players are at increased risk of injury compared to players in other sports and professions[7]. Hawkins et al[7] reported a 1000-fold increased rate of soccer injuries compared to industrial and occupational injuries. The development of the game worldwide requires African soccer players to work hard to reach their maximum potential and to participate at the top level of competition. Many youth players dream of becoming professional players in Europe[8]. Players experience increased physical and psychological demands, which subsequently increase the risk of sustaining injuries[9;10].

Epidemiological studies, predominantly of international players, have explored the characteristics of players[11;12;13], the frequency and characteristics of injuries[14;15;16;17], and the risk factors and causes of injuries[18;19;20]. Studies indicated an incidence of 4.7 to 21.8 overall injuries per 1000 hours of exposure among professional players[21;22;23;24]. A great variation of the rate of match injuries from 14.5 to 103.9 injuries per 1000 hours was also observed among published studies[25;26]. Training injuries varied from 2.4-13.8 injuries per 1000 hours across these studies[27;28]. The incidence of overall injuries was higher in professional players compared to amateur (5.1-9.6 injuries per 1000 hours)[29;30] and youth players (1.2-4.8 injuries per 1000 hours)[31].

A few research studies have attempted to determine the occurrence of soccer injuries in African players[32;33;34;34;35;36;36;37]. However, there is lack of uniformity between different epidemiological studies conducted in Africa.

For example, Owoeye et al[32] collected retrospective musculoskeletal injury data from hospitals over seven years[32]; whereas a prospective study investigated injuries during the West Africa Football Union Nations' Cup competition[33]; and Azubuike and Okojie[34] conducted a cross-sectional study of amateur and professional players who participated in a national soccer season from one city in Nigeria. Further, Lislevand et al[34] performed a cross-sectional study of 938 female children and youth soccer players participating in a two-day tournament in Kenya, and reported on match injuries considering player exposure time[34]. Similar methodology was used by Ani et al[35] to determine injuries in Nigerian male soccer players over one season[35]; and by Calligeris et al[36] to assess the incidence of injuries in 32 South African Premier Soccer League players during a full soccer season[36]. In addition, Jelsma et al[36] reported on the physiotherapy services provided to athletes that participated at the sixth All African Games and ascertained the injury prevalence of various sporting codes including soccer. Frantz et al[37] also evaluated injury incidence at a South African inter-provincial under-20 soccer tournament.

Limited research has been conducted in Rwanda, with three studies investigating injury prevalence and the need for physiotherapy interventions in male soccer players[38]; injury incidence in male high school players[39]; and factors associated with injuries in first division female soccer players[40] respectively. Unfortunately, there are many inconsistencies between studies with regards to injury definitions, methods of data collection and injury reporting. Further, comparisons between studies conducted in Africa and internationally are limited, as many of the African studies did not record player exposure time, which is paramount for epidemiological studies in soccer. Therefore, there is a strong need for well-designed studies that prospectively document injuries and exposure times of participants to identify risk factorsfor injury.

Teams and players encounter numerous challenges due to injuries resulting from soccer participation[41]. Players face problems related to missed training sessions and matches during treatment and rehabilitation of injuries. During the rehabilitation period physical form reduces, which may subsequently delay the return to soccer participation. Sports injury treatment may be challenging, lengthy, costly, and burdensome to players, the team and medical personnel[42;43]. Non-participation of injured players may also result in poor match performance and losses[44]. Injury prevention interventions are needed to minimise the burden of injuries and maximise the benefits of soccer participation[45].

1.2 Conceptual Framework for Injury Prevention Research

Injury prevention should be based on epidemiological research to counter the occurrence of injuries in sports[46]. The authors explained the steps to be followed while conducting sports injury research. The first step in injury prevention in sports is the establishment of the magnitude of the problem with incidence and severity. The second step is to discover factors related to the aetiology and mechanism of injuries. The third step is the introduction of measures that could minimise the occurrence of injuries based on the factors identified in the second step. The final step is to evaluate the effect of the intervention by repeating the procedure carried out in the first step. In 2006, Finch argued that an intervention may prove to be effective in a controlled research setting without taking into consideration that the wider context may not have the same effect. Therefore, the broader context should be considered with regard to athletes, coaches and sports bodies for the acceptance and compliance with an intervention programme[47]. Therefore, two steps were introduced and a new framework proposed, named the Translating Research into Injury Prevention Practice (TRIPP) (Figure 1-1).

Many studies have been conducted following the proposed model and interest has grown in the last decade. An extensive review of published studies indicated an increased number of injury prevention publications in the last 20 years[48]. In 2005, Engebretsen and Bahr[49] reported that RCTs increased by two-fold in the five preceding years[49]. Previous studies focussed mainly on protective equipment[50;51;52], but recent investigations focussed on training programmes and interventions, such as balance and coordination[53], stretching[54] and strength training[55]. Multi-intervention programmes have also been investigated[56;57;58]. Therefore, there is a constant need to update injury prevention body of knowledge because of the diversity of the studies and the rapid expansion of soccer as a sport.

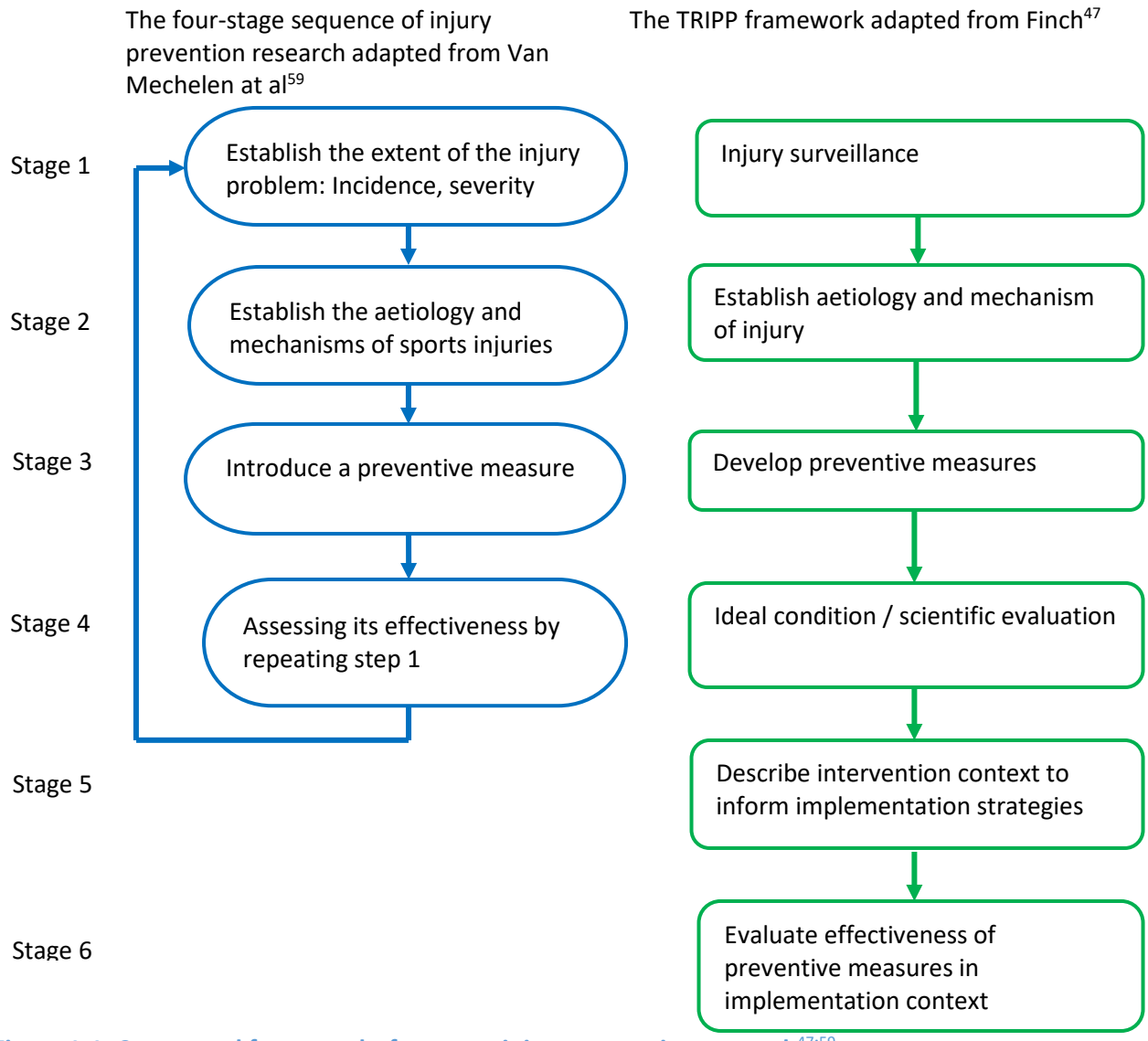


Figure 1-1: Conceptual frameworks for sports injury prevention research[47;59].

1.3 Research Setting

The empirical research components of this thesis were conducted in Rwanda, which is a land-locked country situated in central Africa with a surface area of 26338 km[260]. Rwanda is bordered by Uganda to the North, Tanzania to the East, the Democratic Republic of Congo to the West, and Burundi to the South. The most recent census conducted by the Rwanda National Institute of Statistics(NISR) in 2010 showed that the population of Rwanda was 12 million, with 54% of the population under 19 years of age[61]. This is seen as a huge opportunity by the government of Rwanda to develop talent and the sport of soccer specifically.

The performance of Rwanda in sports in the past decade has improved because of the interest and investment of the government and the population in different aspects. In its quest to be recognized a "*sporting*" nation, the government of Rwanda tries to fairly support all sports disciplines. There are approximately 26 national sports federations in Rwanda. Some of them have gained international recognition, namely, football (soccer), Paralympics, athletics, cycling, basketball and volleyball[38].

Currently, the Rwanda soccer governing body, the Federation of Rwandan Football Association (FERWAFA), is a member of the Confederation of African Football (CAF) and has been affiliated with the Federation of International Football Association (FIFA) since January 1976[62]. Each year, clubs from Rwanda are called upon to participate in tournaments that are organized by the regional, continental and world governing bodies. There are 16 clubs competing in the first division, which is the top level of competition; and 24 clubs in the second division male category, while 10 clubs participate in the female category. There are other soccer competitions organized at primary and secondary school- and university-levels that involve the participation of a great number of young sports men and women; however, school- and university-level sports are not the focus of this thesis[63].

The first division competition is the country's primary soccer competition, where each club plays other clubs twice during the season. At the end of the completion, the teams are ranked according to the total points accumulated during the season. In case of equal number of points, the goal calculation of the number of goals scored and conceded is used to determine the winner. The league winner qualifies to represent the country in the CAF champions' league, while the two lowest placed teams are relegated into the second division. Many teams in the first division are sponsored by private business companies or government institutions; for example, the police, the army and other governmental parastatals[63].

The second division teams do not play every team in the division, because of the large number of teams. Therefore, the teams are randomly divided into two groups. Teams in each group play each other and accumulate the points according to the win or draw rules. The first two teams in each group qualify to the semi-final stage where they play the teams from the other group. The winners of the semi-final stage qualify to the final and are automatically promoted to the first division[63].

In Rwanda, many young people participate in soccer at different levels. Players incur injuries as they increase their involvement in trainings and matches. Top level players sustain performance limiting injuries every year[64].

The predisposition to injuries may be associated with a number of conditions. Anecdotally, limited coaching skills may lead to poor preparation and conditioning of the players. Many teams also train on poor quality playing fields with poorly maintained grass or ground pitches. Therefore, many players may not have the opportunity to properly practice soccer and proceed to the top level of play. The development of the young players may also be affected due to psychological and behavioural problems associated with injury[65].

Moreover, many teams have insufficient financial resources and a shortage of medical personnel, which limits access to treatment and rehabilitation. There is a very poor medical coverage in the teams in Rwanda[38]. Anecdotally, almost all the medical personnel in the teams are working on a voluntary basis and for the love of the game. Many of the medical personnel are new graduate physiotherapists that do not have permanent jobs. Many team leaders and coaches also undermine the importance of employing medical support personnel. This is reflected in the salary allocated to the medical personnel, which is far less than other technical staff members. In addition, medical personnel often do not have sufficient support from team management to provide adequate treatment and rehabilitation to injured players. As a result, players may be forced to stop their careers at an early stage due to injuries. Therefore, there is a need for injury prevention interventions in Rwandan soccer that should be guided by knowledge of the extent of injuries in Rwandan soccer players.

1.4 Research Questions

This study aimed to answer the following questions:

1. What are the incidence, nature and pattern of injuries among in first division soccer players in Rwanda?
2. How does the injury incidence, and nature and pattern of injuries in first division soccer players in Rwanda compare to the findings in published literature, which is predominantly from players in high-income countries in the Global North?
3. What physiological and functional variables are associated with injuries to different body parts?
4. What is the impact of a coach-led injury prevention programme on the incidence and severity of injuries in second division soccer players in Rwanda?
5. What is the impact of an injury prevention programme on second division coaches' behaviours towards injury prevention practices in Rwanda?

1.5 Aims and Objectives of the Thesis

The purpose of this thesis was to explore the nature and incidence of soccer-related injuries in first division soccer players, and the impact of a coach-led intervention on injury incidence and severity in second division soccer players in Rwanda. This thesis is comprised of two major empirical studies: an injury surveillance study in first division soccer players; and an RCT of a coach-led injury prevention intervention in second division players respectively.

The objectives of the injury surveillance study were:

1. To determine the incidence, nature, severity and location of injuries among Rwandan first division soccer players for two consecutive seasons.
2. To determine the relationships between injury patterns and training and match times among Rwandan first division soccer players for two consecutive seasons.
3. To establish potential risk factors for injury in first division soccer players in Rwanda.

The objectives of the RCT of a coach-led intervention study were:

1. To assess if there are any reductions in the overall occurrence of injuries in the intervention group compared to the control group.
2. To assess if there are any differences in injury patterns in the intervention group compared to the control group.
3. To assess the impact of training on coaches' behaviours towardsinjury prevention practices.
4. To assess if the compliance to the injury prevention warm up programme is associated with a potential reduction in injuries.

1.6 Significance of this Thesis

Even though there are many benefits from soccer participation[66;67;68;69;70;71;72;73;74;75;76;77;78;78;79], there is also a risk of incurring related injuries and other illnesses associated with short- and long-term complications[41;42;43;44]. The present study is the first prospective research that followed up players for two consecutive seasons in African soccer. The study would provide the basis for establishing a surveillance system of injuries that would be adopted to be used in low-income countries specifically in Africa. Through the surveillance system, players, coaches, medical personnel and governing bodies would be aware of the incidence, patterns and severity of injuries.

The knowledge of risk factors of injuries in the most popular sport in Africa is scarce. The present study established intrinsic risk factors for injuries through multivariate analyses that would serve as the model for future research with similar objectives. Practically, the information obtained in the surveillance results would inform evidence based prevention interventions informing the role of each stakeholder in the endeavour.

In addition, the present study provided the results of athropometric measurements and functional test that would be incorporated in the pre-season assessment of players. The present study described the anthropometric measurement and functional test that are easy to use, do not require sophisticated materials and may be conducted on the training ground. Therefore, this study showed that it is possible to conduct the pre-season examination of the players with minimal resources in teams that do not have sufficient financial support especially in African context.

The study showed the preventive effect of the FIFA 11+ warm up programme on the incidence and severity of injuries shows the need to incorporate the prevention programme in Rwanda to minimise the inherent risk associated with soccer participation. The results may be used to advocate to the wider soccer population to implement the programme; as well as to advocate for the incorporation of an injury prevention programme in the training package for the coaches at all the levels of soccer in Rwanda.

1.7 Organisation of the Thesis

The work is organised in six chapters to illustrate the development of the thesis. The first chapter provides the introduction and the rationale of the thesis. The chapter also introduces the burden of soccer injuries and the framework for prevention. The aims and objectives of the study are also stated in chapter One and ends with the synopsis of the thesis.

Chapter Two presents the literature review on the epidemiology of injuries specifically in male soccer players at all levels. The chapter focuses on the incidence of injuries at elite, amateur and youth level, with emphasis on type and location, severity, mechanisms and aetiology in terms of intrinsic and extrinsic factors leading to injury. The chapter includes studies that followed the FIFA-Medical assessment and research centre (F-MARC) recommendations for epidemiological studies.

Chapter Three includes the review of the musculoskeletal screening procedures in sports categorised in flexibility, strength and endurance, balance and proprioception, and functional testing. The chapter also present the reliability of the selected tests.

Chapter Four presents the results of the prospective epidemiological study conducted among first division male soccer players. The chapter explains the methodology used to collect data that follow the consensus statement for data collection in soccer. The procedure followed for musculoskeletal screening of the players is outlined. The chapter presents the results of the epidemiological data of injuries collected for the period of two seasons. The analyses of the risk factors for all and lower limb injuries are also presented. The chapter ends with the conclusion and recommendations.

Chapter Five consists of a literature review of the studies that presented injury prevention measures in soccer. Under different subheadings, the effect of injury prevention programmes was reviewed such as protective equipment, different types of training including strength, stretching, flexibility, balance and proprioception. Multimodal interventions have also been reviews as well as other modalities.

Chapter Six presents the results of the RCT that investigated the effect of an injury prevention programme on the reduction of injuries among second division male soccer players. The chapter presents the methodology used to assess the effect of the soccer specific warm up programme in the reduction of injuries. The results are presented in relation to the overall, lower extremity, location, types and severity of injuries. The chapter also discusses the results in the subsequent section. The conclusion and recommendations are provided.

The last chapter of the thesis provided the general conclusion of the thesis. The chapter also provides the recommendations for clinical implications as well as further research endeavours.

CHAPTER 2. LITERATURE REVIEW: EPIDEMIOLOGYAND RISK FACTORS FOR INJURIES IN MALE SOCCER PLAYERS

2.1 Introduction

Information on the incidence, nature and patterns of injuries constitutes the first step in injury prevention[59]. More importantly, understanding the causes and risk factors for injuries provides the benchmark for developing appropriate interventions[47;59]. This chapter reviews the literature on injuries sustained by youth and adult soccer players at both professional and amateur levels. The chapter also discusses the extent of injuries in terms of incidence, severity, time off play, and body parts affected. The review includes published research that follows the Federation of International Football Association Medical Assessment and Research Centre (F-MARC) guidelines for epidemiological studies in soccer[4]. The research includes cohort, longitudinal, and prospective studies that report the incidence of injuries sustained by soccer players considering exposure time. The review includes studies published from 2006, the year of the dissemination of the guideline.

Additional characteristics reviewed include risk factors contributing to soccer injuries and were classified into intrinsic and extrinsic risk causes. The chapter further reviews studies which reported on injury risk factors using univariate or multivariate analyses, as well as the mechanisms leading to soccer injuries. The review was not restricted to the time of publication due to limited studies that established the risk factors for injuries in soccer.

2.2 Literature Search

2.2.1 Literature sources and searches

The review was guided by a structured literature search and comprised of three steps. In step one, a computer-based database search utilising the University of Cape Town's open access databases was conducted querying for original research articles published in English or French during the period from January 2006 to July 2017. Several studies published prior to this period reported on the occurrence of injuries differently, making comparison difficult. Medical Subject Heading (MeSH) terms were used in Pubmed, including Medline (Table 2-1). Literature searches were also conducted in Scopus, Web of Science, EBSCOhost for CINAHL and Academic Search premier databases.

Following this, the list of titles and abstracts of studies generated by initial literature search were reviewed for relevance and a detailed examination of selected full-text copies was performed.

Finally, reference lists were examined to retrieve relevant citations and an additional manual search was conducted for additional studies.

Table 2-1: Search terms used in Pubmed and in other databases.

Key words	Search terms
Soccer	(("Soccer"[Mesh] OR ("soccer"[MeSH Terms] OR "soccer"[All Fields])) OR football[Title/Abstract]) OR "Sports"[Mesh]) OR ("sports"[MeSH Terms] OR "sports"[All Fields])) OR (team[All Fields] AND ("sports"[MeSH Terms] OR "sports"[All Fields]))) OR (("Contact"[Journal] OR "contact"[All Fields] OR "Contact"[Journal] OR "contact"[All Fields]) AND ("sports"[MeSH Terms] OR "sports"[All Fields]))) OR ("sports"[MeSH Terms] OR "sports"[All Fields] OR "athletics"[All Fields]))
Injury	((("Athletic Injuries"[Mesh] OR ("athletic injuries"[MeSH Terms] OR ("athletic"[All Fields] AND "injuries"[All Fields]) OR "athletic injuries"[All Fields])) OR (sports injured[All Fields] OR sports injures[All Fields] OR sports injuries[All Fields] OR sports injury[All Fields])) OR "Wounds and Injuries"[Mesh]) OR injur*[All Fields])) OR (wound injuries[All Fields] OR wound injury[All Fields])) OR "Sprains and Strains"[Mesh]) OR (strain[All Fields] OR strain*[All Fields])) OR (sprain[All Fields] OR sprain*[All Fields])) OR "Contusions"[Mesh]) OR (contusion[All Fields] OR contusion*[All Fields])) OR ("brain concussion"[MeSH Terms] OR ("brain"[All Fields] AND "concussion"[All Fields]) OR "brain concussion"[All Fields] OR "concussion"[All Fields])) OR ("Brain Concussion"[Mesh] OR "Post-Concussion Syndrome"[Mesh]))
Type of studies	((("epidemiology"[Subheading] OR "epidemiology"[All Fields] OR "incidence"[All Fields] OR "incidence"[MeSH Terms]) OR ("Incidence"[Mesh] OR "Epidemiology"[Mesh])) OR ("epidemiology"[Subheading] OR "epidemiology"[All Fields] OR "epidemiology"[MeSH Terms]))) AND ((("Cohort Studies"[Mesh] OR cohort studies[All Fields] OR cohort study[All Fields] OR cohort study objective[All Fields])) OR "Longitudinal Studies"[Mesh]) OR longitudinal studies [All Fields] OR longitudinal studied[All Fields] OR longitudinal studies[All Fields] OR longitudinal study[All Fields]))
Population	Search limited to human, male at all levels (Adolescent, high school student, teenage, child, amateur, elite, professional, semi-professional)
Aetiology	((((("aetiology"[Subheading] OR "aetiology"[All Fields] OR "causality"[MeSH Terms] OR "causality"[All Fields]) OR ("risk factors"[MeSH Terms] OR ("risk"[All Fields] AND "factors"[All Fields]) OR "risk factors"[All Fields])) OR "Risk"[Mesh]) OR cause[All Fields])

2.2.2 Definitions of injuries used in this study and reviews

The estimated incidence of soccer injuries can be determined if the amount of time players participate in training or matches is precisely recorded. The risk of incurring an injury is defined as the number of new injuries divided by the total time that players spend in either training sessions or playing matches[80]. The time is calculated and presented in terms of hours,while the injury incidence is presented in terms of 1000 hours of total exposure. As training and match exposure hours can be collected separately, injury rates can be further presented per 1000 hours of training or match exposure[81]. The following section discusses the results of studies that presented the incidence of injuries, while also considering individual training and match exposure.

2.2.3 Study Selection

Types of studies: The review included prospective cohort studies published in English or French describing the epidemiology of injuries (prevalence, incidence, type, distribution, severity). Studies on risk factors were also reviewed.

Types of participants: As the focus of this research, studies focusing on male players participating in soccer at any level were included in the review to further contribute toward the understanding of injuries in male players. The review included players from all age groups, ranging from children to adults. In addition, data collected from studies that were conducted on participants of both genders were also included in the review, provided that separate data for male and female players were obtained.

Types of outcomes: The review was limited to any data pertaining to the incidence, nature, and severity of injuries occurring as a result of playing soccer. All injury types were included ranging from acute (fractures, sprains, strains, concussion) to chronic and overuse injuries. The review incorporated studies that defined injury as "*any physical complaint resulting from soccer participation*"[4]. Specifically, studies that reported injuries restricting full soccer participation, classified as "*time loss*" [4] injuries were reviewed to allow for comparison among studies. Equally, studies which followed up players for a full season or tournament and thus presented data in terms of injury incidence (injuries per 1000 exposure hours) were also reviewed. Finally, studies that defined injury severity in terms of time away from soccer participation as well as studies that reported one or more risk factors in relation to the incidence of overall or specific types of injuries were included in this review[4].

2.2.4 Description of reviewed studies

General information was extracted pertaining to the level of play, gender, country, number of players involved, follow up period, type of injury, and methods of data collection used in each of the studies that were reviewed. Information on injury risk factors was also gathered from reports that used either univariate or multivariate analyses.

Globally, many studies have been conducted on soccer as a sports code. Several authors have contributed to the understanding of the extent of injuries in soccer, the majority of which conducted in Europe, either in specific countries like France[82;83;84;85], England[86;87;88], Germany[30;89;90], Norway[19;91;92], and Sweden[93;94] or with participants from two[95;96] or more countries where most teams selected to participate in competitions organised by the Union of European Football Associations (UEFA)[97;98;99;100]. A few of the studies reviewed related to South American countries such asin Brazil[28] and Argentina[26;101]. Three African studies, two in Nigeria[33;35] and one in South Africa[36], prospectively collected exposure and injury data among male soccer players. Few other studies were conducted among soccer players in Africa[102;103]. Furthermore, four out of six studies from Asia were conducted in Qatar[24;104;45;105], while the rest were conducted in Japan[106] and Saudi Arabia[107]. The aim of the present study is to expand the present situation of the deficiency of studies conducted on the African continent.

The review included studies from the United States of America(USA) which presented the incidence of injuries in terms of 1000 hours of exposure[108;109;110]. In contrast, several North American injury surveillance systems are noted as having established recording methods whereby a player participating in a training session or match constitutes a unit of risk[111;112;113]. These systems do not take into consideration training or match duration while computing individual exposure. Data from these studies were presented in terms of injuries per 1000 athlete exposure, which differs from studies that present data as injuries per 1000 hours of exposure. Nevertheless, these studies were not included in the review as the systems were found to be incomparable.

Most studies reviewed were conducted among male soccer players, however a further review of literature yielded eleven studies that explored the incidence of injuries among male and female soccer players. The incidence of injuries has been studied at across all age levels ranging from youth under nine years of age[87;96] to adolescent and youth soccer players between the ages of 12[109;84;85] to 19 years of age[114;115].

Additionally, several studies have been also conducted among adult soccer players participating at either elite or professional level[45;116], sub-elite, and semi-professional levels of play. Moreover, the narrative review search found that many studies were conducted among high-income countries, especially in Europe, with few publications emerging from middle- and low-income countries with a minority in Africa.

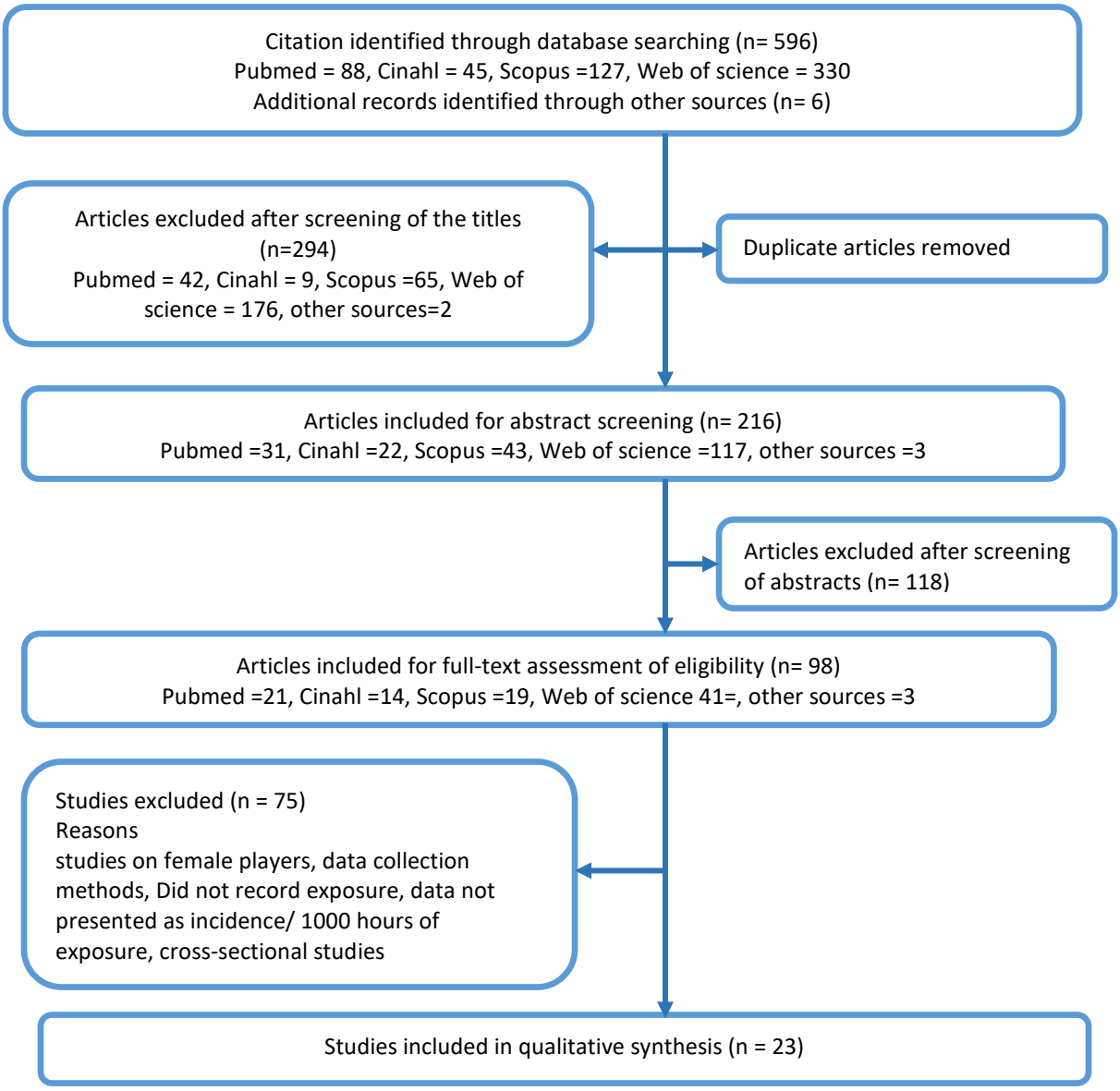


Figure 2-1: Flow chart of study selection process

The following sections discuss the incidence of injuries in male soccer players across amateur and professional levels and across youth and adult age groups. The review will discuss the anatomical location, type and severity of injuries reported in the studies. Finally, the review will discuss risk factors and mechanisms of soccer injuries as well as various screening tests for intrinsic risk factors.

2.3 Incidence of Injuries in Male Soccer Players

2.3.1 Incidence of injuries in elite and amateur soccer players

Almost all reviewed studies conducted among male soccer players at both adult and youth level focussed on professional or elite level of play[117;118;119;120]. There is a wide variation of the overall incidence of injuries among professional or elite level players ranging from 4.7 to 21.8 per 1000 hours of exposure[26;27;28;116]. A great variation of the incidence of match injuries was also observed among published studies varying from 14.5 to 103.9 per 1000 hours[26;45]. Training injuries also varied across these studies (2.4-13.8 injuries/1000 hours)[26;28] (Table 2-2).

An early study[26] conducted among players from a professional team in Argentina reported an incidence of match and training injuries as high as 103.9 and 13.8 per 1000 hours respectively. In contrast, another study conducted later among 54 elite soccer players in England reported lower incidences of match (77.89/1000 hours) and training (6.44/1000 hours) injuries over one season[25]. The incidence of injuries from the aforementioned studies is considered high compared to a further study conducted among 23 players from a single team in England[116] which yielded much lower results. Players sustained 87 match injuries and 32 training injuries within a two-year period. Taking into consideration the hours of exposure, the incidence of match and training was 54.1 and 6.7 per 1000 hours of exposure respectively. Similarly, a study conducted on a team of 32 soccer players in Scotland over two consecutive seasons reported match and training injury incidences of 48.7 and 3.7 per 1000 hours respectively[121]. Somewhat similar incidences were reported in other studies[27;28].

Upon review, the occurrence of injuries reported among sub-elite players appears to be somewhat lower when compared to their elite peers. A study conducted among sub-elite level professional players across four seasons in Spain reported an overall incidence of 10.9 injuries per 1000 hours of exposure, while the training and match injuries were 5.2 and 44.1 per 1000 hours of exposure respectively[27]. A further study investigating injuries among 456 amateur players over one season in the Netherlands reported lower general (9.6/1000 hours), training (3.9/1000 hours) and match (20.4/1000 hours) injury

incidences[30]. The authors of a later study reported a lower incidence of the overall (6.2/1000 hours) and training (2.1/1000 hours) injuries while match injuries (31.8/1000 hours) were higher among professional players followed up in the same period[122].

2.3.2 Incidence of injuries youth level soccer players

A number of predominantly European-based studies have been conducted among youth soccer players[31;84;123;124]. Some studies reported injuries in general[84] or on training and match injuries[123]. Other studies reported the occurrence of specific type of injuries in youth; for example the knee[125], the thigh[126], the ankle[86], and musculoskeletal injuries in general[114].

A study conducted among elite youth players under 16 years of age in France over a period of 10 seasons reported an incidence rate of 4.8 injuries per 1000 hours of soccer play[84]. The study found an incidence rate of 3.9 and 11.2 injuries per 1000 hours of training and match exposure respectively. In this cohort, younger players were found to have sustained more training injuries that their older peers.

Similar results were observed in a study conducted in England comparing the risk of injuries among 85 senior and 112 youth players. The study found that young players had a higher incidence of training and match (6.1 and 25.0/1000 hours) injuries compared to that of the senior players (4.2 and 23.2/1000 hours)[123]. The occurrence of injuries was also investigated where players participated in the pre-season period[124]. During the six-week pre-season period, the same pattern was observed, with a higher match injury incidence (6.8/1000 hours) than training injury incidence (1.8/1000 hours). Following the same players for the full season, the incidence of all (1.2/1000 hours), match (4.7/1000 hours) and training (0.9/1000 hours) injuries was less than that reported during the pre-season period[31] (Table 2-2).

Table 2-2: Prospective epidemiological studies in adult and youth professional and amateur players.

Reference Country, follow up period	Population (players)	Age (years)	Incidence (95% confidence interval)/ 1000 hours Mean ± standard deviation/ 1000 hours		
			Overall	Training	Match
Adult, Male					
Professional					
Dauty and Collon[21] France, 15 seasons	173 players	27.0±6.0	4.7±5.0 ‡ #		
Konopinski et al[25] England, 1 season	54 players	22.5±4.17	11.5±11.4#	6.4±8.3#	77.9±142.1#
Gallo et al[26] Argentina, 2 seasons	41 players	23.4±3.7	18.7	13.8	103.9
Mallo et al[27] Spain, 4 seasons	296 players	24.8±3.5	10.9 (8.7-13.0)	5.2 (3.8-6.6)	44.1 (33.6-54.6)
Reis et al[28] Brazil, 1 season	48 players	25.2±4.5		2.4	42.84
Van Beijsterveldt et al[30] Germany, 1 season (33 weeks)	456 players	24.8±4.2	9.6 (8.7-10.5)	3.9 (3.3-4.7)	20.4 (18.1-23.1)
Eirale et al[45] Qatar, 1 season	230 players	28.4±4.4	6.0 (4.9-6.5)	4.4 (3.7-5.2)	14.5 (11.6-18.0)
Bjorneboe et al[91] Norway, 6 years	14 teams	Not specified	4.8 (4.6-5.0)		
Aoki et al[106] Japan, 15 seasons	237 teams	Not specified			21.8 (21.0-22.3)
Owen et al[116] Not specified, 2 years	23 players	25.6±4.6	18.8 (14.7-22.9)	6.7(3.7-9.6)	54.1 (39.7-68.6)
Ekstrand et al[117] UEFA injury study, 7 seasons	50 teams	25.4±4.4	8.0±3.4#	4.1±2.0#	27.5±10.8#
Hagglund et al[118] European teams (UEFA champions League), 11 seasons	24 teams	Not specified	7.7±3.3#	4.0 ±2.1#	26.6±10.7#
Salces et al[119] Spain, 1 season	427 players	26.8±4.1	5.65	3.55	43.53
Stubbe et al[120] Netherlands, 1 season (39 weeks)	217 players	24.6± 4.3	6.2 (5.5-7.0)	2.8 (2.3-3.3)	32.8 (28.2-38.1)
Dupont et al[121] Scotland, 2 seasons	32 players	25.6±3.8	8.9 (7.6-10.3)	3.7 (2.7-4.6)	48.7(29.4-58.0)
Walden et al[127] Europe (northern and southern Europe), 9 seasons	1357 players	Not specified	Northern: 7.9 (7.7-8.1); Southern: 7.2 (6.6-7.4)	Northern: 4.08 (3.90-4.26); Southern: 3.52 (3.23-3.83)	Northern: 27.89 (26.64-28.75); Southern: 25.68 (23.87-27.62)
Carling et al[128] France, 4 seasons	31 ± 3 players/ season	Not specified			40.5 (33.5-47.5)
Amateur					
Sousa et al[29] Portugal, 1season	231 players	24.7 Range: 18-35	5.1 (4.3-5.9)	2.4 (1.8-3.0)	32.2 (23.1-41.3)
Amateur and professional					
Van Beijsterveldt et al[122]	763 players	Amateur: 24.8±4.2	Amateur:	Amateur:	Amateur:

Reference Country, follow up period	Population (players)	Age (years)	Incidence (95% confidence interval)/ 1000 hours Mean ± standard deviation/ 1000 hours		
Netherlands, 1 season (Amateur 33 weeks; Professional 36weeks		Professional: 24.6±0.06	9.6 (8.7-10.5); Professional: 6.2 (5.5-7.0)	3.9 (3.3-4.7); Professional: 2.1 (1.7-2.6)	20.4 (18.1-23.1) Professional: 31.8 (27.3-37.1)
Youth, Male					
Brito et al[31] Portugal, 1 season	674 players		1.2 (0.8-1.6)	0.9 (0.6-1.3)	4.7 (3.0-6.5)
Gall et al[84] France, 10 seasons	66 players	U14-U16 Elite youth	4.8*	3.9*	11.2*
Merron et al[123] England, 4 years	112 youth 85 senior	16-18 years		Senior: 4.2 Youth: 6.1	Senior : 23.2 Youth: 25.0
Brito et al[124] Portugal, Pre-season period (6 weeks)	912 players	12-19years	2.5 (1.6-3.5)	1.8 (0.9-2.7)	6.8 (2.9-10.6)

Results are presented as the author, country and follow up period. Injury incidence (95% confidence interval) or mean ± standard deviation per 1000 hours of overall, training and match injuries are presented.

Blank: Not reported *U: Under* **: Injury causing absence of* 48hours or more
‡: *Injury causing absence of 72hours or more* #: *Mean ± Standard deviation incidence per 1000 hours*

2.4 Soccer Injury Location and Type

2.4.1 Location of injuries

Injury location has been widely reported across the reviewed studies, with many studies reporting injured body parts in terms of percentages[23;26;27;30;84;91;106;116;121;124;128;120]. Consequently, the following review will use percentages to discuss the occurrence of injuries according to the body part affected.

Several studies reported that lower extremities were the most affected body parts, representing 66.0% to 89.0% of all injuries in adult soccer players[23;26;27;30;91;106;116;121;128;120], and 46.5% to 89.7% in youth soccer players[84;124;114;129] ; with a greater occurrence of injuries in the thigh, knee, ankle, and foot (Table 2-3 and Table 2-4).

An early study published in 2006 reported that the ankle (25.4%) was the most commonly occurring lower limb injury followed by the thigh (20.7%), knee (16.8%) and groin (9.4%)[26]. The results from a further study conducted among professional soccer players indicated that the most common lower extremity match injuries were in the knee (25.4%), followed by the ankle (25.4%), thigh (25.4%), and lower leg (25.4%)[128].

A different injury pattern was reported in a prospective study investigating acute traumatic match injuries among professional soccer players in Japan[106], with results indicating a higher proportion of thigh (22.1%) injuries followed by the knee (20.2%) and the ankle (19.2%). Similar patterns of lower extremity injuries were also found in other investigations among male professional players in Scotland[121], Norway[91], and several other European teams[23]. A recent study which investigated the incidence of injuries among professional soccer players found that the ankle joint (22.7%) was primarily involved in injuries followed by the lower leg (18.5%), the knee (16.0%), and the thigh (14.4%). However, contrasting results were noted in a study conducted among Dutch amateur players[30] with the most frequently injured body parts noted as being the thigh (25.2%), the ankle (18.2%), as well the knee (15.1%). A year later, the same authors reported the same pattern among professional players[122].

Conflicting patterns of lower extremity injuries were found among studies conducted in youth soccer players. A study conducted among young players from France indicated that the ankle joint incurred the highest proportion of injuries (17.8%) followed by the knee (15.3%) and the foot (8.2%). On the contrary, a prospective cohort study that followed 912 young players over the pre-season period indicated that the ankle was the least injured body part (13.0%)[124], with the thigh (23.0%) and the foot (17.0%) the most commonly injured. Two additional studies also reported thigh injuries as more common than injuries to other parts of the lower limb in youth players[114;129] (Table 2-4).

Specifically, thigh injuries represented 14.3% to 28.5% of all injuries in adult elite professional players[26;27;30;121;128] and 23.0% to 34.0% of injuries in youth players[114;126;124;129]. Many studies did not provide the details of the area of the thigh that was affected by the injury, as there was a greater focus on overall injuries rather than injuries to a specific area[26;27;30;121;114;126;124;128;129]. Some studies, however, indicated whether the anterior or the posterior thigh was affected by injury[23;30;120]. It was reported that the anterior thigh area accounted for 7.7% to 9.9% of all injuries[30;120]. Similarly, a large prospective study conducted among 2299 European professional male players from 51 soccer teams investigating the incidence of muscle injuries indicated that the anterior quadriceps were the most commonly injured in the thigh[23]. Studies that provided details of the exact area of injury collected the information with the assistance of experienced medical personnel. For example, four medical doctors and a physiotherapist employed by an Argentinean team reported anterior thigh injuries as quadriceps (14.0%) and Sartorius (3.0%) muscles[26]. Another study conducted among professional soccer players in Brazil indicated that the rectus femoris muscle sustained 46.4% of the anterior thigh injuries[28].

Posterior thigh injuries or hamstring injuries were the most prevalent, representing 11-28% of all acute soccer injuries[26;30;54;120;117]. Earlier literature subdivided acute hamstring injuries into two types according the mechanism of injury[130;131;132]. The first type of hamstring strain that affects most players is the long head of the biceps femoris muscle, which occurs when players are running at high-speeds. The second type of strain occurs when players perform movements that involve excessive lengthening of the hamstring muscle. This type of strain affects mostly the proximal tendons of the semimembranosus muscle[130;131;132]. However, there are no studies that have presented the incidence of injuries according to the two types of acute hamstring strains.

The comparison of the occurrence of groin injuries between studies presents a challenge as there is no clear definitions or criteria to be followed for diagnosing and presenting this type of injury. Some studies presented the occurrence of groin injuries separately[26;106;116;128;117;120], while others presented groin injuries together with hip injuries[27;30;121;133]. The studies that presented only groin injuries defined the injury as "*any physical symptom located in the groin region resulting from playing soccer*"[134]. The occurrence of groin injuries ranged from 4.2% to 14.0% of match and training injuries in adult players[26;106;116;128;120] and 8.0% to 27.6% in youth[124;129]. According to Holmich[135], pain or discomfort around the groin region can originate from a multitude of tissues surrounding the area. Furthermore, Holmich[135] indicated that pain or dysfunction of one tissue could affect the surrounding structures. It is for this reason that a broader definition has been used in other studies.

Werner et al[133] defined hip and groin injury as "*injury located to the hip joint or surrounding soft tissues or at the junction between the anteromedial part of the thigh, including the proximal part of the adductor muscle bellies, and the lower abdomen*"[133]. Their study reported that the hip and groin constituted 15.0% of all injuries in elite professional players. Radiological investigations including ultrasounds, Magnetic Resonance Imaging, plain radiography and electromyography were used in diagnosis. Eighteen different diagnoses were identified in groin injuries, and the majority (64.0%) were related to adductor muscles followed by the iliopsoas muscle (8.0%)[133].

A slightly higher proportion (16.6%) was reported in a study that used a similar definition among players from a sub-elite Spanish team, but did not use similar investigative procedures as the study relied on a physical examination conducted by a physiotherapist[27]. A study conducted among professional players in Scotland reported a slightly lower proportion (13.9%) of hip and groin injuries[121].

A further study conducted among 998 sub-elite Nordic soccer players indicated that 54 players sustained 58 groin injuries[134]. Clinical examinations indicated that the majority of groin pains were related to the adductor muscles. A study conducted among amateur players over a single season indicated that 11.1% of injuries were located in the hip and groin areas[30]. As such, based on these studies, elite professional players appear to suffer more hip and groin injuries than amateur players[26;106;116;128;117;120;133;134].

The knee joint is among the top three body parts at risk in soccer, accounting for 16.0% to 21.3% of all injuries in professional adult male players. The proportion of knee injuries in adults is higher compared to their youth counterparts (9.0% to 15.3% of all injuries). The majority of knee injuries are classified as sprains sometimes more serious like tear of the cruciate ligaments[136]. Many studies were conducted on the Anterior Cruciate Ligament (ACL) injuries in sports, particularly in soccer. Of growing interest is the consequences of ACL tears in terms of treatment and rehabilitation that are mostly lengthy[137;138] and may end a player's career[139]. The anterior cruciate ligament has been extensively studied in women[140;141;142;143]; however this literature review will focus on the occurrence of anterior cruciate ligament injuries in male soccer players.

Studies indicated that ACL injuries range from 0.7% to 2% of all injuries in male players[22;111;144]. A study conducted among 2329 European players over several seasons found that 76 players suffered from 78 ACL injuries, constituting 14% of knee sprains and 0.9% of all injuries[144]. The study further indicated that Swedish male soccer players suffered from a higher proportion of ACL injuries (0.8%) than did male soccer players from other European countries (0.7%)[144]. Similar results were found ina five-season study among collegiate athletes in the USA[111]. Higher proportions of ACL injuries (1.5% of all injuries) were reported in a study conducted among first division soccer players in Sweden[22]. Furthermore, higher results were also reported in a study investigating the occurrence of ACL injuries among professional (5.2%) and amateur (1.9%) levels of play[90]. Details of the causes and risk factors as well as injury prevention measures will be discussed in Section 2.6 and Chapter Four.

Posterior Cruciate Ligament (PCL) injuries have been less studied compared the ACL injuries[145]. Few PCL studies have been conducted in soccer, although it is reported to be among the structures that cause serious knee injuries[146]. A hospital-based study in Germany indicated that soccer accounted for 24.7% of all diagnosed PCL injuries[146].

Another study reporting athletic injuries received in a hospital over a 10-year period reported that soccer was the second leading cause of PCL injuries (11.8%) following skiing (33.3%)[147]. Both studies used radiographic examination to diagnose injured structures in the knee[146;147], which was not otherwise available for most researchers. This may be one reason for fewer PCL injury reports.

Medial Collateral Ligament (MCL) injuries have also been less frequently identified in male soccer players. The UEFA injury study on the incidence and pattern of injuries in professional soccer over seven consecutive seasons indicated that MCL injuries accounted for 5.0% of all injuries[23]. The same group of researchers further analysed MCL injuries that occurred over an 11-year period through a prospective cohort study[99]. The study reported that 346 MCL injuries were sustained during the period of the study, which in turn represented 4.3% of all injuries and 0.03 injuries per 1000 hours of exposure. The study further indicated that the rate of MCL training injuries were nine times lower than match injures[99].

Studies reported that ankle injuries account for 10.5% to 25.4% of all injuries in adult professional players[26;82;106;116;117;120] and 6.9% to 18% of all injuries in youth male players[31;84;85;86;87;114;124]. The UEFA injury study reported the trend in the occurrence of ankle injuries over a period of 11 years[100]. The study reported that 1743 players sustained 1080 ankle injuries, representing 13.0% of all injuries recorded. The study further indicated that sprains account for 68.0% of all ankle injuries and 9.0% of all injuries. In a similar study, the lateral ligament was found to be affected in more than three quarter of all ankle sprains[51]. A literature review of ankle sprains indicated that the lateral ligaments were involved in approximately 85.0% of all ankle injuries[148]. Variously, the anterior talofibular, posterior talofibular, and calcaneofibular ligaments were injured in ankle sprains[148;149].

Many studies placed greater emphasis on reporting of injuries to the lower extremities compared to the upper extremities and spine.This may be due to the nature of soccer and the less severe effects of upper extremity injuries in terms of days lost. The proportion of upper limb injuries in adult soccer players was lower (0% to 7%)[23;26;116,121;150] compared to youth players (7.0% to 10%)[31;84]. An extensive study conducted among 64 professional male teams from 16 European countries over 10 seasons found that upper extremity injuries constituted 3.0% of all injuries[151]. The study found that the distribution of upper limb injuries in training and matches was similar to lower extremity injuries, however these injuries were noted to be significantly higher during matches than training.
The study further reported that half of upper limb injuries affected the shoulder and clavicle, and a quarter affected the hand and fingers. Joint and ligament sprains were predominant, followed by

fractures and bone stress. The study found that goalkeepers were more most affected compared outfield players[151].

Spine or back injuries have been less reported in soccer. Studies have reported an injury occurrence of 3.8% and 10.4% in adult soccer players respectively[26;27;30;106;121;120], while youth soccer players sustained between 3.4% and 9.8% respectively[31;84;124;129].

Table 2-3: Location, type and recurrent injuries in adult male soccer players.

Values are percentages of the total number of injuries.

Authors	Ekstrand et al[23]	Gallo et al[26]	Mallo et al[27]	Van Beijsterveldt et al[30]	Bjorneboe et al[91]	Aoki et al[106]	Owen et al[116]	Dupont et al[121]	Stubbe et al[120]	Carling et al[128]	Hassabi et al[150]
Level of play	Pro	Pro	Sub-elite	Amateur	Pro	Pro	Elite	Pro	Pro	Pro	Pro
Total number of injuries	4483	391	313	424	2365	2947	119	165	286	130	50
Type of Injuries	All	All	All	All	Match	Match	All	All	All	Match	All
Injury location											
Head/ Neck	2	0	1	2		2	3	2	4	2	7
Upper limbs	4	6	2	2		6	2	0	2	5	7
Trunk/ Back		8	8	7		6		8	10	4	9
Pelvis/hip			17	11		8		14	3		
Groin	14	9					4		11	9	33
Thigh	23	21	35	25	22	22	14	29	23	15	
Knee	18	17	10	15	16	20	16	17	21	22	7
Lower leg	11	5	8	9	10	6	19	11	12	10	14
Ankle	14	25	14	18	18	19	23	13	11	20	14
Foot	6	6	5	6		9		6	6	5	14
Other				4					0	5	
Injury type											
Sprain	18	4	17	24	27	32	20	21		22	16
Strain	35	5	20	39	46	18	46	56		34	30
Contusion	17	5	21		14	27	31	7		18	30
Fracture	4		1	3		9		0		5	7
Dislocation	1		0				1			1	2
Concussion	1					2	1				5
Laceration	1						1	3			
Other	2		1								
Overuse	6		40				47		8		9
Re-injury		16				21		22	8	9	

Pro: Professional *Blank: not reported*

Table 2-4: Location, type and recurrent injuries in youth male soccer players.

Values are percentages of the total number of injuries.

Authors	Brito et al[31]	Gall et al[84]	Deehan et al[114]	Brito et al[124]	Ergun et al[129]

Players		66	210	912	52
Level of play		Elite			
Injuries			685		
Age		U14-U16	U9-U19	Between 12-19	U17-U19
Injury location					
Head/ Neck	2	2		4	7
Upper limbs	7	10			
Trunk/ Back	5	10		11	3
Pelvis/hip	7	7			
Groin				8	28
Thigh	30		31	23	35
Knee	12	15	15	9	10
Lower leg	7	5		9	7
Ankle	18	18	18	13	7
Foot/ toe	13	8	6	17	3
Other					
Injury type					
Sprain	25	17		38	14
Strain	31	15		15	55
Contusion	23	31		25	21
Fracture	3	6		4	0
Dislocation	3				
Concussion	1			2	7
Laceration				4	
Other	6				
Overuse	43				
Re-injury					8

Pro: Professional *Blank: not reported* *U: Under*

2.5 Severity of Soccer Injuries

The severity of injuries reported in studies is classified according to the days that the players are unable to participate in training or competition. An injury that causes no time loss is classified as "*slight*", while injuries that result in an absence from training or matches for 1-7, 8-21 and more than 21 days are classified as "*mild*", "*moderate*" and "*severe*" injuries respectively[4]. Other studies have classified injuries that restricted play for 1-7 days as "*minimal*"[26;91]. Bjorneboe et al[91] further classified moderate injuries as causing players to miss training or matches for 7-21 days, and severe injuries as causing a lay-off time of more than 21 days.

Minimal injuries ranged from 19.0% to 55.0% in youth players, and 2.0% to 51.0% in adult players (Table2-5). On average, young players sustained more minimal injuries (mean=34.8%)[84;94;124;129] than

adult players (mean=20.3%)[127;23;27;45;128]. In adult players, most of injuries were classified as moderate (range: 11-69% of all injuries) followed by mild (range: 11.0% to 32.0% of all injuries) and severe injuries (range: 3.3% of all injuries)[84;94;124;129]. A similar pattern was observed in youth players[127;23;27;45;128], who sustained a less severe proportion of injuries (range: 3.0 to 15.0% of all injuries) compared to adult players (range: 3.0% to 29.0% of all injuries).

Table 2-5: Severity of injuries according to the classification of the days of absence in adult and youth male soccer players.

Values are percentages of the total number of injuries.

Reference	Population	Slight	Minimal	Mild	Moderate	Severe
		0	1-3	4-7	8-28	>28
Adult, male						
Ekstrand et al[23]	Professional		14	27	47	11
Konopinski et al[25]	Professional		26	23	37	14
Gallo et al[26]	Professional	59		27	11	3
Mallo et al[27]	Sub-elite		51	22	23	4
Reis et al[28]	Professional		23	21	40	16
Sousa et al[29]	Amateur		2	29	40	22
Van Beijsterveldt et al[30]	Amateur		5	20	43	29
Eirale et al[45]	Professional		33	31	30	6
Bjorneboe et al[91]	Professional			1-7 days: 54	8-21 days: 29	>21days: 22
Stubbe et al[120]	Professional		18	32	34	15
Dupont et al[121]	Professional		29	30	30	11
Walden et al[127]	Professional		21	25	38	16
Carling et al[128]	Professional		2	11	69	18
Youth, Male						
Gall et al[84]	Elite		31	29	30	10
Timpka et al[94]	Community		19	28	42	12
Brito et al[124]	Sub-elite		34	11	40	15
Ergun et al[129]	Elite		55	17	24	3

Many studies have shown that soccer participation constitute a risk for injuries all levels with significantly higher incidence of match injuries than training injuries[27;28;30;116;121;123;114;125]. All these studies indicated that lower extremities were the most affected body parts with more mildly to moderately severe[23;26;27;30;84;91;106;114;116;121;124;128;120;129]. The next section will review the risk factors for injuries in soccer categorised into intrinsic and extrinsic factors.

2.6 Risk Factors for Injuries in Soccer

The game of soccer is associated with a multifactorial risk of injury[152]. Therefore, the surveillance step should be followed to establish the risk factors and causes of injuries in order to inform prevention[47;59] (Figure 2-2). Meeuwisse[153] developed a model to describe the interconnections between the contributing factors of injury. According to the model, risk factors in soccer are classified as player-related or intrinsic factors and environmental-related or extrinsic factors. Meeuwisse further explained that intrinsic factors predispose players to injuries, but are not sufficient to cause injury on their own. Exposure to extrinsic risk factors, however, contributes to the susceptibility to injury. The model indicates that intrinsic and extrinsic risk factors are indistinct from injury and their presence may not be sufficient to cause injury. The culmination of intrinsic and extrinsic factors associated with an incidence of injury were found to cause the player to be injured[154;155]. The injury incidence was described as the "*inciting event*" or "*injury mechanism*" which is the immediate situation leading to injury. Bittencourt et al[156] further highlighted that the interaction of the a number of determinants produce the risk profile for injury susceptibility. Therefore, establishing the risk profile for injuries in sports requires the recognition of risk patterns instead of identifying individual risk factors.

Risk factors were also classified as modifiable and non-modifiable. Modifiable risk factors such as strength, speed, and the condition of the playing ground can be altered[16;59;154]. Non-modifiable risk factors such as age, gender and weather conditions cannot be changed but may have an impact on modifiable risk factors and injuries. Therefore, interventions may be targeted towards the web of modifiable risk factors and their interaction with other factors to prevent injuries[157].

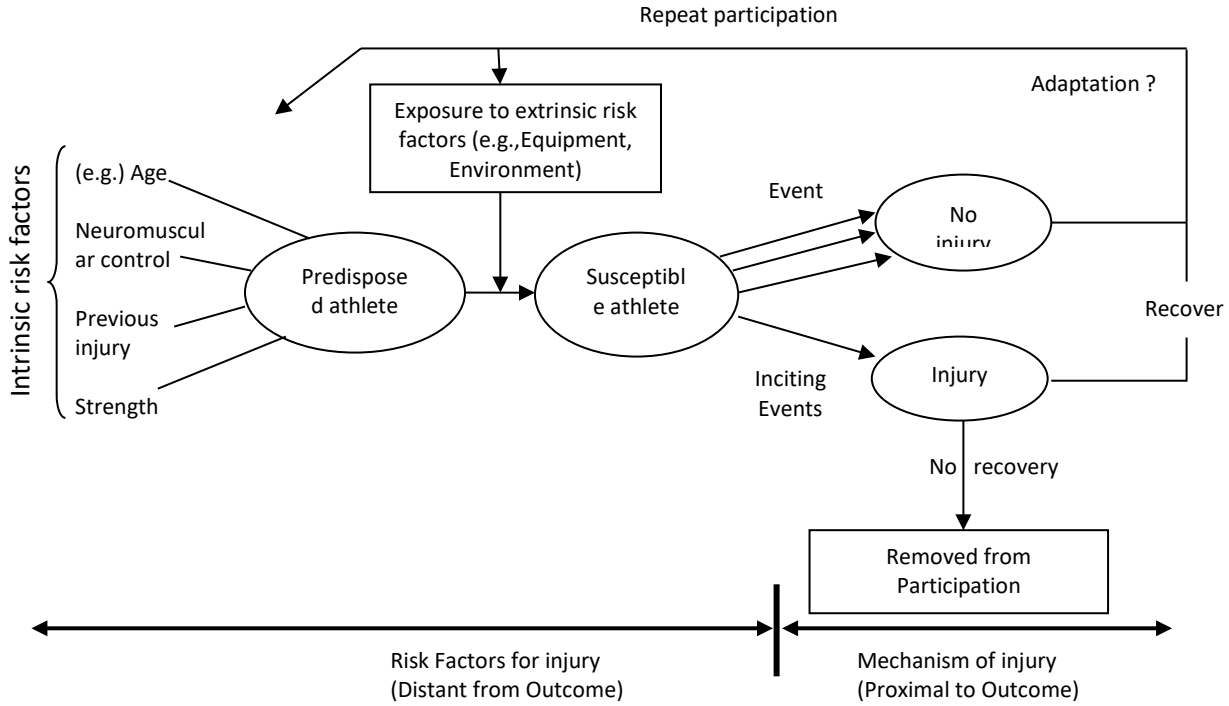


Figure 2-2: A dynamic, recursive model of aetiology in sports injuries. Adapted from Meeuwisse et al[158].

Several factors have been identified as risk factors for injuries in soccer. The following subsections will review the intrinsic and extrinsic factors that predispose injuries in soccer.

2.6.1 Intrinsic risk factors

The intrinsic risk factors presented in the studies on male soccer players will be discussed in this section. Non-modifiable risk factors reviewed include age (Section 2.6.1.1.1), previous injury (Section 2.6.1.1.2), body size and composition (Section 2.6.1.1.3), and limb dominance (Section 2.6.1.1.4). Modifiable risk factors discussed include joint laxity, range of motion and muscle flexibility (Section 2.6.1.2.1), muscle strength and imbalance (Section 2.6.1.2.2), postural stability (Section 2.6.1.2.3), psychological (Section 2.6.1.2.4) as well as genetic factors (Section 2.6.1.2.5).

2.6.1.1 Non-modifiable intrinsic risk factors

2.6.1.1.1 Age

It has been argued that age has constituted a risk factor for injuries affecting mostly older athletes in many sports[159]. The same trend was reported in several studies focusing specifically on soccer. A prospective investigation that studied risk factors for injuries among 306 soccer male players in Iceland found an increased risk of injuries among players older than 28 years[157]. Another study among professional players from 10 European countries found that age was a significant injury risk factor[160], reporting that the incidence of injuries increased with increasing age[160].

In contrast, a prospective study conducted among Swedish elite soccer players aged 17-39 years over two consecutive seasons indicated that age was not a risk factor for all injuries. However, specific injury analysis indicated that age was a risk factor for hamstring injuries[18]. Similarly, a study conducted among 48 soccer players in a Brazilian team found no association between age and overall injuries, yet age was positively associated with the number of muscle/tendon injuries[28]. In addition, a study that specifically reported the occurrence of hamstring injuries indicated an increased risk of hamstring injuries as the age of players increased[161]. Moreover, a UEFA injury study concluded that increased age was a risk factor for lower extremity muscle injuries[162].

Additional studies identified that increased age was a risk factor for muscle[23] and Achilles tendon[163] injuries. A study that reported injuries among Belgian soccer players for two consecutive seasons indicated that older players were at risk of sustaining lower leg fractures[164]. Studies conducted among youth players found that age was not a risk factor for muscle and tendon injuries, however age was a significant risk factor for ankle injuries in players above 12 years of age[87;165].

Increased age was also associated with incidence of match injuries. A study conducted among elite youth Turkish national team players found no association between age and all injuries, but found that increased age was associated with increased match injuries[129]. Similarly, the results of a study conducted among youth players in France indicated that players aged 16 years and older were at an increased risk of sustaining match injuries[84].

Several studies found contradictory results regarding the risk of sustaining injuries in youth players compared to their older peers. A study investigating the occurrence of injuries according to age groups found an increased incidence of injuries in young players (14-16 years of age) compared to their older peers (16-18 years of age)[166]. Similar findings were reported among youth players in France[84], where players under the age of 14 were more susceptible to overall injuries compared to players aged 15 years and above[84]. A study specifically analysing the occurrence of stress fractures among European professional soccer players indicated that players who sustained stress fractures were significantly younger[167]. Certain studies have also shown an increased risk of overall injuries in older soccer players[157;129;160], while others found that age was specific and significant factor for muscle[18;23;161] , tendon[28;163], and fractures injuries[164].

2.6.1.1.2 Previous injury

Factors associated with the effect of previous injuries on the occurrence of new or recurrent injuries include inadequate rehabilitation and delayed recovery[126;168;169]. Early studies suggested that inadequate rehabilitation constituted a risk for all injuries[168] and severe injuries[169]. Additionally, Cloke et al[126] reported that delayed recovery with prolonged symptoms resulted in an increased risk of subsequent hamstring injury as well as new injuries among youth soccer academy players. Injuries recurring from previously injured body areas and types have been reported to range between 7.0% to 42.0% in adult players[28;117;120;170;161] and 3.0% to 9.0% in youth players[31;171;85;94;170;172]. A history of previous injury has been identified as a significant risk factor for injury recurrence overall[157;173] as well as for ankle[51;168;174;175], knee[18;51;168] , groin[176], and Achilles tendon[163]. In an analysis of risk factors for lower extremity muscle injuries in professional players, Hägglund et al[162] found that previous muscle injury was the strongest predictor of recurrent muscle injuries. However, the study did not find any association between ankle injuries and subsequent injuries to the same limb[177;178].

2.6.1.1.3 Body size and composition

Few studies included body mass, stature and body mass index included in injury risk factor analysis[18;157;177]. In a multivariate analysis of the risk factors for injuries in soccer players, Arnason et al[157] found no association between body size variables and injuries. Similar results were found by Hagglund et al[18]. Furthermore, Baumhauer et al[177] found no relationship between injuries and players' body mass or stature.

2.6.1.1.4 Limb dominance

Several studies investigated the relationship between limb dominance and injury. A UEFA study analysing risk factors for lower extremity muscle injuries among players in top professional teams in Europe indicated that the dominant leg was at an increased risk for injury[162]. The results of this study are in accordance with previous studies that found an increased risk of contact knee[169] and ankle injuries[168;174] in the dominant limb. However, Surve et al[51] did not did not find any association between the incidence of ankle injuries and the kicking leg[51].

2.6.1.2 Modifiable intrinsic risk factors

2.6.1.2.1 Joint laxity, range of motion, muscle flexibility and tightness

It is thought that flexibility plays a role in the reduction of injuries mainly affecting the muscles, tendons and joints[179]. Appropriate flexibility may be important for performance and injury prevention in certain sports like gymnastics. However, the probability of injuries may increase with excessive ligament flexibility in other sports such as soccer or rugby[180].

Studies that investigated the effect of muscle flexibility and injury in male soccer players provided conflicting results[25;88;179;181]. Witvrouw et al[179] found an increased susceptibility of lower limb muscle injuries in players who had reduced flexibility in the hamstring muscles. On the contrary, while an increased risk of injuries was observed in elite hypermobile players, as measured by the Beighton scale for flexibility in one study[25], a further study could not establish a significant difference in the incidence of injuries between players with higher and lower scores on the Beighton scale[88]. A third study did not find any relationships between muscle tightness and injury occurrence[181].

The effect of joint laxity on the occurrence of injuries has also been investigated. Knee and ankle joint laxity have been a central focus in male soccer players[169;181;157;182;183]. A study conducted by Ekstrand et al[182] found that increased knee joint laxity was a strong predictor for all injuries[182]. Arnason et al[181] found that medial knee laxity was a significant predictor for knee injuries among soccer players in Iceland. However, the study found no relationship between ankle joint laxity and ankle injuries[181]. Chomiak et al[169] found that players with increased knee joint laxity and instability, as measured by an anterior drawer test and Lachman test, had increased susceptibility to severe knee injuries. The study further showed that ankle instability, as measured by anterior drawer test and talar tilt test, was a significant risk factor for severe ankle injuries, with similar results reported in a study conducted among collegiate level soccer players[183].

Few studies investigated the association between joint range of motion and injury. Reduced hip joint abduction range of motion has been found to be a risk factor for groin strains[157;182]. Arnason et al[157] found no significant associations between the flexibility of hip flexors and injuries. Beynnon et al[183] found no association between reduced ankle range of motion, measured in a non-weight bearing position using a goniometer, and ankle injuries[183]. Furthermore, ankle dorsiflexion range of motion, measured by a weight bearing dorsiflexion lunge test, was not a predictor of non-contact ankle injuries in amateur male soccer players in Australia[20].

2.6.1.2.2 Muscle strength and imbalance

Reduced hamstring muscle strength has been associated with the increased risk for hamstring injuries in elite soccer players[184]. The same results were obtained by Ekstrand and Gillquist[182] reporting that weak quadriceps muscles were associated with a risk of quadriceps injury. Engebretsen et al[185] found that reduced adductor muscle strength increased the risk for groin injuries[185].

The relationship between muscle strength ratios and injuries has also been investigated[56;177;183]. A study conducted among collegiate soccer players found that those who sustained ankle injuries had significantly greater eversion-to-inversion strength ratio compared to non-injured players[177]. The study also found that the increased strength of plantarflexors associated with reduced dorsiflexion-to-plantarflexion strength ratios increased the risk of ankle sprains[177]. In addition, muscle strength imbalance, as measured by hamstring-to-quadriceps peak torque, was also associated with an increased likelihood for overall and hamstring injuries[56]. However, Beynnon et al[183] analysed ankle ligament injuries among 118 college-level athletes, including soccer players, found no association between strength imbalances, measured by dorsiflexion-to-plantarflexion strength ratios or eversion-to-inversion strength ratios and the incidence of ankle ligament injuries.

2.6.1.2.3 Postural stability

Few studies established general body postural stability as a risk for injuries among male soccer players[175;183;186]. Tropp et al[186] studied postural stability with stabiometric ankle tests among 127 soccer players. The results indicated an increased risk of ankle injuries with reduced ankle stability on the stabiomertic balance test[186]. Another study investigated the risk of ankle injuries using a one or two-leg balance tests with measurement of the angle of body sway from the centre of gravity[183]. The study found no association between the body sway measurements and ankle injuries[183].

A further study assessed the balance of collegiate players using a single-leg balance test and found that positive tests increased the risk of ankle sprains[175].

2.6.1.2.4 Psychological factors

Other than physiological factors, psychological factors have also been related to the increased risk of injuries with subsequent development of injury psychological risk factor models[187;188;189;190]. Broad categories of psychological factors presented in these models include personal stress or psychological factors, stressors and their related history, as well as coping strategies or resources[188;189;190]. Studies that used any of these model was reviewed to avoid overlooking possible important findings.

A study that prospectively followed up players for eight months analysed the influence of player-related psychological factors on the rate of injuries among 1430 Swedish soccer players[191]. The study assessed the perception of success and motivation climate, live event stress, anxiety and coping mechanisms. High negative life stress levels and a mastery climate were strongly associated with the occurrence of new injuries[191]. Other studies found that increased negative life stress events were associated with an increased injury risk in youth soccer players[192;193].

A prospective cohort study by Brink[194] examined the influence of measures of stress and recovery in the prevention of injuries and illnesses in elite youth soccer players. A total of 53 male players aged between 15 and 18 years participated in the study. The state of psychosocial stress and recovery was assessed each month using the Recovery Stress Questionnaire for athletes (RESTQ-Sport) and injury data was collected daily by the teams medical personnel. There was a positive relationship between physical stress as well as injuries and illness. Psychosocial stress was also related to the occurrence of illness[194].

Ivarson and Johnson[190] tested the influence of personality variables, coping strategies and daily hassles on injury risk in adult soccer players. A total of 48 male soccer players from three teams in Sweden, aged between 16 and 36 years, participated in the study. Questionnaires (Football worry scale, Swedish university Scales of personality, Life Event Survey for Collegiate Athletes, Daily Hassle Scale and brief COPE) were distributed to players and injury data were obtained from the team athletic trainer each week for a period of three months. The study found a higher somatic trait anxiety and psychic trait anxietyin injured players than uninjured players. Behavioral disengagement and self blame were elements of coping strategies that were used more by injured players than non-injured players.

However, no other psychological variables were associated with injuries[190]. The above mentioned studies recommended that players and coaches should use the physchological information of the players to inform individualised training for injury prevention. Medical personnel could also use the information to monitor players during rehabilitation.

2.6.1.2.5 Genetic/ hereditary factors

Few studies have assessed the potential contribution of genetic characteristics to the risk of injuries in soccer. An RCT conducted by Hägglund and Waldén[195] among 4,556 players from eight districts in Sweden aimed at establishing risk factors for acute knee injuries with particular interest in ACL ruptures. While considering other intrinsic and extrinsic covariates in the multiple Cox regression analysis, the study found that ACL tears were strongly associated with a family history of ACL injuries. This indicates that hereditary or genetic factors can predispose players to injuries. Analysis of genetic characteristics and variations among players is increasing to complement existing methods of establishing injury predisposition[196;197;198].

Ficek et al[199] investigated the distribution of A9285G Polymorphism in Collagen Type XII α1 Gene in 91 male professional players with ACL injuries compared to 143 healthy players. The study reported that the combination of polymorphisms was associated with a reduced risk for ACL rupture. However, in another publication[200], the authors found that COL12A1 polymorphism was not associated with ACL rupture.

In a three-year prospective study, Pruna et al[201] performed DNA testing in 73 elite players and analysed the relationship with non-contact muscle, tendon and ligament injuries according to their types and severity. An in-depth analysis of polymorphisms indicated that an insulin-like growth factor II (IGF-II) was associated with muscle injuries. The study also found that Chemokine Ligand 2 (CCL2) gene players with GG genotype suffered more severe injuries compared to CC/GC genotype.

Pruna et al[202] also found that three Single Nucleotide Polymorphisms (SNPs) in the Hepatocyte Growth Factor (HGF) gene were strongly associated with muscle injury incidence, severity and recovery time. Artells et al[203] conducted a study in 60 professional soccer players from three top leagues in Europe analysing the influence of SNPs for the Elastin (ELN) gene on soft tissue injuries. SNPs for ELN gene play a role in tissue repair and regeneration. The study found that SNPs in ELN gene were associated with an increased in severe ligament sprains.

Massidda et al[204] analysed Monocarboxylate Transporters (MCT) MCT1rs1049434 polymorphism and its effect on muscles injuries among 173 elite soccer players in Italy. Monocarboxylate Transporters (MCT1) are responsible for lactate transport across the plasma membrane governed by the SLC16A1 gene locatedon chromosome 1[205]. The study found significant differences between MCT1 genotypes and muscle injuries. Players with TT genotype carriers had significantly lower muscle injuries compared to players with MCT1 AA genotype distribution. In a further study[206], the same authors examined the contribution of the combination of five genetic polymorphisms on the incidence of muscle injuries in 64 young elite soccer players in Italy. The study found that a single genotype could not predict injuries while combined polymorphisms was significantly associated with muscle injuries. The risk of muscle injuries was accentuated when the polymorphisms were combined with increased training volumes.

Another study conducted among 54 Italian elite soccer players assessed the vitamin D receptor (VDR) genes profile located on human chromosome 12 and their relationship with the incidence of musculoskeletal injuries[207]. VDR polymorphisms were categorised into ApaI, BsmI and FokI genotypes. Musculoskeletal injury data were obtained from medical personnel's clinical examination and the use of radiological imaging for the period of four seasons. The study found that ApaI was the only VDR genotype that was associated with the risk of severe muscle injuries[207]. The reviewed studies indicated that genetic assessment may be important in defining injury predisposition[204;206;207]. Genetic profiling may assist in designing individually targeted training for optimal conditioning and injury prevention[196;197;198].

2.6.2 Extrinsic risk factors

The extrinsic or environmental risk factors presented in the studies on male soccer players will be discussed in this section.

Non-modifiable risk factors such as the level of competition (Section 2.6.2.1.1), playing surface (Section 2.6.2.1.2), time of the game (Section 2.6.2.1.3), time of the season (Section 2.6.2.1.5), Ramadan fasting (Section 2.6.2.1.6) and geographical location (Section 2.6.2.1.7) will be discussed. The modifiable risk factors discussed include playing position (Section 2.6.2.2.1), training and match load (Section 2.6.2.2.3), as well as match congestion (Section 2.6.2.2.2).

2.6.2.1 Non-modifiable extrinsic risk factors

2.6.2.1.1 Level of competition/ skills level

The literature review has outlined how injuries occur at different levels of play from youth to elite levels (Section 2.3.1). It was discussed that the rate of match injuries was higher than training injuries at all levels (Section 2.3.2). Specifically, playing at the professional level increased the risk of hamstring[161], minimal[122] and overuse[122] injuries, while playing at lower levels of competition and amateur players were associated with more moderate[122], severe[169] and recurrent[122] injuries. A prospective follow up of professional players over nine years studied the incidence of injuries among established and a newly professional players[160]. The results indicated that established professional players had an increased injury incidence when compared with new professional players. However, newcomers to professional soccer have reported an increased risk of stress fractures[160].

2.6.2.1.2 Playing surface

Nowadays, artificial playing grounds (artificial turfs [AT]) have been installed in many countries worldwide and are used at various levels of play. Several studies have investigated the risk of injuries while playing on artificial turf compared to natural grass[208;209;210;211;212]. Arnason et al[181] reported an increased risk of injuries on first generation artificial turf when compared with natural grass[181]. Since then, there has been an evolution of AT with new and advanced turf construction are believed to have the same properties as natural grass[213]. Consequently, second and third generation turfs are currently used in soccer[213].

Two studies reported no difference between natural grass and second generation artificial ground and injury risk in collegiate level men's and women's soccer players in the USA[208;209]. A single-season prospective study conducted among 15 male and five female Swedish elite soccer players found no difference in acute overall injury incidence between third generation artificial turf and natural grass[210]. Similarly, no differences in overall injury incidence were reported in professional teams that played on third generation artificial ground when compared to teams that played on natural grass in Norway[211]. Furthermore, a study that prospectively followed up national team players in Saudi Arabia found no difference in the incidence of injuries while playing a tournament on third generation artificial pitch compared to natural grass[107].

No differences in the rate of injuries were observed at youth level for overall[214] and acute injuries[212]. However, youth that played on the third generation artificial turf had more back and spine injuries[212] with more lower back pain complaints[214] compared to those who played on natural grass.

A prospective study was carried out to identify the difference in the rate of injuries over one season in teams that had third generation artificial turfs and natural grass as their home ground in Norway and Sweden[160]. The study found a higher incidence of acute and overuse injuries in teams that played on the artificial ground compared to the teams that played on natural grass. It was further indicated that shifting the play from natural grass to third generation artificial turf or vice-versa was not associated with a change in injury risk, therefore indicating the ability of the body to adapt to change[215].

2.6.2.1.3 Time of game play

The characteristics of injuries related to playing time have also been reported in several studies[23;126;161;170]. Walden et al[170] found an increased risk of non-contact injuries during the second half of matches. This may indicate the onset of fatigue towards the end of a match or toward the end of the first half with an increased risk for overall injuries[23] and hamstring strains[161]. Another study reported an increase in thigh muscle injuries towards the end of the first half, which increased during the second half of the game[126].

2.6.2.1.4 Game situations

Studies have examined associations between changes in score and risk of injuries[45;170;216;217;218]. A study conducted in European teams found an increased match injury incidence rate in teams that were eliminated compared to teams that proceeded to subsequent rounds[170]. The authors concluded that the risk of injury increased with defeat[170]. A six-year follow up study of Swedish national team players found an increased injury incidence while the team was losing[216].

Bengtsson et al[218] found that the final score of a draw or loss was associated with more than twice the likelihood of injuries compared to winning in European professional teams[218]. Similar results were also found among professional soccer teams in Qatar[45]. Highly ranked teams in Qatar had significantly lower injury incidence indicating that team success was associated with a decreased risk of injuries[45]. In contrast, winning situations increased the risk of injury compared to drawing or losing situations in teams that played the World Cup and the occurrence of injuries varied following the changes in the score[217].

The effect of the playing venue, in terms of home, away or neutral playing grounds, on the incidence of injuries was also studied. A study conducted among Swedish national team players found no difference in the incidence of injuries according to the playing venue[219]. This was found to be in contrast with the results of the study conducted in 26 professional clubs from 10 European countries, which found that home games were associated with an increased injury incidence compared to away games[218].

An analysis of 192 games played during the 2002, 2006 and 2010 FIFA World Cups reported on the occurrence of injuries following a transient arrest of the games caused by injury, goal or foul with issuing of either a yellow or a red card[220]. There were on average 10 transient arrests in the game, while the majority were caused by fouls. The study found a higher incidence of injuries in the five-minute period following the transient arrest than other periods during the match[220].

2.6.2.1.5 Time of the season/ seasonal organisation

A study conducted amoung 51 English professional teams reported an increased injury incidence during the pre-season period as well as during the early months of the season[221]. Another study reported an increased risk of Achilles tendon injuries in the pre-season period compared to the competitive season among European professional players[163]. European professional players had an increased risk of injuries not only at the beginning but also toward the end of the season[163]. Mallo and Dellal[222] found an increased incidence of muscle strains at the beginning and at the end of the season in Spanish professional players in a follow up over two seasons. However, a six-year prospective study carried out among Norwegian professional players did not find any differences in the risk of injuries in either the pre-season or the competitive season[91]. It was further identified that the amount of training performed during the pre-season period may have impacted on the incidence of injuries over the entire season[167], and increased training intensity during the pre-season constituted a risk factor for stress fractures among elite professional players[167].

Aus der Funten et al[89] studied the occurrence of injuries in the second half of the season among seven German professional teams after the mid-season break was reduced from 6.5 to 3.5 weeks. The incidence of overall injuries did not significantly change after the three-week mid-season break. However, an increased incidence of training, knee and severe injuries was observed[89].

2.6.2.1.6 Ramadan fasting

The occurrence of injuries during the period of the Islamic holy month of Ramadan has also been studied. Only two studies were found to analyse the pattern of injuries among fasting Muslim players[105;223]. The first study indicated that the incidence and pattern of injuries sustained by 462 fasting Qatari players were similar to the 65 non-Muslim players who were not fasting[105]. A prospective study followed 42 Tunisian Muslim professional players for two consecutive seasons. The study investigated the occurrence of injuries one month before, during and one month after fasting for the holy month of Ramadan. There was an increase in overuse and non-contact injuries among fasting players during the period of Ramadan compared to the non-fasting periods[223].

2.6.2.1.7 Geographical location

Few studies have investigated the influence of climate and geographical location on injuries[127]. A study conducted among 25 teams from nine European countries over nine seasons divided the countries into two geographical regions[127]. Countries with common climates were grouped into the same geographical region. The Northern group had calm Summers and very cold Winters while the Southern group had a Mediterranean climate. The study reported a higher incidence of overall, traumatic, overuse and severe injuries in the Northern group teams compared to the Southern group teams. However, the study reported a lower incidence of ACL injuries in the Northern group teams, specifically resulting from non-contact injuries[127].

2.6.2.2 Modifiable extrinsic risk factors

2.6.2.2.1 Playing position

Several studies identified the influence of playing position on injuries[21;28;160;161]. A study that prospectively investigated injuries in a Brazilian soccer team reported that wingback players had an increased number of muscle/tendon injuries compared to other playing positions[28]. The study divided playing positions into goalkeeper, defender and wingback, midfielder and forward. In addition, midfielder players sustained significantly more joint and ligament injuries than other playing positions.

Defenders were reported to have suffered more minimal injuries, while forward players sustained injuries that were more moderate. The study did not include the goalkeeper in the analysis as these players did not incur any muscle or joint injuries[28]. This is in accordance with the findings from other studies which indicated that outfield players sustained more overall[160] and hamstring[161] injuries than goalkeepers.

Additionally, Ekstrand et al[98] found that the goalkeeping position had an increased risk of upper extremity injuries than outfield players. In contrast, Dauty and Collon[21] did not find any difference in the rate of injuries based on the playing position[21].

There are conflicting results as to the position most prone to injuries among outfield players[217;222;224]. The results of a study conducted in three consecutive FIFA men's World Cup games reported a variation of injuries according to the playing position with the highest rate of injuries were observed in forward players[217]. A study conducted on a professional team in Spain found a high proportion of injuries among forwards and central defenders[222]. Furthermore, a study on 26 European professional teams followed up for nine years found that defenders were at a greater risk for head, neck and concussion injuries than any other playing position[224].

2.6.2.2.2 Match congestion

The match congestion period is the time of the season when the period between two consecutive matches is three daysor less[128;218], or when three consecutive matches are separated by an interval of four days or less[225]. Match congestion induces fatigue, which is considered to be detrimental to the performance of players and, most importantly, the general health of players, with an increased risk of injuries[216].

Several studies reported injuries from teams that played in the UEFA Champions League or Europa League while continuing to play league games and other in-country competitions[97;121;128;226;227]. Increased risk of overall and muscle injuries was observed in teams that played matches with a four day or shorter interval compared to teams that played matches with a six day or greater interval between matches[97]. Similarly, an injury incidence that was five times higher was reported among teams who played two matches per week compared to the teams that played one match per week[121].

Dellal et al[226] reported an increased risk of match injuries during the congested period among the professional soccer players in France. Further analysis indicated an increased risk of injury in the last quarter of matches when the teams played two matches within a three-day period. An increased incidence of injuries was observed when the teams played three matches within a four-day period[225]. However, Carling et al[128;227] did not find any differences in the incidence of match injuries between the congested match period and periods outside match congestion.

Vilamitjana et al[101] examined the incidence of injuries in teams that played two matches per week (high match frequency period) compared to teams that played one match per week (low match frequency period). The study found an increased incidence of severe injuries during the high match frequency period than the low match frequency period[101].

2.6.2.2.3 Training and match load

The work subjected on players during training sessions and competitive matches constitutes the physical load[9]. Training and match physical stress or external load causes a range of physiological and psychological responses and adaptations classified as internal physical load[228;229;230]. Therefore, coaches should be aware of the appropriate external load necessary to produce the desired internal load responses. More attention is needed in the case of team sports, as individual players' internal load response to an exercise may be different[229]. As such, training should be well organised to offer a balance between load and recovery. Inappropriate management of the training load may constitute an important risk factor for poor performance and injuries[231] caused by fatigue and maladaptation[232]. It is difficult to know with precision the amount of training load enough to yield maximum match performance of the teams as a whole. Similarly, assessing all physiologic internal load responses to exercise is particularly difficult[230;233] due to the disparities in the health condition, body composition, age, previous injury and playing level with the team[234].

Many tools have been used to measure the internal and external loads in athletes. For example, external load has been examined by recording the duration[235], quantity[121] or type[218] of training sessions and competitions. Time motion analysis using Global Positioning Systems (GPS) have been used to measure the distance covered by athletes[236]. The repetition of certain movements such as the number of jumps, throws, bowls, and serves have also been recorded to quantify the load[237], as well as the distance covered by athletes[238].

The internal physical load has been assessed by physiological and biological assessments, questionnaires and observations[239;240;241;242;243]. Heart rate measurements have been used in a some studies[244;245]. Blood samples have been drawn to assess blood lactate concentration[246]. Biochemical and immunological responses to exercises have been examined[228;232].

Questionnaires such as the rating of perceived exertion (RPE)[239], the profile of mood states (POMS)[240], the recovery-stress questionnaire for athletes (REST-Q-Sport)[241], the sport anxiety scale (SAS)[242], the perceived motivational climate in sport questionnaire (PMCSQ)[243] have been used in assessments.

Investigations of the load imposed on athletes in one week (determined as acute load) in relation to the average of acute loads for four weeks (referred to as chronic load) have been conducted to determine performance and the likelihood for injuries[9]. This is known as "*acute:chronic work load*"[9]. The values of acute:chronic ratio of less than one indicates a decreased workload in a past week compared to the average of a four-week load, while the opposite indicates an increase in the workload in one week versus an average four-week load. The extensive work of Gabbett[9] indicates that acute:chronic workload ratios between 0.8-1.3 are considered to be the "*sweet spot*" which constitutes a decreased injury risk zone. The preparation of athletes should aim to maintain a ratiowithin the "*sweet spot*" zone.

Gabbett[9] also reported that acute:chronic workload ratios of more than 1.5 constitute a spike in the training load. A ratio of between 1.5 and 2.0 constitutes the "*danger zone*", with increased risk of injuries[9]. Considering the interrelationship between training load, physical capabilities and injury risk, Gabbett[9] further explained that low training load indicates poor fitness which may lead to poor performance and an increased risk of injuries and re-injuries. Adequate training load leads to greater fitness levels, good performance as well as decreased risk of injuries. In addition, high training load leads to greater fitness levels, good performance and may reduce the risk of injury[9;247].

According to Brooks et al[248] it is important to understand the association between training load and injuries to inform prevention and rehabilitation interventions[248]. The idea has been further supported by the consensus statement on load and injury in sports from the International Olympic Committee[247]. The influence of load and the risk of injuries have been reported in different sporting populations. Several studies have indicated that increased training and competition loads constitute the risk of injuries in running [249;250], cricket[251;252], swimming[253] and volleyball athletes[254].

A few studies have been conducted which examine the association between load and injuries in soccer[116;222;255]. A prospective study conducted among 53 Dutch youth soccer players across two seasons examined the influence of training stress and recovery on the incidence of injuries and illnesses[255].

Physical stress was measured by recording the individual training and match exposure duration, while the perceived exertion questionnaire assessed players' perceptions of the training load. The internal load and recovery were measured using the Recovery Stress Questionnaire for athletes (RESTQ-Sport). The study reported that increased training and match load constituted a risk for traumatic injuries. Furthermore, the disturbance of the balance between physical stress and recovery was associated with the risk of match injuries[255].

Other studies examined the incidence of injuries according to the internal load. Mallo and Dellal[222] followed players of a Spanish professional team for two consecutive seasons measuring the heart rate at each training session. The study found that the odds of sustaining muscle strains were associated with the mean heart rate. However, the study did not report on the heart rate values according to the intensity of the training sessions, which was found to be an objective and reliable tool to quantify exercise intensity[116;230;256]. Owen et al[116] assessed the relationship between training intensity as measured by heart rate and the incidence of injuries. The study found that an increased volume of intensity during training positively correlates with the incidence of injuries. The study revealed an increased risk of injuries for players that spent more time in an elevated training zone, as indicated by the recorded heart rates[116]. Despite the use of heart rate measurements to monitor the intensity of the training[257;258]; these are the only studies that investigated the relationship between heart rate measurements and soccer injuries[116;222].

2.6.3 Mechanisms leading to soccer injuries

Many studies have reported on intrinsic risk factors that lead to injuries. However, injury risk identification is not sufficient on its own[155]. Recognition of specific mechanisms leading to injuries is important for injury prevention development. Injury prevention programmes should focus on the mechanism directly linked to the injury event. Comprehensive descriptions of the mechanisms of injury at the time of injury should be provided by indicating the playing circumstances, player or opponent action, as well as body and joint positions and movements[155;259].

Krosshaug et al[259] identified player interviews as the most effective approach of accurately reporting injury mechanisms. Players are well positioned to provide precise details regarding the mechanisms of their own injuries[259].

However, several studies have relied on information from medical staff instead[35;82;86;96;120;172]. This may explain why many studies have not reported on the mechanisms of injuries. Additionally, there is no clear definition of the terms used to describe inciting events leading to injury. Consequently, upon review it was found that the few studies that reported injury mechanisms made use of a variety of terminologies[22;33;28;90;98;111;104;260;261;262;263].

Several studies simplified the mechanisms of injury and reported them as contact and non-contact[22;28;90;98;104;260;261;262;263], while others provided details of the contact injuries describing them as contact between players, or between the player and an object, piece of equipment, or the ball[33;111;129;160]. A number of studies provided a comprehensive list of evens detailing injury mechanisms[30;35;82;86;96;120;172;264]. The details of these studies and their findings are presented in Table 2-6.

Table 2-6: Terms used to describe Injury mechanisms in studies among adult and youth male soccer players.

Data are presented in percentages unless otherwise indicated.

Reference	Playing level	Injury	Injury mechanism
Hagglund et al[22]	Elite	Time loss	Contact 35 Non-contact 65
Reis et al[28]	Professional	Time loss	Contact 20, Non-contact 80
Van beijsterveldt et al[30]	Amateur	Time Loss	Contact with player 40.2, distortion 15.2, turning/ twisting 13.4, contact with the ball 11.1, fatigue 11.1, jumping 10.9, playing field condition 10.6, artificial turf 10.1, sprinting 10.1, reaching for the ball 9.8, shooting 7.6, fall 6.8, weather condition 5.3
Akodu et al[33]	Professional	Match injuries (all)	Contact with another player 73/89, contact with the ball 2/89, contact with another object 1/89, non-contact 12/89
Ani et al[35]	Professional	Time loss	Tackle event 34, falling/ diving 8, running/ sprinting 7, stretching 7, twisting/ Turning 6, sliding 6, shooting 6, collision 5, heading 5, Jumping/ landing 3, blocked 3, dribbling 3, use of arm or elbow 2, hit by ball 2, kicked by other player 2
Carling et al[82]	Professional	Time loss	Non-contact (incidence): Acceleration 5.5, Change in direction 2.8, Fall 2.8, Kicking the ball 1.4, Landing 1.4, tackle 0.0
Cloke et al[86]	Youth	Time loss Ankle injuries	Tackled 31.3, Tackling 11.4, running 10.8, twisting/ turning 10, landing 7.7, kicked 6, collision 2.3, falling 1.6, hit by ball 1.3, shooting 1.3, jumping 1.3, passing 1.2, stretching 0.5, dribbling 0.4, diving 0.3, heading 0.003 Non-contact 3.6

Reference	Playing level	Injury	Injury mechanism
Krutsch et al[90]	Professional and amateur	Time loss ACL and PCL	Contact ACL: amateur 53.8 vs pro 100; PCL: amateur 80 Non-contact: ACL: amateur46.2% vs pro 0; PCL: amateur 20
Timpka et al[94]	Youth	Time loss	Collision 29, player blow 24, fall 10, ball blow 5, foul tackle 5, turn 2
Rossler et al[96]	Adolescent	All injuries	Duel 16.1, running 12, foul contact 11.8, Collision with other player 8.6, Change in direction 8.4 Ball contact 7.4, falling 7.4, header duel 6, , Jumping 2.4
Ekstrand et al[98]	Professional	Time loss Ligament injury	Non contact : training 80, match 57
Eirale et al[104]	National team	Time loss	Contact : 32/78 incidence 3.2 Non-contact : 46/78 incidence 4.6
Agel et al[111]	collegiate	Time loss	Player contact: practice 26 vs game 61 Other contact : practice 24 vs game 17.9 Non-contact: practice 47 vs game 19.9
Stubbe et al[120]	Professional	Time loss	Contact with player 32.9, jumping 11.8, fatigue 11.4, distorting 7.1, turning/ twisting 7.9, contact with the ball 6.4, reaching for the ball 6.2, shooting 5.7, playing field condition, 5.7, fall 2.9, artificial turf 2.1, weather condition 2.1
Ergun et al[129]	Youth	Time loss	Player contact: 8/18 Object contact: 1/18 Non-contact : 9/18
Froholdt et al[172]	Children and youth	all	Tackling duel 43, running 29, Collision with other player 13, collision with other 2, falling 2
Lion et al[260]	Professional	Time loss	Contact 36.6, Non-contact 53.6
Kristenson et al[160]	Professional Newcomers (NC) and established (E)	Time loss	Contact with player (incidence): NC 1.2 vs E 1.9 Contact with object: NC 0.04 vs E 0.1 Non-contact: NC 2.7 vs E 3.7
Kock et al[261]	Amateur	All	Contact : Recreational 50, Amateur50 Non-contact : Recreational 63.6, Amateur 36.4
Babwah[262]	Elite	All	Contact 40, Non-contact 60
Lee et al[263]	Professional	Time loss	Contact 45 Non-contact 55
Mc Noe et al[264]	Community youth	Medical attention injury	Running 24, Being tackled 19, Tackling 22, Kicking 8, heading 7, being hit by the ball 3, ball skill 2, goalkeeping activities 1%, shooting 1

2.6.4 Summary of the literature review: Epidemiology of injuries in male soccer

The literature suggests that playing soccer predisposes players to injuries[7]. The overall incidence of injuries was higher among professional players[25;26;27;28;116;121;122] when compared with sub-elite[27], amateur[30] and youth[84;86;123;114;125;126] players. Across all reviewed studies, match injuries were consistently higher than training injuries. The lower extremities were the parts of the body that were injured more often, with varying dominance of the knee, thigh and ankle joints[23;26;27;30;84;91;106;114;116;121;124;128;120;129]. Sprains, strains and contusions were the most prominent types of injuries.

Many soccer injuries were mild and moderate, resulting in an absence from play for four to 28 days; however severe injuries were also reported[127;23;27;45;128]. The causes of injuries have been found to have a multifactorial aetiology with intrinsic[28;84;157;162;163;185;192;193;196;197;198] and extrinsic[161;122;169;208;209;218;220] factors.

Studies identified several modifiable risk factors that could be targeted with prevention programmes. Therefore, it is important to identify the appropriate tools that may be used to assess risk factors. The following section describes the screening tools and tests used to identify intrinsic risk factors.

CHAPTER 3. PRESEASON RISK FACTOR SCREENING AND TESTING

3.1 Introduction

The literature has identified the contribution of several intrinsic factors to injury causation[28;84;157;162;163;185;192;193;196;197;198]. Factors including body alignment and stability, joint range of motion and laxity, muscle strength, tightness, and flexibility may be corrected through proper conditioning and specific training[265]. As such, the analysis of injury predisposing factors should be conducted prior to players engaging in long-term play, and more specifically during the pre-season period. Examinations and tests carried out during the pre-season period enquire about past injuries and their persistence. Pre-season examinations assist in identifying the potential risk factors to injuries to develop the appropriate prevention strategies[47;155]. On one hand, the preseason examination performed to identify medical conditions that may hinder the participation is the medical screening often done by physicians[266]. Pre-season medical screenings performed to identify any presenting medical conditions that may hinder participation is often conducted by physicians. Whereas, the pre-season examinations performed to identify musculoskeletal risk factors are primarily conducted by physiotherapists[267]. The review will specifically focus on the pre-season musculoskeletal screening tests used to identify risk factors for lower extremity injuries.

3.2 Preseason musculoskeletal screening in soccer

FIFA has developed a comprehensive assessment form to record baseline health information of players. The form named the "*Pre-competition Medical Assessment*" (PCMA) was designed to record past and present medical conditions as well as the orthopaedic assessment results of the players[266]. Team doctors would record past and present medical complaints. Additionally, the form provides space for recording the results of cardiovascular tests, including electrocardiogram and echocardiography. These tests will not be discussed in the present literature review as they are not relevant to the present study.

Orthopaedic test results should also be recorded with musculoskeletal examination findings primarily for the thigh and groin, hip, knee and ankle joint range of motion. The validity of the orthopaedic component of the PCMA was established in the study conducted among male players participating in the 2006 FIFA World Cup[268]. Prior to the World Cup, all 32 qualified teams received the PCMA forms; 26 teams (75.0%) returned the completed assessment forms.

Several sections were completed in full, however the section on joints range of motion was poorly completed, specifically the sections relating to the hip and knee joints. It was also noted that players reported a wide variation of means on the range of motion measurements. The authors therefore recommended that clear instructions of the measurements are provided to the teams for quality measurements. A feasibility study was conducted among women participating in the 2010 FIFA World Cup[266], thereafter, the PCMA was a compulsory component in all FIFA tournaments. However, it must be noted that the PCMA form has not been used to predict injuries in soccer.

Musculoskeletal screening batteries have been specifically developed for use in soccer[268]. Rosh et al[269] presented the normative data of a test battery for soccer performance developed by F-MARC. The test battery included measurements of movements and activities similar to activities performed during soccer. The assessment was grouped into seven flexibility and eight soccer skills tests. The authors presented the results according to age and skills level. However, the reliability of the tests was not established[269]. Similarly, the authors developed and tested the reliability of an additional musculoskeletal screening battery[270]. The screening comprised of nine tests derived from other musculoskeletal screening batteries reported to assess specific movement patterns important for soccer. Eight physiotherapists tested 18 players on two occasions. The intra-class correlation coefficient for the total score was 80.0% and 81.0% for both measurements respectively. The authors recommended that further studies investigate the ability of these measurements in predicting injuries[270]. Most musculoskeletal screening tests are easy to administer and do not require sophisticated equipment, contrary to the screening of strength and power[271]. It was also recommended that screening tests that can be carried out on the field be selected for use. The following sections will discuss the screening tests employed in this study, divided into flexibility, stability and strength, proprioception and functional tests.

3.2.1 Flexibility tests

3.2.1.1 Hamstring flexibility tests

3.2.1.1.1 Active knee extension test

Many tests have been used to assess hamstring flexibility. These include the toe touch test, passive straight leg raise, Sit and Reach test, back server Sit and Reach test, and the active knee extension test[272;273;274;275].

Several studies have been conducted to ascertain the reliability of these tests. A test-retest reliability study conducted by Gabbe et al[276] among Australian football players indicated that the active knee extension test was the most reliable with an inter-rater reliability of 0.93 (95% CI: 0.80-0.98) and a test-retest reliability ranging from 0.94 to 0.96. The test-retest reliability of the active knee extension test was also established by Dennis at al[277] in a study conducted among cricket players.

The active knee extension test, or knee extension angle test, is a test of the hamstring muscle flexibility, measuring knee extension range of motion when the hip is flexed. The test is performed when the subject is in supine position. Active knee extension range of motion is measured in degrees. A plinth, wooden frame and a goniometer is required to perform this test[277]. Several tests, such as the toe touch, straight leg raise, or Sit and Reach tests, create neural tension as they involve further ankle dorsiflexion. In addition, the pelvic tilt was also found to be a significant confounder for the tests[278]. Furthermore, tests performed in sitting position simultaneously assessed the bilateral hamstrings[279].

Reliability studies confirmed the recommendation made by Davis et al[279] that this test should be adopted as the standard for hamstring flexibility measurements[279]. The few studies that assessed hamstring muscle flexibility in soccer made use of tests other than the active knee extension test[278;280;281]. As such, an active knee extension was preferred as the appropriate test to assess hamstring flexibility among the cohort of soccer players in this study.

3.2.1.1.2 Sit and Reach test

The flexibility of the hamstrings and lower back have been commonly assessed using the Sit and Reach test[275;282]. Derivatives of the test have also been described, such as the modified Sit and Reach test, the back saver Sit and Reach test, "*V*" Sit and Reach test and unilateral Sit and Reach test[272;283;284;285;286]. Earlier studies documented that the Sit and Reach test was reliablewhen measuring of hamstring and trunk flexibility[287]. In addition, Liemohn et al[288] supported its validity, but found that it was not reliable for lower back flexion range of motion. Other studies have indicated moderate validity of the test to assess hamstring muscle flexibility[279]. Gabbe et al[276] reported intra-tester reliability of 0.98 to 0.99 and an inter-tester reliability of 0.97 to 0.98.

A study conducted in university students reported no differences in the concurrent validity of the standard Sit and Reach test and the back saver Sit and Reach test[289].

A test-retest laboratory study among 243 recreational youth indicated an acceptable reproducibility of the Sit and Reach test (ICC=0.92) that was higher than other hamstring tests[279]. Similar results were found in a study conducted among professional indoor soccer players[290]. Ayala et al[290] found that the Sit and Reach test was more reliable than other hamstring flexibility tests[290]. A further study analysed the contribution of each joint in the Sit and Reach test in comparison with the back saver Sit and Reach test[284]. An angular kinematic analysis indicated that hip movements were determining factors in the back saver Sit and Reach test[284]. However, both tests provided similar results globally[284;290].

A study comparing the physical profile of soccer players, American football and hurlers found that soccer players were more flexible as measured by the Sit and Reach test[282]. This test can be used to assess the profile of players during the pre-season period[276]. Gabbe et al[291] reported an increased risk of injuries with increases in Sit and Reach scores[291]. However, another study conducted in amateur soccer players did not find any relationship between hamstring injuries and Sit and Reach measurement results[275]. Further studies are recommended to assess the use of the Sit and Reach test in predicting hamstring injuries[292].

3.2.1.2 Quadriceps and iliopsoas flexibility testing

The assessment of the quadriceps and iliopsoas muscles is necessary as they are important muscles for soccer performance in terms of speed and kicking the ball[293;294;295]. The flexibility of the hip flexors, specifically the iliopsoas muscles, knee flexors, rectus femoris muscle and iliotibial band are measured using the modified Thomas test[276;296;297]. It is convenient as the flexibility of three muscles are measured in the same testing position. While standing at the edge of a measuring table, the individual is requested to hold the non-tested leg in hip and knee flexion with the arms, with the thigh against the chest. The individual is then asked to roll back into supine position while holding the non-tested leg and the other leg hanging over the edge of the table. Instructions are given to the participants to relax to allow gravity to influence the hanging leg. Goniometric measurements are performed to assess the length of rectus femoris, iliopsoas and the iliotibial band[276;296;297].

The modified Thomas test was included in the reliability assessment in the musculoskeletal screening of 91 cricketers[277]. As measured by physiotherapists, the test-retest reliability of the modified Thomas test yielded significant results with an ICC ranging between 91.0% and 94.0%, with similar results reported in a study conducted among 117 elite athletes[298]. Lower test-retest results were found in the reliability of the modified Thomas test in a study conducted by Gabbe et al[276] among 15 participants.

The study argued that this maybe due to the low number of participants comprised of university staff and students. Dennis et al[277] found poor inter-rater reliability for the modified Thomas test with an ICC of 0.27-0.29, whereas Gabbe et al[276] found higher inter-tester scores. Harvey[298] did not analyse the inter-observer reliability.

The modified Thomas test has been found to have some limitations in its ability to accurately measure the rectus femoris muscle length[299]. Poor reliability results have been reported when using pass or fail scores for both intra-rater (40.0%) and inter-rater (33.0%) reliability. Kim and Ha[300] assessed the reliability of the modified Thomas test with and without lumbo-pelvic stabilisation. Participants performed the test while emphasis was placed on lumbo-pelvic stabilization whether active or passive. The study found that the modified Thomas test results were more reliable with active lumbo-sacral stabilization (ICC=99.0%) than passive lumbo-sacral stabilization (98.0%) than without stabilization (97.0%). It further recommended that the addition of limbo-pelvic stabilization is considered while performing the modified Thomas test to improve the reliability of the measurements[300].

3.2.1.3 Hip internal and external rotators flexibility testing

The flexibility of thehip internal and external rotators is measured by hip internal and external rotation range of motions assessments respectively. Hip rotations range of motion is assessed while the participant is lying prone on a plinth[301]. With the knee flexed to 90°, the participant is asked to perform the rotation movements. The position held is then captured with a digital camera and the angles are measured on the picture.

Other studies have used the supine position to assess active[302;303] or passive[304] hip rotation. Several authors assessed hip rotation range of motion with hip extension and knee flexion[277;302;305]; while others assessed this with the hip and knee in flexion[303;304]. The supine position with hip extension provided more stability and facilitated goniometric measurements[277]. Goniometers or inclinometers are low cost instruments that provide measurement advantages. Their simplicity allows for the measurements of many participants and does not require sophisticated equipment that are generally found in laboratories. It was also reported that results from goniometric measurements of hip joint movements did not differ with the results of the video tracking motion analysis[306].

Reiman and Manske[307] reported excellent inter-rater reliability of goniometric internal rotation (ICC=98.0%) and external rotation (ICC=99.0%) measurements.

Slightly lower reliability results were found in other studies that used the same measurements. Gabbe et al[276] reported the inter-tester reliability of hip internal rotation to be 94.0% and 88.0% for external rotation. The study reported an excellent intra-rater reliability for internal rotation (ICC=83.0% to 92.0%) and external rotation (ICC=83.0% to 90.0%) range of motion assessment. Therefore, conventional goniometric measurements can be used with participants in supine position[276;304].

3.2.1.4 Hip adductors flexibility testing

Several movements in soccer such as passing the ball with the inside of the foot, dribbling, and tackling require the use of the adductor muscles. Therefore, the adductor muscles should be flexible enough to accommodate the demands of the athlete[294;308]. Rosch et al[13] described a functional test to assess the length of the adductor muscles. The test is included in the F-MARC test battery for soccer and required players to abduct their legs, sliding them apart on a smooth surface while the arms support their upper body to control the movement. The distance between the symphysis pubis and the ground as well as the distance between the heels measures the flexibility of the hip adductors. However, the reliability of this test has not been determined.

There is no standardized method of assessing the flexibility of hip adductors. However, the procedure to position the subject in supine with the non-tested leg hanging at the side of the treatment table to limit movements of the pelvis towards the contra-lateral side is widely used. The tested leg moves away from the midline with the toes directed upwards to limit the contribution of hip external rotation[157;179;304]. Therefore, a more conventional method for measuring soccer players was adopted in this study.

3.2.1.5 Ankle plantarflexors flexibility testing

Ankle dorsiflexion range of motion was measured to assess the flexibility of the gastrocnemius and soleus muscles[309]. Ankle dorsiflexion is measured while the individual is in long sitting or supine[307;309] or prone[310;311] lying position, with the ankles and feet over the edge of the treatment table. The individual dorsiflexes the ankle and the angle is measured between the longitudinal line of the fibula and the line parallel to the fifth metatarsal, while the lateral malleolus serves as the axis[307]. Measurements of passive ankle dorsiflexion have also been described using a special devices[312]. The Lidcombe template apparatus was tested in a clinical setting and was found to be reliable (ICC=0.97) with an inter-rater agreement of 0.77. Normative data for ankle plantarflexors flexibility has not been determined. However, a study that tested the inter-rater reliability in long distance runners indicated a good ICC of 98.0%[310].

A systematic review of the reliability of goniometric ankle range of motion reported aide range between intra-rater reliability with an ICC from 0.64 to 0.99 and the inter-tester ICC reliability between 0.29 and 0.81[313].

A more functional method of ankle dorsifexion range of motion testing with weight-bearing has been described. The weight-bearing dorsiflexion range of motion or weight-bearing lunge test is performed with individuals in a forward lunge position. The test foot is required to remain in full contact with the surface of the floor while the knee is moving forward to the maximum dorsiflexion range[314]. The flexibility of the ankle plantarflexors is measured as the distance between the big toe[314;315] and the wall, angle of ankle range of motion[179;315;316], or the extent of tibial inclination from the vertical[314;315]. Cejudo et al[317] described a simplified version of the modified weight-bearing lunge test. The test leg is placed on a box. In the starting position, the box should allow the knee to be in 90° and the tibia vertical. The individual performs the forward lunge by flexing the hip and knee to the maximum. The inclination of the forward movement of the tibia in relation to the vertical starting position is measured. The study reported an excellent test-retest reliability in the new version of the test (ICC=0.95)[317]. A systematic review of reliability studies on the weight-bearing ankle dorsiflexion lunge found good inter-rater (ICC=0.80-0.99) and intra-rater (ICC=0.65-0.99) reliability[318]. The review reported that the average minimal detectable change scores were 4.6° and 4.7°, or 1.6 and 1.9 cm, for inter-rater and intra-rater reliability respectively. The weight-bearing lunge technique was recommended for use in a clinical setting, irrespective of the method used. In addition, the test has also been found to be reliable in athletes[179;296].

3.2.1.6 Active Slump test

The slump test or modified slump test evaluates the physical capability of the neuro-meningealstructures, peripheral nervous system and their related connective tissues. It aims to reproduce or alter the symptoms by movement of a body part far from the painful area[319]. The test is performed with individual in a high sitting position at the edge of the examination table. The arms are place behind the back with hands resting on the table. The individual is then instructed to round the shoulders together with thoracic and lumbar flexion, and to add flexion of the cervical spine. The individual is then asked to perform ankle dorsiflexion with the toes fully extended, followed by a knee extension while maintaining the position of other body parts[320;321;322].

In clinical and laboratory setting, the appearance or changes of the symptoms provoked by the test are recorded in terms of area, intensity and type. For example, Kuilart et al[323] identified the frequency and area of symptoms in 42 individuals with hamstring tightness. Posterior aspect of the knee was the most pointed area (67.0%) followed by the posterior leg (36%). The normative data of the slump test in 84 asymptomatic participants reported that 98.0% reported at least asymptom[324]. The posterior knee (36.0%) was the most commonly reported area, followed by the posterior calf (32.0%) and posterior thigh (27.0%). The feeling of stretch was the most common type of symptom described by the participants followed by the feelings of pull and strain[324].

A more objective measure was advocated since many of the studies relied on the symptoms reported by the participants. Consequently, knee extension range of motion was used to obtain a quantitative measure[325;326]. Reduced full knee extension range of motion of 16-35° has been reported[327] additional to the reliability studies conducted earlier[328;329]. Philip et al[329] examined inter-tester agreement for slump tests conducted by physiotherapists on 93 low back pain patients with or without leg symptoms. The authors reported a mean pair-wise agreement value of 0.89 (95% CI: 0.81-0.97) for positive and negative results when sensitized with cervical flexion and extension. Using the knee movements as a sensitising element, the positive slump test mean value was 0.83 (95% CI: 0.75–0.91)[329]. Similar results were reported in a study conducted among 60 females with a history of whiplash injury and 40 asymptomatic participants. The study reported the results of two examiners recording 12 observations.

The intra-examiner agreement was excellent (r=0.940) with good inter-examiner reliability (r=0.854)[328]. A study conducted by Gabbe et al[276] on musculoskeletal screening tests indicated that the slump test was reliable. An ICC value of 0.92 (95.0% CI: 0.77-0.97) indicated that the inter-rater reliability was excellent as well as the intra-rater reliability with an ICC value of 0.95 (95% CI: 0.85-0.98) and 0.80 (95% CI: 0.51-0.93) for both examinersrespectively[276].

Furthermore, another case control study compared the sensitivity and the specificity of the slump test tothe straight leg raise test in low back pain patients[330]. The participants included 75 low back pain patients diagnosed with a disc herniation by Magnetic Resonance Imaging and 37 low back pain patients without disc herniation. The slump test showed high sensitivity (84.0%) for disc herniation assessment compared to the straight leg raise test (52.0%). The specificity was also higher for the slump test (89.0%) compared to the straight leg raise test (83.0%)[330].

Gabbe et al[331] included the slump test in the screening of Australian footballers. Players with more than 15° of knee flexion had an increased risk of injury. In another study[291], the author found no associations between the slump test and the occurrence of hamstring injuries in Australian football players.

3.2.2 Stability, strength and power tests

3.2.2.1 Prone four-point hold test

Core strength and stability is important for soccer players to generate powerful movements while maintaining dynamic joint stability force[293;332;333]. An electromyographic study of erector spinae muscle activity indicated that core strength had an impact on balance ability[334]. Improved balance has also been found to improve agility[335] and speed[336]. Core strength and stability are important to generate enough force for maximum lower limb momentum[308;337].

A commonly utilised objective measurement of the core muscular strength and endurance is the prone four-point hold test or plank test. The starting position of the test is prone with participants lying with the upper part of the body supported by their elbows which are placed directly under the shoulders. Following the instruction of the examiner, the trunk is then moved up while the full body remains as straight as possible in the same position. The weight of the body is supported by the elbows and the feet. The time spent in the position is recorded. Other tests have also been derived from the original plank test with a numerous of variations[338]. The inter-rater reliability of the plank test was found to be good with ICC 0.89 (95% CI: 0.79-0.97) as well as the intra-rater reliability with ICC=0.89 (95% CI: 0.62-0.97)[277;296]. Furthermore, Liemohn et al[339] recommended the use of repeated measurements on at least three consecutive days to obtain accurate measurements where possible. No normative data of plank test results available in soccer players.

3.2.2.2 Calf endurance test

Calf muscles and their strong Achilles tendon, acting as plantarflexors, are important in soccer performance[340]. The musculotendinous complex plays a significant role in running activities including sprinting, dribbling as well as jumping for heading the ball[341]. Therefore, the muscles are continuously required to function at an optimal level for the total playing period during which soccer is played, highlighting the need for the assessment of calf muscle endurance[340].

A test that has been widely used to assess the endurance of calf muscles is the calf raise test[342]. The test was performed by standing on one foot. The individual isrequested to raise their body and heel up to full plantarflexion while maintaining full extension of the knee and then smoothly lowering down to the starting position. The up and down cycle should be completed in one second; and individuals should continue the cycle for up to 60 seconds, or may stop as a result of fatigue[343;344].

The test is a valid and reliable measure of calf muscle endurance. A systematic review of studies that examined participants using the calf endurance test found a range of ICC from 0.57 to 0.99 for intra- and inter-rater reliability and a correlation coefficient value of 0.56-0.98[345]. The reliability of most of the studies ranged from good to excellent[345]. However, in another review, the same authors reported a wide variation among studies in terms of participants, sample size, outcome measurement and key testing parameters[346]. Many studies did not report on the key testing parameters such as the rhythm of the cycle, elevation of the heel, body position and criteria to terminate the test[346].

An important testing parameter that determines the completeness of the cycle is to maintain the heel in the highest position possible. However, the examiner cannot accurately determine the height of the heel during the cycle. Haber et al[347] and Sman et al[348] designed devices that could assist examiners by visually assessing the performance of subjects in terms the height of the heel. The devices use the same principle of placing a horizontal material that serves as a reference for the maximum heel raise height of the individual. The apparatus can be adjusted to accommodate different individuals and should be made before the start of the test[348].

A general asymptomatic population had on average 25 cycles[349]. Another study reported that males completed more cycles than females and active subjects had a higher frequency when compared to their sedentary counterparts. Furthermore, younger participants completed more raises than older people[350]. Dannis et al[296] found an increased risk of injuries when cricket players completed less than 25 repetitions[296]. Although the device is portable, easy to use and cheap, it is still not available in all the parts of the world especially in Africa. Consequently, traditional testing may be used since this method was found to be valid and reliable[345].

3.2.2.3 Hop tests

The hop test is often used to assess the performance of lower limb function[351]. The hop test was used in most of the literature as it assesses the strength, power and stability aptitude of lower extremity muscles[352;353;354]. Several variations of the hop test have been described in the literature with varying outcome measures such as distance, height or time. Vertical jump tests were used to measure the ability of subjects to jump high[355;356;357;358] while the majority of the studies used a single leg hop tests to evaluate distance and time[359;360].

The single leg jump test has been preferred because of its multicomponent measure. The test has four components of measurement. The first component measures the distance of a single hop. The second component measures the time lapsed while hopping six meters. The third component measures the distance of three consecutive hops. The fourth and final component measures the distance of three consecutive hops performed over the line. The test begins while the subject stands on the tested leg and is requested to land on the same leg. The distance is measured to the closest centimetre using a tape measure and the time is measured to the nearest second using a stopwatch[361;362].

Hop tests are most commonly used in clinical settings to assess the function capacity of knee injury patients to monitor their performance during rehabilitation[363;364;365]. Hop tests were found to be a good predictor of successful outcomes at after ACL reconstruction duringrehabilitation[366]. Triple hop for distance was found to be a functional predictor of strength and power in the male and female youth athletes[354]. Excellent reliability of the hop test had been found when assessing athletic (ICC=0.80)[367] or non-athletic (ICC=0.89-0.96)[368], male or female (ICC=0.80)[368], or other patients who have undergone ACL surgery (ICC=0.88-0.97)[369].

3.2.3 Balance and proprioception

3.2.3.1 Y-balance test

Dynamic balance has been found to be an important component in many sports, particularly in soccer[370]. Dynamic balance is vital in all soccer performance techniques such as kicking. Balance and coordination together with core stability are imperative in all soccer skills[308]. Lack of balance has been associated with increased risk of injuries, especially to the knee and ankle joints[371]. Alentorn-Geli et al[140] reported that players with deficits in balance and coordination had an increased risk of incurring non-contact ACL injuries[140].

As such, assessing balance would be of great importance towards the understanding of its contribution to injuries in general. Specifically, the contribution of balance to ankle and knee joint injuries should be known, as these are most commonly affected body parts in soccer and have been linked to many losses in terms of time and finances[140;372;373].

The Star Excursion Balance Test (SEBT) has been used to assess dynamic balance together with its simplified version called the Y-balance test[374;375;376]. The SEBT is performed with the individual standing in the centre of a grid of lines that are arranged in 45°apart from each other. The lines provide eight directions for reaching with the non-stance foot. The reaching orientations are anterior, anterolateral, lateral, posterolateral, posterior, posteromedial, medial, and anteromedial[377].

For the Y-balance test, the grid is composed of three lines arranged at 60 degrees from each other. The individual stands with one leg in the centre of the three lines so that one line is directed interiorly while the other two lines are directed posteromedially and posterolaterally. Using the non-stance foot, the individual is instructed to reach the lines in each direction with the farthest part of the foot as far as possible, and come back to the initial position. The test is considered invalid when the individual transfers their weight to the reach leg or displaces the stance foot[370;375]. The Y-balance test with three reach lines was found to be more practical than the SEBT with eight reach lines. Additionally the three reach distances were able to identify bilateral asymmetries and to predict injuries[378]. Butler et al[370] indicated that repeated measures of dynamic balance using the Y-balance test was good compared to the SEBT.

A study examining the reliability of the SEBT and the Y-balance test, excellent inter-rater reliability of the Y-balance test (ICC=0.97-1.0), was established, which was greater than the SEBT (ICC=0.35-0.93)[378]. Additionally, Plisky et al[378] found a good and less varied intra-rater reliability for the Y-balance test (ICC=0.85-0.89) compared to the SEBT (ICC=0.67-0.97). Furthermore, Coughlan et al[375] reported that the anterior reach results of the Y-balance test were significantly different from the SEBT for both legs[375]. Anterior reach, together with posteromedial reach, was able to identify players with chronic ankle instability[379]. Other studies found a relationship between the posteromedial reach and strength of hip extensor and abductor muscles[380;381]. Therefore, in this study the Y-balance test will be used to assess functional stability of soccer players.

3.2.4 Functional test

3.2.4.1 Lower extremity function test

Screening tests have been limited in assessing and identifying potential situations that cause injuries. The tests do not account for the various forces that stress the body in sports-related movements. However, the lower extremity function test (LEFT) was designed to mimic the specific activities that are performed in many sports[277;283;284;285;302;305;331;340]. Therefore, the lower extremity function test (LEFT) was designed to mimic the specific activities that are performed in many sports[382]. The LEFT is a timed test consisting of eight multi-directional agility drills. The individual executes the skills around diamond shaped cones performing forward run, backward run, side shuffle, carioca, figure of eight running, 45 degrees cutting and 90 degrees cutting drills. The individuals are required to perform the drills in sequence and in the shortest possible time[383]. The LEFT was designed to monitor the progression of injured players during rehabilitation by simulating movements related to sports[383]. The test could also be incorporated among screening tests in athletics.

The test-retest reliability of the LEFT was conducted by Tabor et al[384]. The reliability between the two weeks was excellent with an ICC of 0.95 and 0.97[384]. Brumitt et al[382] found that males had a mean score of 105 seconds (SD=9), while females had a mean score of 117 seconds (SD=10). Approximate results were reported by Haitz etal[385], determined that the average time was 109±10 seconds for males and 117±8 seconds for females[385]. The association between the LEFT results and injuries was also studied in 110 female and 83 male collegiate athletes[382]. Female players that used more time in completing the LEFT test had an increased risk of sustaining knee or thigh injuries. On the contrary, faster male players had an increased risk of back and lower extremity or ankle and foot injuries[382]. The LEFT was also included in the screening tests of the Rwandan soccer players to assess its ability to predict injuries.

3.2.4.2 Functional Movement Screen (FMS)

The Functional Movement Screen (FMS) was introduced in 2006 by Cook based on fundamental kinematic patterns[386]. The FMS was designed to analyse movement and stability dysfunction by subjecting an individual to extreme positions[387]. The positions used in the assessment include the "*deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability*"[387]. It was advocated for use in the pre-season screening of athletes[386;387].

The reliability of the FMS has been examined in professional athletes[388]. Kiesel et al[388] indicated that the sensitivity and the specificity of the FMS to depict injury risk factors in professional athletes was 0.54 and 0.91 respectively. Players with lower scores on the FMS had increased risk of severe injuries[388]. Schneiders et al[389] showed that the composite scores of the FMS in young active persons had an excellent inter-tester reliability with ICC of 0.97. Shultz et al[390] found a good reliability of the FMS with test-retest ICC of 0.6. The study indicated that live testing was provided reliable results than using video analysis. However, the study indicated that the poor inter-tester reliability with Kα=0.38 could be improved with training[389].

A number of studies reported normative data of the FMS results in an active population[389], of teenage school children[391]. Samar and Bansal[392] examined the relationship between subjective reported results and lower extremity assessment tools in athletes with hip disorders. The FMS was also included among these tests and was found to be related to other lower extremity function tests, excluding the hop tests. Samar and Bansal[392] concluded that the FMS was not a useful tool to assess hip dysfunctions in athletes. In the present study, the FMS was not included in the screening tests as its use requires training and certification[389].

3.3 Summary of the Literature Review: Preseason Musculoskeletal Screening in Athletes

The identification of risk factors is important to provide the basis for injury prevention in athletes[47;155]. FIFA developed and disseminated the validated PCMA form to be used to assess soccer players[266], which is continuously used in all FIFA tournaments[268]. However, a comprehensive musculoskeletal assessment composed of many tests could be used to provide a broad understanding of the contribution of each body component towards injuries. The procedure of the tests pertaining to the flexibility of the body[272;276;283;284;285;286;296;297;307;328;329], stability, strength and power[277;296;345;363;364;365], balance and proprioception[374;375;376] were reviewed. Additionally, their relevance to soccer has also been discussed. Where possible, the reliability of the tests and the normative values were also indicated[276;277;279;278;290;300;307;329;345;368;384]. Finally, functional measurements have also been advocated, considering that the aetiology of soccer injuries is multifactorial in nature[382;383;386;387].

Pre-season screening tests may be performed to assess the functional capability of players related to the game, as well as to monitor progression during rehabilitation[276;277;296;300;307;329;345;383;386;387]. Many tests described in the literature review will be used to assess intrinsic risk factors of first division soccer players in Rwanda in the next chapter.

CHAPTER 4. INCIDENCE, MECHANISM AND RISK FACTORS FOR INJURIES IN FIRST DIVISION SOCCER PLAYERS IN RWANDA: A TWO-YEAR PROSPECTIVE STUDY

4.1 Introduction

According to the conceptual models of injury prevention, the first step is to establish the incidence and severity of injuries though epidemiological studies[47;59] (Section 1.2). Internationally, prospective surveillance studies indicate an increased predisposition to injuries with increased soccer involvement at all levels[25;26;27;28;84;86;114;116;121;122;123;125;126] (Section 2.3 and Section 2.6.4). In Africa, scientific attempts to establish the occurrence of injuries in soccer are still scarce and there are several methodological discrepancies. There are studies that targeted targeting a single team[36], one competition[33;393], or players from a specific region[34]. Investigators have studied specific populations and the results could not necessarily be generalised to playing population. Another important limitation to the studies conducted in Africa is the lack of systematic recording of exposure associated with soccer playing[32;33;34;393]. Hence, the relationships between soccer exposure and injuries have not been fully explored. There is thus a need to conduct prospective studies recording soccer exposure to determine injury incidence over time.

African players may present a somewhat different pattern of injury to those reported internationally. Most of the studies that report on potential injury risk factors derive from high-income counties where sports facilities are more advanced and sports medicine more developed, whereas soccer in Africa remains at the amateur and semi-professional level. This may be linked to poor or inappropriate physical and physiological preparation of the players which may constitute intrinsic risk factors to injuries. The literature review presented in the previous chapter found a paucity of studies that investigate the possible injury risk factors in soccer in low-income countries, particularly in Africa.

Therefore, the aim of this study was to determine the incidence, mechanisms and causes of injuries sustained by soccer players in Rwanda through a prospective, longitudinal study of injuries and exposure for two consecutive seasons. The specific objectives of this study have been described in Chapter 1, Section 1.5.

4.2 Methodology

4.2.1 Design

A prospective cohort study design was used to track players for a period of two consecutive soccer seasons: the 2014-2015 and 2015-2016 seasons. The first season began on 13 October 2014 and concluded on 17 May 2015; a total duration of 33 weeks.

The second season began on 14 September 2015 and concluded on 10 July 2016; a total duration of 44 weeks. The latter season was longer in duration as it was interrupted by the preparation and hosting of the African Championship Cup organised by the CAF during January and February 2016.

4.2.2 Participants

The study population comprised of Rwandan male soccer players from first division teams who held valid player in the 2014-2015 and/or 2015-2016 seasons. Players were also required to hold valid league participation licenses, as issued by the Rwandan Football Federation. Players presenting with pre-existing injuries were only included in the study once they had been assessed by medical personnel and cleared to participate in training and matches. A total of 368 players from 14 teams took part in the first season, and 454 players from 16 teams participated in the second season. Therefore, 822 player-seasons were eligible for recruitment (Table 4-1). Players participating in one or both soccer seasons were included in the study.

Table 4-1:Name of the teams and number of players eligible for inclusion in the study.

Number	Name of the teams	Seasons	
		2014-2015	2015-2016
		Number of players	Number of players
1	Amagaju FC	27	28
2	Mukura VS	28	29
3	Rayons Sports	26	28
4	AS Kigali	24	28
5	Kiyovu FC	25	27
6	Entincelles FC	27	30
7	Marine FC	26	29
8	Espoir FC	25	29
9	Police FC	24	28
10	Sunrise FC	26	29
11	APR FC	28	28
12	Gicumbi FC	27	28
13	Musanze FC	30	27
14	Isonga FC	25	
15	Bugesera FC		29
16	Muhanga FC		30
17	Rwamagana FC		27
Total		368	454

FC: Football club, VS: Victory sport, AS: Association sportive, APR: Armée Partiotique Rwandais
Season One: n=14 teams, 368 players Season Two: n=16 teams, 454 players.
Blank: The team did not participate in the season

Clubs and/or players who did not agree to participate were excluded from the study. Players who had received surgery prior to the start of the season and were still undergoing rehabilitation were excluded.

4.2.3 Sample size calculation

The anticipated sample size of over 800 players was large enough to support the identification of a two tailed odds ratio of 1.4, with a significance level of p=0.05 and a power of 95%; given that the odds ratio attached to the null hypothesis was that the independent variable would result in an odds ratio of 1(N=480) (Figure 4-1).

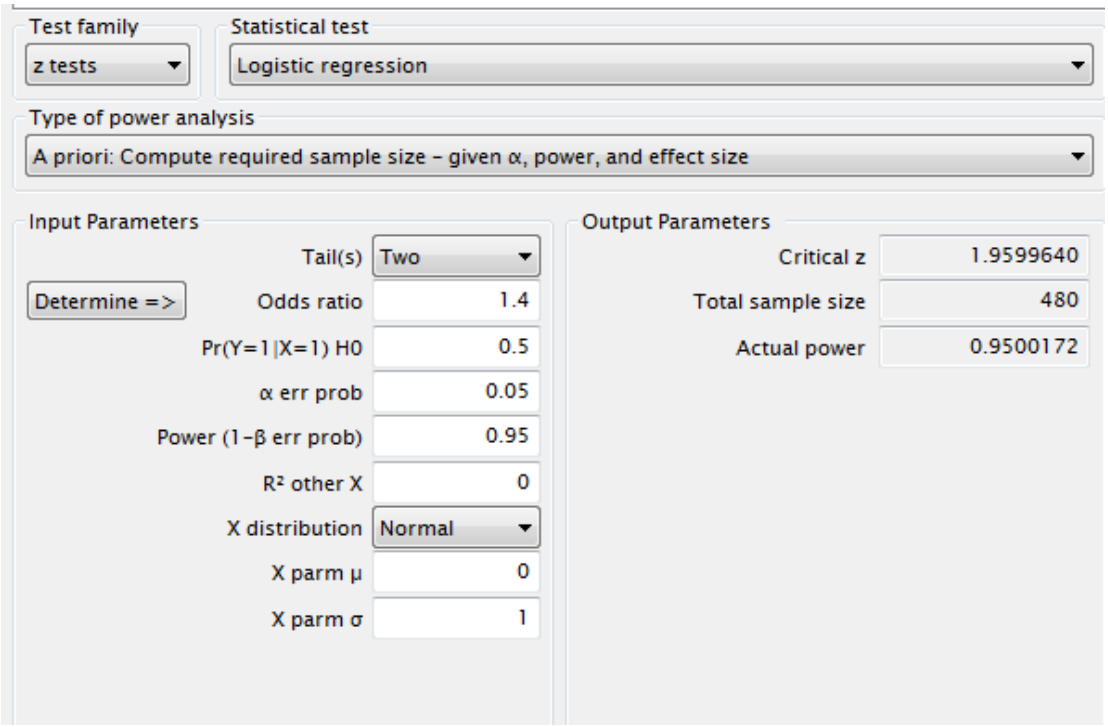


Figure 4-1: G*Power output for logistic regression sample size calculation[394]

4.2.4 Instrumentation

Instruments that were completed at the initiation of the study collected demographic, medical and functional data. The demographic information of the players was collected by coaches using self-designed forms; and the pre-season medical form were completed by the medical personnel employed by each team. Qualified physiotherapists who were trained as research assistants collected the musculoskeletal and functional data. Standardized forms were used to collect longitudinal data on exposure (completed by the coaches) and injury (completed by the medical team). These forms were completed daily and collected by the research team twice a month.

4.2.4.1 Demographic information

A short form which included information related to demographic and player profiles, was sent to the management of each team. The form included the age of the players, playing position, soccer experience, first division playing experience and current team experience (Appendix I). The information included was based on the literature, which identified relationships between age[157;161;162], playing position[28;98;161] and injury. Increased experience of playing at high levels was also associated with increased injury incidence in soccer[160]. The number of years playing in the first division and for the player's current team were included in the form. The form was completed at the start of the season and at the beginning of each second leg for newly recruited players. The information was captured once for each player.

4.2.4.2 Medical record form

A baseline medical record form was used to obtain information relating to the injury history of each player over the previous season (Appendix II). The history of injury sustained in the season prior to the study was assessed, including the number of injuries sustained and the body part affected. The form included information on treatment and recovery[395]. This allowed for the identification of the players undertaking the study with prior injuries. Further details pertaining to type and duration of injuries, history of injuries, recovery and management of injuries were not requested, as recall bias might result in unreliable results. The medical personnel of the teams which were comprised of English speaking physiotherapists, completed the questionnaires on behalf of the players. Therefore, no translation was required (Section 1.3).

4.2.4.3 Risk factor screening and functional measurements

Players were tested for potential risk factors for injuries at the beginning of the study or whenever a player entered the study. Appendix III provides the details of the tests performed. Anthropometric measurement of body mass using a digital scale (Omron HN-283 Digital Body Weight Scale); and stature, using a tape measure fixed on a wall were performed, and Body Mass Index (BMI) was calculated[396]. The digital scale was not adjustable and provided measurements to the nearest hundredth of the kilogramme. Therefore, calibration of the weighing scale was not performed and one scale was used for all the teams. A single research assistant performed body mass and stature measurements. The research assistant was trained to reduce measurement error and improve intra-rater reliability. In addition, the limited validity of BMI as an anthropometric measure is recognized. However, BMI will be used as a descriptive measurement only and no interpretation of body composition or fat distribution will be conducted

Flexibility tests includedthe active knee extension test to assess the flexibility of the hamstring muscles. Players were in supine with hip of the tested leg flexed at 90°. A wooden rectangular box was used to support the flexed position of the thigh. Goniometric measurement of the available active knee extension range of motion was performed[276;277]. The active knee extension test was reliable in measuring the flexibility of the hamstring muscles (Section 3.1.1.1).

Players were then requested to sit on a mat with their legs extended and the soles of their feet against a Sit and Reach box. They were instructed to place one hand on top of the other and reach the toes by bending forward as far as possible while maintaining the knees straight. The distance from the tip of the fingers and the toe line was measured[275;282]. The reliability of the Sit and Reach test has been established (Section 3.1.1.1.2).

The flexibility of iliopsoas muscles was measured using the modified Thomas test[276;296;297]. Participants were positioned in supine with the legs hanging at the edge of the plinth at the hip level. To stabilise the hip, they were requested to hold with arms the flexed leg on the non-tested side against the chest leaving the other leg freely handing. The angle of hip flexion range of motion was measured using the goniometer. Using the same position, the angle of knee flexion range of motion was performed to test the quadriceps muscle flexibility[276;296;297]. The reliability of the test was discussed in Section 3.1.1.2.

Hip internal and external rotation range of motion was measured in supine to assess the flexibility of hip external and internal rotators respectively[277;302;305]. Placing the movable arm of the goniometer in the longitudinal axis of the tibia, the hip rotation range of motion was measured by the angular movement of the tibia in relation to the perpendicular line with the floor[307]. The test was found to be reliable (Section 3.1.1.3). The test was performed with the players in supine position with the non-tested leg hanging off the side of the plinth. Using the goniometer, the angle of hip range of motion was assessed[157;179;304]. This conventional test was used as no attempt was made to assess its reliability[157;179;304] (Section 3.1.1.4).

Ankle plantaflexors flexibility was assessed by placing the players in a forward lunge position. They were instructed to move the knee forward as far as possible to the maximum dorsiflexion range of motion

without lifting the heel off the ground[314]. The distance between the big toe and the wall in front was measured[314;315]. The test has been found to be reliable[317;318] (Section 3.1.1.5).

The slump test was performed with players in high sitting position at the edge of the plinth. The arms were place behind the back with hands resting in the table. They were instructed to round the shoulders together with thoracic and lumbar flexion, and to add flexion of the cervical spine. Players were asked to perform ankle dorsiflexion with toes fully extended, followed by knee extension while maintaining the position of other body parts[320;321;322]. Knee extension range of motion was measured using the goniometer[325;326]. The reliability of the test was found to be excellent[276] (Section 3.1.1.6).

Stability, strength and power was tested using the four-point hold and calf endurance test tests. The four-point hold test was used to assess the core muscular strength and endurance of the players. Players were placed in prone position with the upper part of the body supported on elbows that are placed directly under the shoulders. Players were instructed to move up the rest of the body and maintain it as straight as possible until the point of fatigue. A stop watch was used to record the time the individuals managed to remain in the same position[277;296;338]. This test has good inter-rater and intra-rater reliability[277;296] (Section 3.1.2.1). A calf endurance test was used to assess the endurance of the calf muscles[342]. Players were requested to step on a small box with the tested leg. They were requested to raise the body and the heel up as high as possible to full plantarflexion while maintaining full extension of the knee and then smoothly lowering down to the starting position. The up and down movement were counted as one cycle till the point of fatigue[343;344;345]. The test was found to have a good to excellent reliability[345] (Section 3.1.2.2).

The Y-balance test was used to assess the dynamic balance of players[374;375;376]. Players were instructed to stand in the centre of a grid of three lines that are arranged at 60° from each other. Using the non-stance foot, players were instructed to reach the lines anteriorly, posteromedially and posterolaterally with the farthest part of the foot as far as possible and come back to the initial position[370;375]. The distance of the reach was measured in centimetres. Good to excellent reliability of the Y-balance test was reported[378] (Section 3.1.3.1).

After these tests, players were invited to the field to perform a warm up for 10 minutes with dynamic flexibility exercises for five minutes to prepare them for the functional tests. The functional testing was

performed using the single hop, timed, triple and cross over hop tests and the Lower Extremity Function Test (LEFT). Hop tests were used to assess the performance of lower limb function[351]. Players were instructed to stand on the tested leg and jump as far as possible to land on the same leg. The distance of one single hop, three consecutive hops on a straight line and three consecutive hops over the line were recorded. The time elapsed while hoping a distance of six meters was captured using a stop watch[361;362]. Players were given some rest between the tests to avoid fatigue. Excellent reliability of the hop test has been determined[367;368;369]. Players were invited to perform the lower extremity function test (LEFT) consisting of agility drills performed around the diamond shaped cones. Players were instructed to perform exercise drills consisting of the forward run, backward run, side shuffle, carioca, figure of eight running, 45° cutting and 90° cutting in the sequence and in a shortest period.
A stop watch was used measure the time taken to complete the test[382;383;384]. The reliability of the test was excellent[384] (Section 3.2.4.1). A data capture sheet was developed to record the results (Appendix IV). The same measurement tools were used for all the teams.

4.2.4.4 Training and match exposure form

A standardised exposure form developed by FIFA was used to record detailed information regarding player involvement in soccer[4] (Appendix V). During training, any form of physical activity supervised by the coach was recorded as training exposure time. Match exposure time was defined as the amount of time the player was physically involved while the team played against another team[397]. This form also recorded attendance and the duration that each player was involved in training or matches in minutes. In addition to their standard field training, training exposure included strength, conditioning, endurance and physical testing as well as recovery training[36].

4.2.4.5 Injury report form

A standardised injury report form was used to collect data pertaining to the incidence of injuries by each team medical personnel[4] (Appendix VI). The form was developed by FIFA and has been used during major tournaments including the Olympic games[398] and has also been extensively used in other studies[399]. The injury report form is comprehensive and injuries are recorded on the front side of the form, while all definitions related to the type, anatomical location, severity and circumstance of the injury are provided on the back of the form. For example, an injury is defined as "*any bodily complaint resulting from soccer training or match participation, whether medical intervention is required or not*"[2;4]. A time-loss injury is defined as "*an injury that caused the player to miss the next training session or match*"[2]. A traumatic injury is defined as "*an injury resulting from a specific, identifiable event*"[4] while an

overuse injury is defined as "*an injury caused by repeated microtrauma without a single, identifiable event responsible for the injury*"[4]. Categories and grouping of injury location and types used in this study followed the recommendation from the consensus statement on injury definitions and data collection procedures in soccer drawn from the Orchard sports injury classification system[4].

4.2.5 Procedure

The study followed the ethical guidelines of the Declaration of Helsinki for research in human participants[400] (Section 4.2.7). After obtaining formal research ethics approval and appropriate permissions to conduct the study, training of research assistants was conducted as well as other research personnel essential for data gathering.

4.2.5.1 Training of research assistants

Four physiotherapy graduates were recruited as research assistants and were invited to attend a three-day training workshop. The training was based on the guidelines for collecting data in studies of soccer developed by FIFA[4].

The training began with an explanation of the aims and objectives of study, the role of the research assistants, the methods of data collection as well as the ethical considerations of the study. The research assistants were then able to familiarise themselves with the procedures and instruments that were to be used for data collection. Discussions were held around the terms used in each of the data collection tools of the study.

On day two of the training, the research assistants were introduced to the methods of screening the players. Each research assistant was provided with copies of the testing manuals and had time to read, discuss and clarify all procedures. The research assistants were introduced to the tools needed to conduct each of the tests, and were then provided with the opportunity to practice the entire battery of tests on a group of 15 soccer players from a conveniently located academy in Kigali. Two research assistants performed one test on each player. At the end of the practical measurement, an analysis of the performance and reflection on the tests was performed. This method of testing proved too time consuming for both the research assistants as well as the players and it was agreed that research assistant should each perform only a sub-section of the tests to ensure consistent measurements (Figure 4-2). Players were also given time to practice the tests on their own. The sequence of testing was also modified to improve execution to avoid tiresome procedures for the players.

On the third day of the training, testing was carried out on 15 players from another soccer academy team. Measurements were performed according to the suggestions provided in the previous days training session. Players were tested once in the morning and again in the afternoon by the same physiotherapist to assess the accuracy of the measurement. The amendments to the procedures resulted in an efficient measurement system with accurate measurements records.

4.2.5.2 Training of research personnel

Team medical personnel were invited to a meeting through the technical directorate via telephone calls. The meeting with the team medical personnel, held at the FERWAFA training room, was organized to explain the purpose of the study and their role in the study. For the two seasons, there were six physiotherapists, seven nurses and one Red Cross agent. The injury report form was presented to the medical personnel and they were taught to report information relating to injuries incurred by the players. The terms pertaining to the location of injury, diagnosis and the severity of injuries and their respective codes were explained. Different scenarios were discussed and the correct method of recording demonstrated.

All the medical personnel agreed that information regarding the intervention of the referee in sanctions should not be included, as there were no referees during team practices. No other changes or suggestions were made. They were requested to start using the forms before the start of the league for familiarisation. The demographic forms and the medical questionnaires were also discussed during the meeting and the medical personnel were requested to record the required information of the players as well. No incentive for attending the meeting was provided to the medical personnel.

The researcher then met the coaches individually at a mutually convenient time and venue. After obtaining consent from the coaches, explanations of the aims, objectives, rationale and procedures for the study were provided. Player exposure forms were distributed and the procedure for recording every match training exposure throughout the season was explained. Many coaches raised the concern that it was not possible for them to accurately record match exposure because of their focus on the game. It was then decided to collect match exposure data from the reports submitted by the referee to FERWAFA. Further individual appointments to meet all the coaches in their teams were organised for additional explanations and to provide the opportunity for coaches to ask questions about the study.

The research team was also available every two weeks over the full study period in case there were concerns raised. The researcher was also contactable on telephone on daily basis.

The recording of training and match exposures, as well as injury recording for the main study started one week before the first game of each season because training performed during that week was regarded as preparation for the first game. Data collection took place throughout the season up to the end of the final game; and this was completed across twoconsecutive seasons (33 weeks for season one and 44 weeks for season two). Players who sustained injuries towards the end of the season were followed up untilthey were deemed to have recovered from the injury by the medical personnel.

4.2.5.3 Gaining access and recruiting personnel to gather data

Medical personnel from each team were contacted telephonically and invited to a meeting at the FERWAFA training room with the technical directorate to explain the purpose of the study and their role in the data collection process. Across the two seasons, six physiotherapists, seven nurses and one Red Cross agent participated in the study as medical personnel. During the meeting, they were presented with the injury report form and were taught to record information relating to injuries incurred by the players. Terms pertaining to the diagnosis, location and severity of injuries and their respective codes were explained.

Various scenarios were discussed and the correct method of recording was demonstrated. All medical personnel agreed that information regarding the intervention of the referee in sanctions should not be included as there were no referees during team practices. No other changes or suggestion were made. The medical personnel were requested to begin using the forms before the start of the league to familiarise themselves with its content. The demographic and the medical forms were also discussed during the meeting, as the medical personnel were requested to record the required information of the players as well. No incentive for attending the meeting was provided to any of the medical personnel.

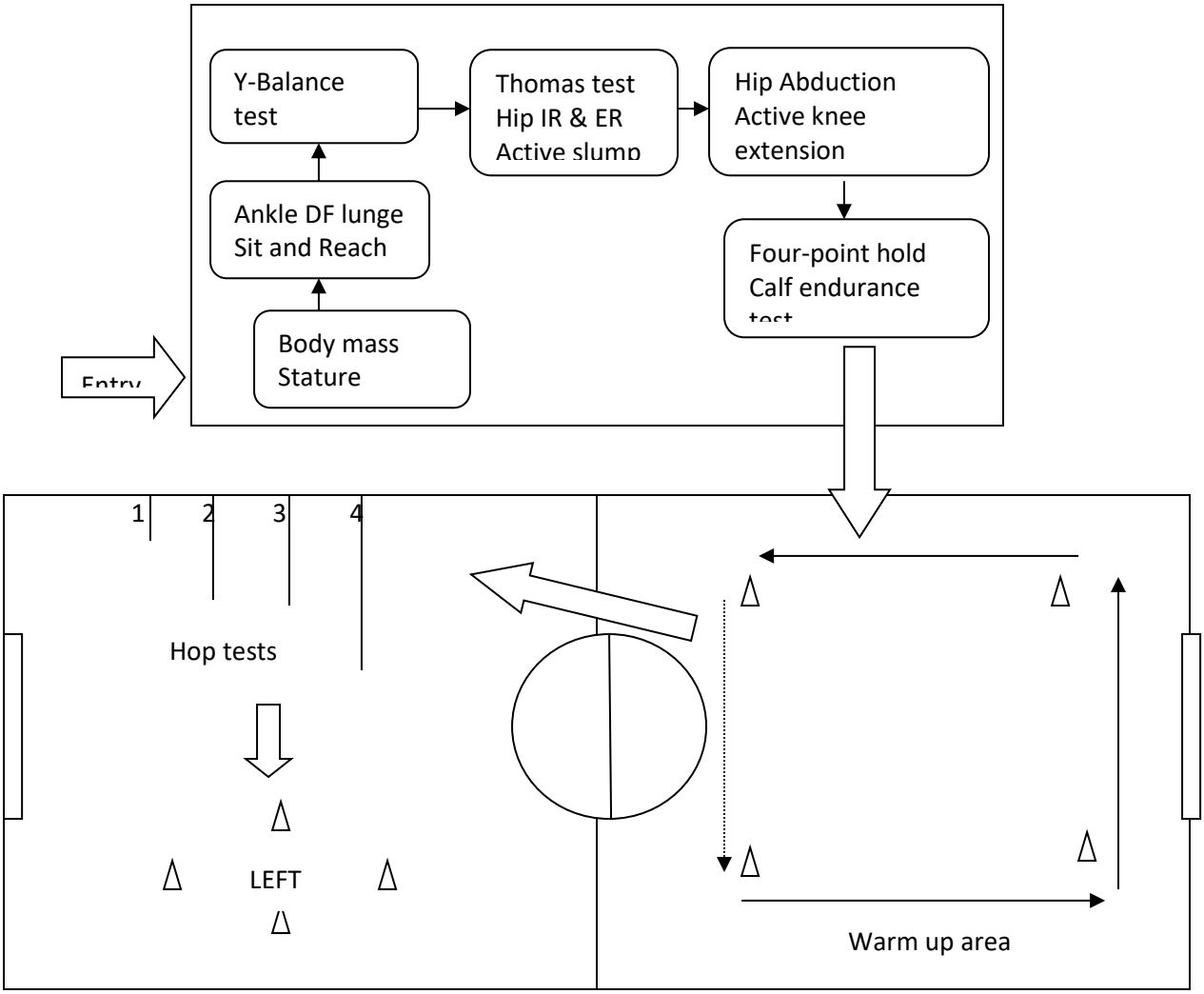
The researcher met with each coach individually at a mutually convenient time and venue and provided them with information pertaining to the aims, objectives and rationale of the study, as well as the procedure for data collection. The player exposure forms were distributed and the procedure for recording match and training exposure throughout the season was explained. Several coaches indicated that it would not possible for them to accurately record match exposure as their primary focus would be on the game. It was then decided to collect match exposure data from the reports submitted by the

referee to FERWAFA. Additional individual appointments to meet each of the coaches and their teams was organised for the researcher to provide a more detailed explanation of the study and to provide an opportunity for the coaches and team members to ask questions. The research team was also available to the teams every two weeks to address any new or ongoing concerns.

Training, match exposure and injury recording for the main study commenced one week before the first match of each season as the training performed during this week was regarded as match preparation. Data collection took place throughout the two seasons, up until the end of the final game of each season. Players who sustained injuries towards the end of the season were followed up until the injury was deemed to be recovered by the medical personnel.

4.2.5.4 Physical and functional testing of players

Each coach agreed on a convenient date to conduct the testing of the players. Each team was tested on a separate day and all the tests were performed from approximately 08h00 to 13h00. Players were encouraged to give their maximum performance. To begin the timed tests, the examiner gave each player a verbal command of “go”. The tests were organised in stations as outlined in Figure 4-2.



1: Single leg hop; 2: Triple hop; 3: Cross over hop; 4: Timed hop
IR: internal rotation; ER: external rotation
LEFT: lower extremity function test

Figure 4-2: Sequence of the screening tests where each box represents the testing station.

As FERWAFA allows teams to recruit new players during the mid-season period, players who joined the teams halfway through each season were recorded from the time they were recruited. Baseline data were gathered for the new players recruited by the teams and players from promoted teams. Players of the teams that were relegated from first division were not followed up but their data from season one was analysed.

4.2.6 Data management and statistical analyses

The researcher collected the once-off demographic and medical forms at the start of each season and second leg. The research assistants collected the forms related to training exposure from the coaches and the injury forms from the medical personnel every two weeks.

The research team checked the completeness of the forms at the time of collection. Any missing information or discrepancies in data were queried immediately. The researcher entered the data into Microsoft Excel which was cross-checked by the research assistants (Version 2000, Microsoft, Redmond, Wash). Completed forms were securely kept in a locked and secure drawer in the researchers' office. The soft copies of the collected data were saved in a password protected computer and external hard drive for back up.

Microsoft Excel (Version 2000, Microsoft, Redmond, Wash) was used to capture the data. Data analysis was carried out using Statistica data analysis software, version 13.2, Dell Inc. and the Statistical Package for Social Sciences (SPSS) for Windows, version 21.0, SPSS Inc, Chicago, USA. Descriptive statistics were used for numerical variables as means, standard deviations (SD) or 95% confidence intervals (CI).

Categorical variables were presented as frequency and percentages.The incidence of injuries was expressed as injuries per 1000 soccer playing hours for the comparison with previous epidemiological studies. It was computed as the total number of injuries divided by the total number of exposure hours multiplied by 1000^2. Specifically, incidence per 1000 hours of exposure per match, training or both was also calculated[2].

The normality of the distribution of the continuous data was assessed individually or with the specification of an additional categorical variable. The visual inspection of the shape of the histogram, Q-Q plot and box plot provided the information about the normality of the distribution of data. Though the values of the skewness and kurtosis and the results of the Kolmogorov-Smirnov statistic were provided in the output, they were not considered because their assumption of normality were violated with the larger samples in this study.

To allow for comparison with other studies, the body part, type, patterns and severity of injuries were presented using frequency and percentages. Time lost due to injuries was presented using minimum, maximum, median, 25^{th} and 75^{th} percentiles as the data were not normally distributed. A Kruskal-Wallis

test was used to assess the difference of time loss according to the body part and type of injury. The variations of injuries during training and matches for the two seasons were presented using incidence and 95% confidence intervals. The variations of injuries across the seasons were presented graphically using GraphPad Prism, version 7.03 software, indicating the overlap of the 95% confidence intervals and Odds ratio for non-significant differences between the incidences of injuries. The relationship between training and match exposure was analysed using a Pearson's correlation.

As the sample was large enough, the Central Limits Theorem applied and parametric tests were carried out for the continuous data. An independent-sample t-test was used to compare measurements results of the left and right side. A difference of more thantwo degrees or centimetres in the range of the different joints and muscles was deemed clinically important.

The average of the non-clinically significant different measurementsfor both sides (left and right) was computed. Univariate analyses were used to evaluate the relationship between individual risk factors and the occurrence of all lower limb injuries. Variables identified to be risk factors with a p-value of <0.05 in univariate analysis, were further analysed using the multivariate model to assess their contribution to predict injury. Multivariate CHAID (Chi-squared Automatic Interaction Detection) analysis was carried out to determine whether demographic variables, identified as significant in the univariate analyses, were associated with injury, over and above measurements results[401]. This analysis was completed with the purpose of determining if musculoskeletal measurement results assessed at the beginning of the study were associated with the probability of sustaining injury.

4.2.7 Ethical considerations

Ethical approval to conduct the study was obtained from the Faculty of Health Sciences Human Research Ethics Committee at the University of Cape Town (HREC/REF: 683/2014) (Appendix VII). No further ethical approval was needed in Rwanda. Permission to conduct the study was also obtained from the FERWAFA as well as from the clubs (Appendix VIII). The aims of the study as well as all the information pertaining to the study was explained in the information sheet distributed to each of the coaches and players, which ensured that they could make informed choices regarding their decision to participate in the study. They were given enough time to read the information sheet and where needed verbal explanations were also provided. Written informed consent was obtained from each of the players, as well as from the parents/legal guardians of minor players (Appendix IX-Appendix XI). The participants were assured of confidentiality. The players and their respective clubs were assigned numeric codes.

Only the researcher had access to the collected raw data. Participants were informed of their right to withdraw from the study at any stage without any implication. There were no physical risks to players associated with taking part in the study. All physical risks were those that were ordinarily encountered through soccer training and playing matches. All interested parties will have access to the findings of the study and the results of the study will be presented to the executive committee of FERWAFA, as well as to the coaches and medical personnel. No team, players or coaches will be identifiable during these presentations. Discussions will be held regarding prevention strategies that may be implemented to reduce the occurrence of injuries among soccer players in Rwanda. Pamphlets outlining the major findings of the study will be distributed to each team. The results of the study will also be disseminated to the public through lay press.

4.3 Results

4.3.1 Description of the study design and participants

Prior to the commencement of the first season, each of the 14 first division teams enrolled to compete in the league (368 players) were invited to participate in the study. Three teams declined to participate (85 players), while eleven teams (283 players) agreed to take part in the study. During the midseason transfer window, 43 new players, were recruited into the various teams and agreed to participate in the study. During this period, a total of 12 players were released from their teams and as a result were no longer eligible to take part in the study. Considering their exposure time, the analysis included their injury data. The final analysis of the first season included data for 326 players.

At the conclusion of the first season, FERWAFA decided to increase the number of teams in the first division to 16 teams. One team was relegated to the second division and three teams were promoted from the second to the first division. The three new teams and players underwent the recruitment process. All the participants agreed to take part in the study. Therefore, 13 teams (371 players) took part in the study from the beginning of the second season. After the first leg of the season, 29 new players were recruited by the teams and agreed to participate in the study. Five players dropped out of the study as they were either not productive for their teams (n=4 players) or recruited by teams outside of the country (n=1 player). Their injury data were once again considered in the analysis as their exposure time had been recorded prior to their release from their teams. The analysis excluded nine players that were selected to join the national team as they had several additional hours of training and match

exposure. Therefore, the analysis of the second season data included 391 players (Figure 4-3). The total number of participants in this study were 717 player-seasons counted as a unit of analysis.

The recruitment rate of 24 team-seasons out of a possible 30 team-seasons indicates that 80% of the eligible teams participated in the study. The position of the three teams who declined participation was 1, 6 and 12 in the 2015-2016 season log and 1, 9 and 14 in the 2016-2017 season log.

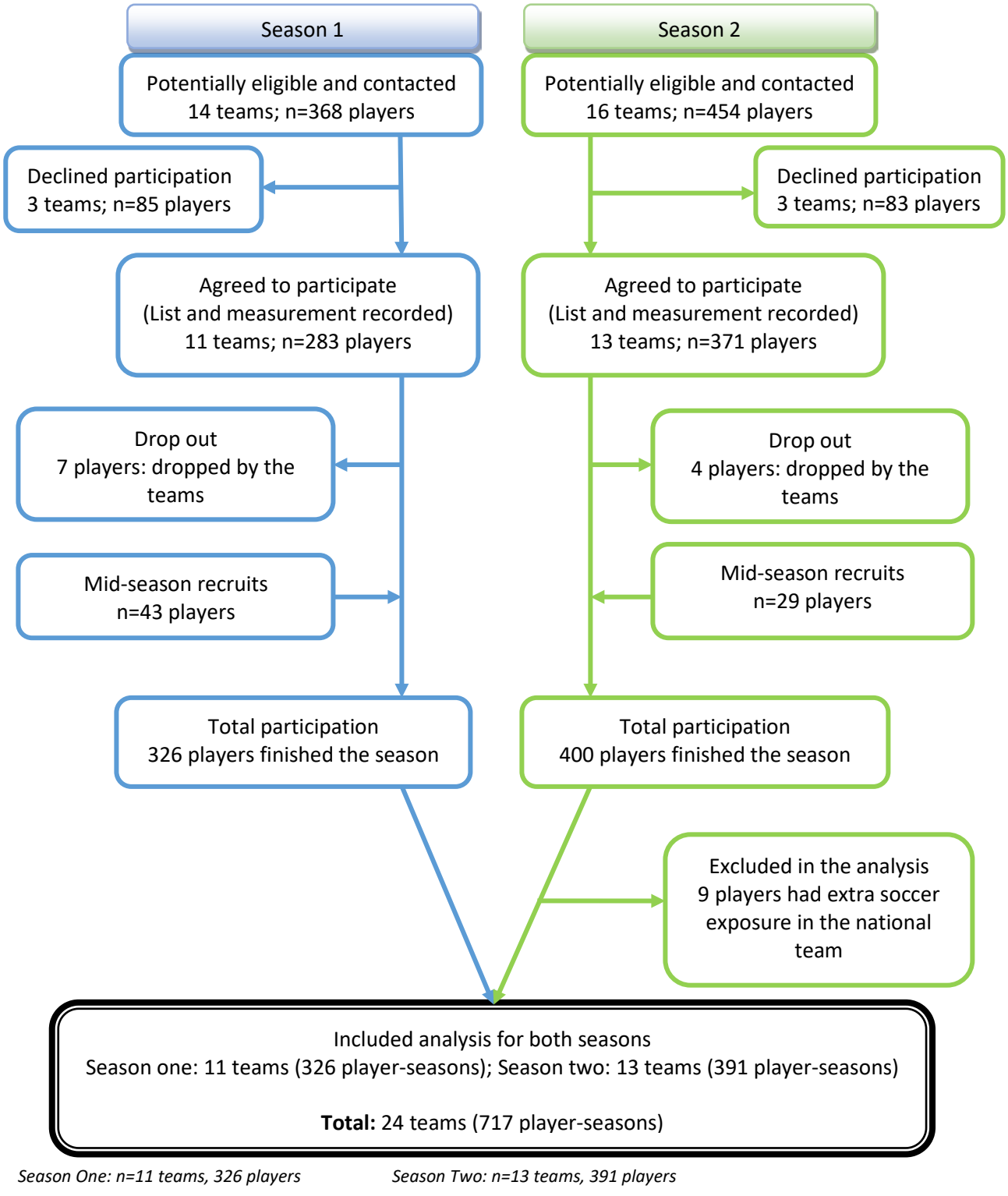


Figure 4-3: Flow chart of the study indicating the number of participating teams and players.

4.3.2 Bio-demographic characteristics of the players

The mean (standard deviation, SD) age of the participants was 24.6 (SD=4.0) years, (median 25; Inter quartile range 21; range 17 to 39 years). Players had a mean of 4.9 (SD=2.4) years of experience. The mean years of experience in the first division and their current team were 3.1 (SD=2.0) and 1.6 (SD=1.0) years respectively. All of the players who had played for five years or more were over the age of 27 years.

Across the two seasons, 502 individual players participated in this study. Midfielders constituted the largest proportion of players (n=184; 36%), followed by defenders (n=170; 34%) and strikers (n=113; 22%). Goalkeepers represented the least number of players (n=35; 8%). An ANOVA test indicated that there was a significant difference between the stature of the players according to their playing position ($p<0.001$). Body mass and body mass index approached the level of significance (Table 4-2).

Table 4-2: Comparison of demographic and anthropometric characteristics of players in different playing positions.

Variables		**Playing position**				**Statistics**	
	All Participants	**Goalkeeper**	**Defender**	**Midfielder**	**Striker**	**F**	**P-value**
	n=502	n=35	n=170	n=184	n=113		
Age (years)	24.6 (4.1)	25.7 (4.9)	24.9 (4.0)	24.2 (3.8)	24.6 (4.2)	1.765	0.153
Soccer experience (years)	4.9 (2.4)	5.8 (2.3)	4.9 (2.4)	4.7 (2.4)	4.8 (2.6)	2.007	0.112
1st division experience (years)	3.0 (2.0)	3.4 (1.8)	3.0 (2.0)	2.9 (1.9)	3.1 (2.3)	0.692	0.557
Current team experience (years)	1.5 (0.9)	1.9 (1.0)	1.5 (1.0)	1.6 (1.0)	1.5 (0.9)	2.208	0.086
Body mass (kg)	73.0 (9.4)	76.9 (8.6)	73.0 (9.5)	72.1 (9.4)	63.0 (9.4)	2.510	0.058
Stature (cm)	173.9(9.8)	184.1 (7.6)	172.7 (9.1)	173.4 (9.7)	173.6 (9.8)	14.929	***<0.001***
Body mass index ($kg.cm^{-2}$)	24.3 (3.7)	22.0 (3.1)	24.6 (3.4)	24.2 (3.9)	24.4 (3.7)	2.523	0.057

N=502 individual players
The values are expressed as mean (standard deviation).

Post-hoc comparisons indicated that goalkeepers were significantly taller than players in any of the other positions (Table 4-3).

Table 4-3: Post hoc multiple comparisons of stature per playing position.

Demographic characteristics	Playing position	Goalkeeper		Defender		Midfielder	
		Mean difference	P-value	Mean difference	P-value	Mean difference	P-value
Stature (cm)	Goalkeeper						
	Defender	11.438	***<0.001***				
	Midfielder	10.718	***<0.001***	-0.720	0.889		
	Striker	10.566	***<0.001***	-0.872	0.871	-0.152	0.999

Mean differences and p-values of the multiple differences between the goalkeepers (n=35), defenders (n=170), midfielders (n=184) and strikers (n=113) are presented.

4.3.3 Musculoskeletal assessment and functional test of first division soccer players

The data of the tests performed comparing the left and right sides are presented in Table 4-4. An independent t-test indicated that many of the functional tests were significant different. However, the calf endurance test, triple hop test and Y-balance tests were the only tests that reached clinical significance with a difference of more than two units (number of repetitions or centimetres) between the left and the right sides. An average value of the two limbs that did not reach clinical significance was then computed and was used in subsequent analyses. The Sit-and-Reach test was included among the flexibility tests while the four-point hold test was included in strength and endurance tests. The lower extremity function test (LEFT) was included with the lower limb functional tests.

Table 4-4: Musculoskeletal screening and functional tests comparing left and right side.

Tests	Left	Right	Statistics		Both sides combined	
	Mean (SD)	Mean(SD)	t-value	P-value	Mean(SD)	95% CI
Flexibility tests						
Ankle dorsiflexionlunge (cm)	15.2 (3.9)	14.7 (3.9)	1.987	***0.047***	15.0 (3.7)	14.7-15.3
Active hip Internal Rotation (°)	26.0 (5.6)	25.9 (5.7)	0.342	0.732	28.0 (6.1)	25.8-30.1
Active hip External Rotation (°)	27.9 (5.6)	28.1 (5.9)	-0.369	0.713	28.8 (6.0)	26.7-30.8
Active knee extension (°)	9.5 (8.3)	10.6 (8.3)	-2.158	0.031	9.3 (7.8)	6.6-12.0
Thomas test hip (°)	-1.3 (6.2)	-0.3 (6.3)	-2.393	0.017	-0.8 (6.2)	-1.35 - -0.26
Thomas test knee (°)*	64.8 (8.0)	65.7 (7.3)	-1.936	0.053	64.1 (7.4)	61.5-66.6
Active slump (°)	7.9 (4.8)	9.0 (5.1)	-3.51	***<0.001***	8.5 (4.1)	7.1-9.9
Hip abduction (°)	43.8 (4.4)	44.2 (5.2)	-1.122	0.262	43.5 (3.8)	42.2-44.8
Sit and Reach test (cm)					5.4 (7.8)	2.7-8.11
Strength and endurance						
Calf endurance test (n)	37.1 (7.1)	39.6 (7.0)	-5.486	***<0.001***		
Four-point hold (sec)					185.2(31.7)	174.3-196.1
Balance and proprioception (cm)						
Y-Balance anterior	80.3 (9.9)	83.8 (10.1)	-5.499	***<0.001***		
Y-Balance Posteromedial	89.3 (11.1)	92.7 (10.7)	-4.902	***<0.001***		
Y-Balance Posterolateral	92.9 (10.5)	97.7 (11.4)	-6.935	***<0.001***		
Lower limb function test						
Single hop (cm)	255.9 (20.3)	255.9 (22.5)	0.029	0.977	251 (20)	244-258
Triple hop (cm)	753.0 (46.4)	760.8 (44.7)	-2.712	***0.007***		
Cross over hop (cm)	713.7 (62.6)	715.3 (66.3)	-0.393	0.694	730 (66)	708-753
Timed hop (sec)	2.4 (0.3)	2.3 (0.3)	5.077	***<0.001***	2.4 (0.3)	2.3-2.4
LEFT (sec)					105.4 (10.9)	104.4-106.3

N=502players, degrees of freedom *(df)=1002, SD: Standard deviation, CI: confidence interval*
*Tested with separate variances; (°): degrees; Sec: seconds; LEFT: Lower Extremity Function Test.
The left and right side average values for clinically non-significant results are presented even if they were statistically significant.

4.3.4 Characteristics of the training and match exposure across the seasons

The following subsection compares the results of the training and exposures per team across the two seasons. Furthermore, the weekly training and match exposure data are presented.

4.3.4.1 Descriptive analysis of training and match exposure

4.3.4.1.1 Frequency and time period of team training and matches

Table 4-5 presents the number of training sessions, matches and the respective exposure time in hours per team across the two seasons. There were no statistically significant differences in the number of training sessions per team between season one (mean=147, SD=7) and season two (mean=161, SD=22) (t (15)= -2.096, p=0,054, tested with separate variances). Similarly, the exposure time in season one (mean=267, SD=32 hours) was not significantly different from season two (mean=274, SD=50) (t (22)= -0.414, p=0.683). As there was no variance in the match hours or frequency between the two seasons, a t-test could not be used to compare the two variables. Season one comprised of 86.6% more matches and match exposure hours than in season two.

Table 4-5: Teams' training and match exposures for the two seasons.

Seasons	Team code	Training Frequency	Time (hours)	Match Frequency	Time (hours)
Season 1	1	130	256	26	39
	2	143	215	26	39
	3	148	289	26	39
	4	152	277	26	39
	5	141	252	26	39
	6	146	218	26	39
	7	154	304	26	39
	8	156	314	26	39
	9	153	250	26	39
	10	148	274	26	39
	11	148	284	26	39
Mean		147	267	26	39
Standard deviation		7	32	0	0
Total exposure time (hours)		1619	2988	286	25740
t-value			-2094		
p-value			0.054		
Season 2	1	175	302	30	45
	2	144	238	30	45
	3	163	280	30	45
	4	160	258	30	45
	5	144	225	30	45
	6	181	308	30	45
	7	192	368	30	45
	8	178	319	30	45
	9	150	264	30	45
	10	199	335	30	45
	11	128	205	30	45
	12	142	231	30	45
	13	137	227	30	45
Mean		161	274	30	45
Standard deviation		22	50	0	0
Total exposure time (hours)		2093	3560	390	35100
t-value			-0.414		
p-value			0.683		

Season One: n=11 teams, Season Two: n=13 teams
Data are presented as the number of training sessions and matches per team and their respective time expressed in hours.

4.3.4.1.2 Total player exposure times for overall, training sessions and competitive matches

Table 4-6 showsthe total overall, training and match exposure times in hours. The average and standard deviation player level exposure times are also presented.

Table 4-6: Overall, training and match total player exposure time in hours.

Seasons	Team code	Overall exposure			Training exposure			Match exposure		
		Sum	Mean	Standard Deviation	Sum	Mean	Standard Deviation	Sum	Mean	Standard Deviation
Season 1	1	6725	231.9	59.6	6296	217.1	53.2	429	14.8	12
	2	5843	224.7	17	5414	208.2	9.3	429	16.5	12.9
	3	7943	240.7	83.1	7514	227.7	76.3	429	13	11.7
	4	7326	261.6	56.4	6897	246.3	50.6	429	15.3	11.7
	5	6570	234.6	75.5	6141	219.3	67.7	429	15.3	11.8
	6	6197	187.8	57.3	5768	174.8	51.5	429	13	12.5
	7	9589	299.7	50.5	9160	286.3	44.7	429	13.4	12.5
	8	9447	304.7	54.4	9018	290.9	50.7	429	13.8	10.6
	9	6109	244.4	46.8	5680	227.2	42.1	429	17.2	9.8
	10	7974	241.6	65.5	7545	228.6	61.2	429	13	9.6
	11	7889	281.8	48.9	7460	266.4	43.5	429	15.3	11.8
Total		81612	250.3	67.1	76893	235.7	62.5	4719	14.6	11.5
Season 2	1	9485	316.2	55.3	8990	299.7	52.4	495	16.5	10.8
	2	6427	257.1	48.4	5948	237.9	44.8	478	19.1	11.1
	3	9423	314.1	29.3	8927	297.6	25.2	497	16.6	13.5
	4	7635	231.4	80.5	7138	216.3	75.1	496	15	12
	5	6866	236.8	35.9	6383	220.1	29.6	484	16.7	15.3
	6	10610	303.2	70.7	10110	288.9	67.3	501	14.3	11.8
	7	8936	357.5	87.2	8503	340.1	81.5	433	17.3	14.7
	8	8432	337.3	54.9	8048	321.9	52.7	384	15.4	10
	9	7705	296.3	36	7253	279	35.4	452	17.4	12.8
	10	10185	351.2	61.7	9700	334.5	60.4	485	16.7	14
	11	7558	236.2	21	7063	220.7	16.5	495	15.5	14.8
	12	7788	222.5	74.8	7293	208.4	72	495	14.1	13.9
	13	8745	236.4	47.6	8255	223.1	42.9	491	13.3	14.4
Total		109796	284.3	74	103611	268.3	71	6185	16	13.1

Season one: n=11 teams, 326 players; Season two: n=13 teams, 391 players
Overall, training and match exposure data are expressed in hour.
Red colour represents the highest mean and the green colour the lowest.

There were no significant differences in the overall and training exposure times between season one and season two; however, there was a significant difference in match exposure time between seasons one and two (Table 4-7).

Table 4-7: Comparison of overall, training and match exposure times between season one and season two.

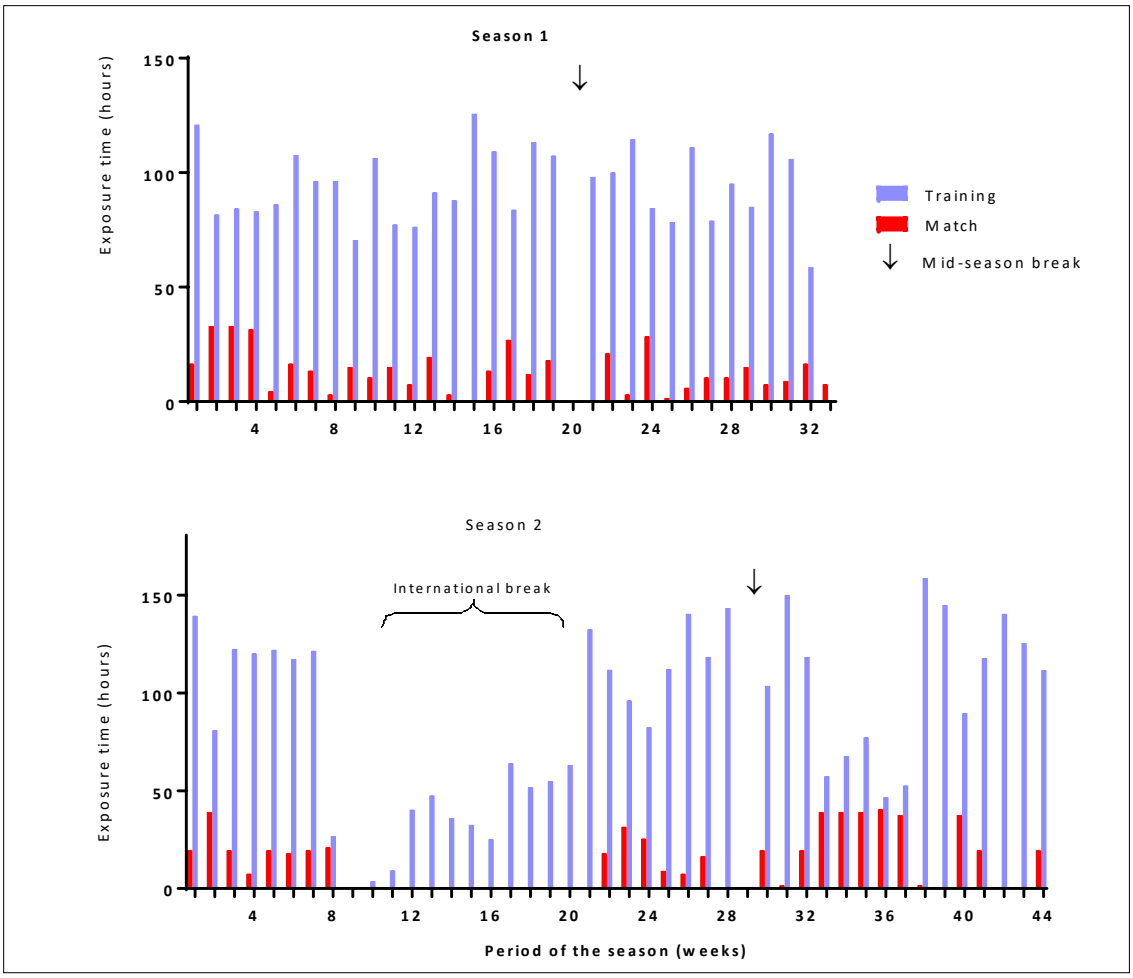
Exposure	Season one		Season two		Statistics		
Period	Mean	SD	Mean	SD	t-value	df	p-value
Overall	250.3	34.45	284.32	49.39	-1.978	21*	0.061
Training	235.70	34.53	268.32	48.85	-1.908	21*	0.070
Match	14.6	1.47	15.99	1.59	-2.213	22	***0.038***

**Tested with separate variances*
Season one: n=11 teams, 326 players; Season two: n=13 teams, 391 players
Team weighted overall, training and match exposure data are expressed in hours

4.3.4.2 Weekly breakdown of training and match exposures

Players were exposed as approximately equal amount of training hours per week across season one (mean=89; SD=28) and season two (mean=86; SD=46) (t (72)=0.327, p=0.727, tested with separate variances). There were no significant differences in weekly match exposure hours between season one (mean rank=41, sum of ranks=1342) and season two (mean rank=38, sum of ranks=1661) (U=671, Z= -0.573, p=0.567). Non-parametric tests were used because match exposure times were not normally distributed. Figure 4-4 shows that the number of training exposure hours decreases as the number of match exposure hours increases. Excluding the 13-week international break period in the season two, there was a significant strong negative correlation between training and match exposure hours per week (rho(31)= -0.707, p<0.001, data not normally distributed).

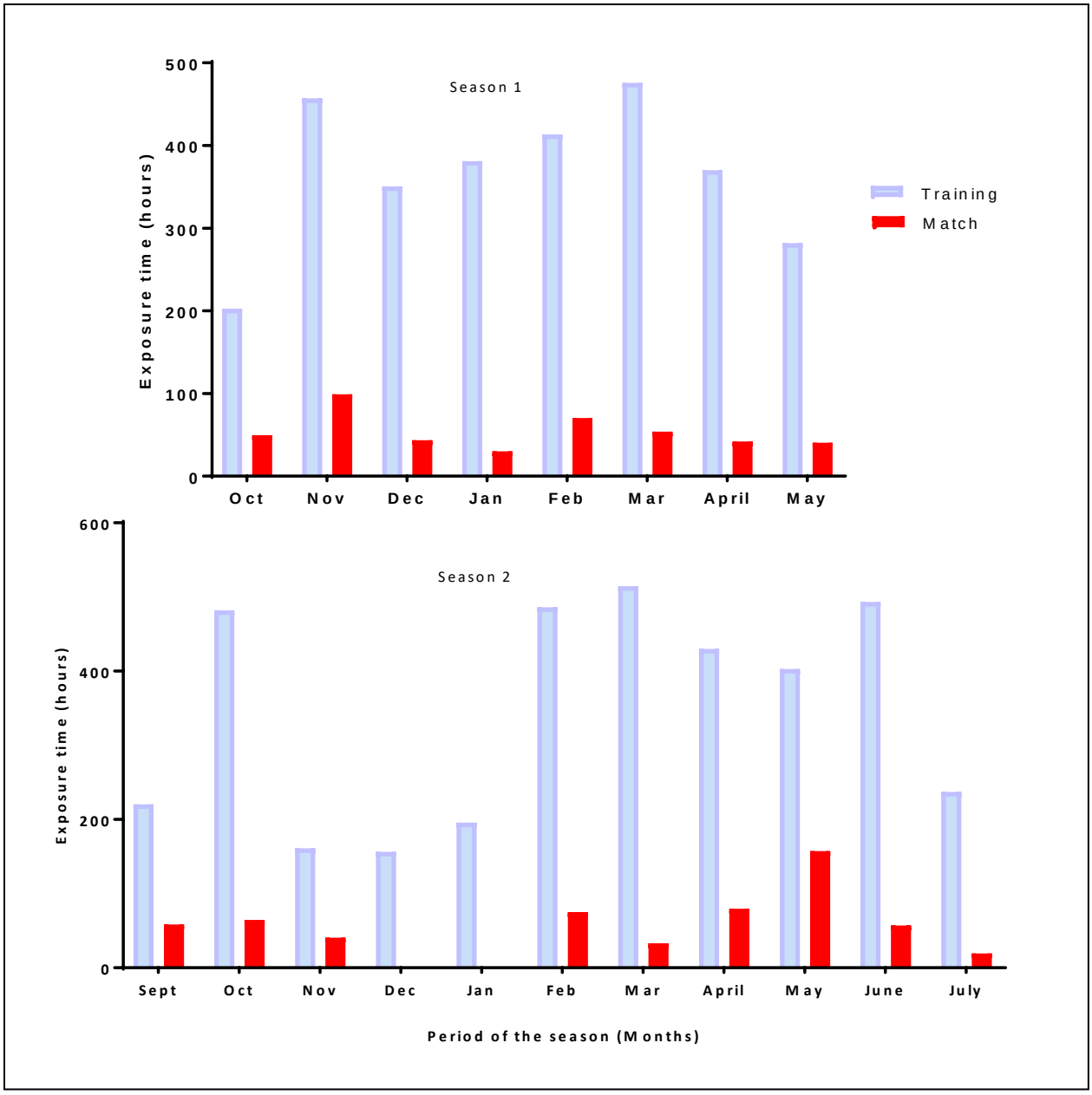
The highest training exposure hours were observed in week 15 during season one and in week 38 of season two. The highest match exposure hours were observed in weeks 2-4 in season one and in weeks 33-37 of season two. These weeks were regarded as peak match periods of the seasons.



Season One: n=33 weeks, Season Two: n= 44 weeks
Weekly exposure was obtained from the sum of player exposure time expressed in hours
The periods of match congestion were weeks 2-4 in Season One and 33-37 in Season Two.

Figure 4-4: Weekly match and training exposure times for season one and season two.

Similarly, the months of March and November saw the highest match exposure times during season one, while May had the highest match exposure time during season two. Figure 4-5 illustrates the distribution of the total match and training exposure times per month.



Season one: n=8 months, Season two: n= 11 months
Monthly exposure was obtained from the sum of player exposure time expressed in hours

Figure 4-5: Monthly match and training exposure time for season one and season two.

4.3.5 Injuries sustained during soccer training and matches

4.3.5.1 Frequency and incidence of all injuries

There were 455 reported injuries in total; 194 (43%) in season one and 261 (57%) in season two. In season one, 93 players (29%) sustained at least one injury; while 129 players (33%) sustained at least one injury in season two.

Fifty-five percent (n=252) of injuries took place during a training session while 45% (n=203) of injuries occurred during competitive matches. During season one, the team with the lowest injury frequency reported eight injuries and the team with the highest frequency reported 34 injuries. During season two, the team with the lowest injury frequency reported 13 injuries, while the team with the highest injury frequency reported 30 injuries. Considering the total exposure hours at team level, Table 4-8 provides the details of the frequency and incidence per 1000 hours of overall, training and match injuries per team.

Table 4-8:Comparison of the incidence of overall, training and match injuries between season one and season two.

Seasons		**Overall**			**Training**			**Match**		
	Team code	Total exposure (hours)	Injury	Incidence	Total exposure (hours)	Injury	Incidence	Total exposure (hours)	Injury	Incidence
Season 1	1	6725	34	5.06	6296	16	2.54	429	18	41.96
	2	5843	16	2.74	5414	13	2.40	429	3	6.99
	3	7943	14	1.76	7514	11	1.46	429	3	6.99
	4	7326	20	2.73	6897	14	2.03	429	6	13.99
	5	6570	8	1.22	6141	7	1.14	429	1	2.33
	6	6197	13	2.1	5768	6	1.04	429	7	16.32
	7	9589	13	1.36	9160	10	1.09	429	3	6.99
	8	9447	21	2.22	9018	8	0.89	429	13	30.30
	9	6109	19	3.11	5680	12	2.11	429	7	16.32
	10	7974	25	3.14	7545	22	2.92	429	3	6.99
	11	7889	11	1.39	7460	8	1.07	429	3	6.99
Total		81612	194	2.38	76893	127	1.65	4719	67	14.20
Season 2	1	9485	29	3.06	8990	12	1.33	495	17	34.34
	2	6427	15	2.33	5948	6	1.01	478	9	18.81
	3	9423	13	1.38	8927	2	0.22	497	11	22.16
	4	7635	30	3.93	7138	20	2.80	496	10	20.14
	5	6866	18	2.62	6383	10	1.57	484	8	16.55
	6	10610	17	1.6	10110	9	0.89	501	8	15.97
	7	8936	24	2.69	8503	13	1.53	433	11	25.40
	8	8432	19	2.25	8048	13	1.62	384	6	15.63
	19	7705	24	3.11	7253	13	1.79	452	11	24.36
	10	10185	27	2.65	9700	18	1.86	485	9	18.56
	11	7558	13	1.72	7063	2	0.28	495	11	22.22
	12	7788	15	1.93	7293	4	0.55	495	11	22.22
	13	8745	17	1.94	8255	3	0.36	491	14	28.53
Total		109796	261	2.38	103611	125	1.21	6185	136	21.99

Overall, training and match exposures are expressed in hours while injury data are presented as frequency and incidence expressed as injuries per 1000 hours of exposure.

As shown in Table 4-8,the incidence of injuries occurring during match play was significantly lower during season one (Mean=14.2, SD= 12.0 injuries/1000 hours) compared to season two (Mean=21.9, SD= 5.4 injuries/1000 hours) (t(22)= -2.092, p=0.048). No difference was observed in the team-weighted incidence for overall and training injuries between the two seasons.

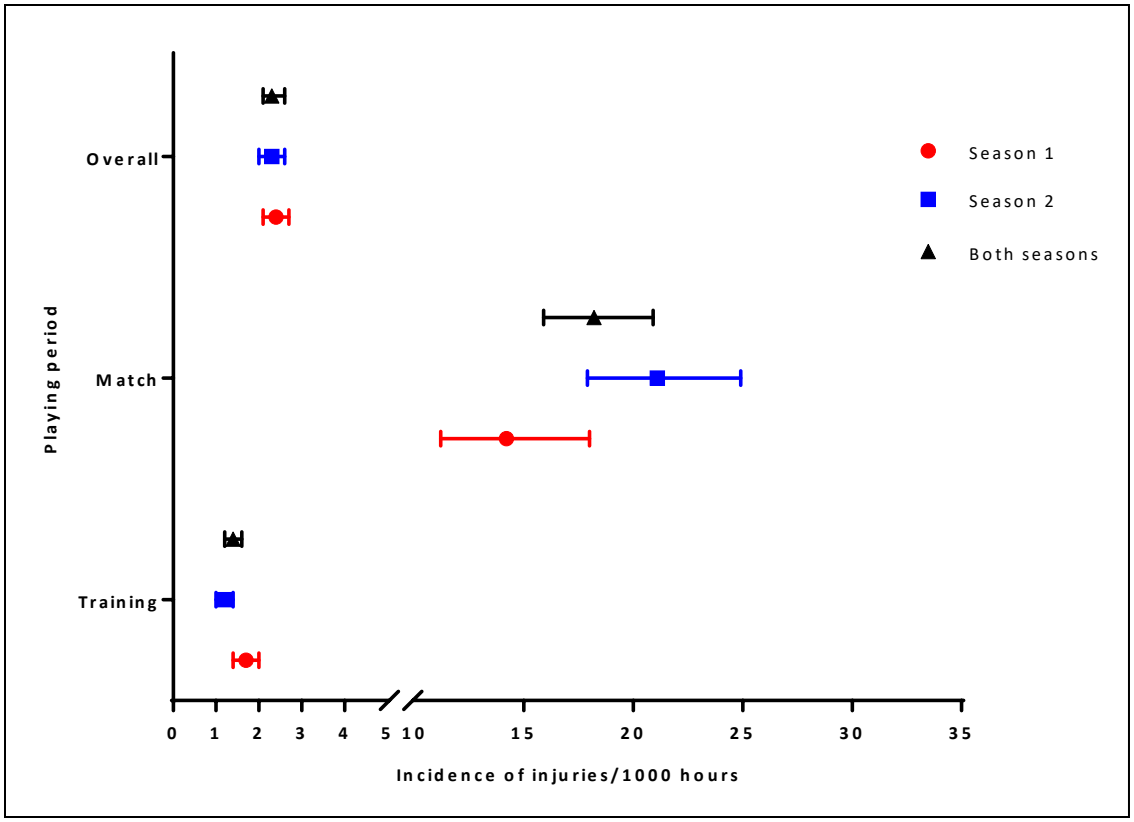
Table 4-9: Comparison of the team level incidence of overall, training and match injuries between season one and season two.

	Season 1		Season 2		Statistics		
	Mean	SD	Mean	SD	t-value	Df	p-value
Overall	2.44	1.11	2.40	0.71	0.102	22	0.920
Training	1.70	0.72	1.21	0.76	1.594	22	0.125
Match	14.19	11.99	21.91	5.35	-2.092	22	***0.048***

Season one: n=194 injuries, 11 teams, 326 players; Season two: n=261 injuries, 13 teams, 391 players
Team weighted overall, training and match injury incidence per 1000 hours of exposure

4.3.5.2 Incidence of time loss injuries

There were no significant differences in the incidence rate for overall (Incidence rate ratio (IRR): 1.0; 95% CI: 0.8-1.2) and training (IRR: 0.8; 95% CI: 0.7-1.1) injuries across either season. There was a significantly higher match injury incidence during season two compared to season one (IRR: 1.5; 95% CI: 1.1-2.0) (Figure 4-6).

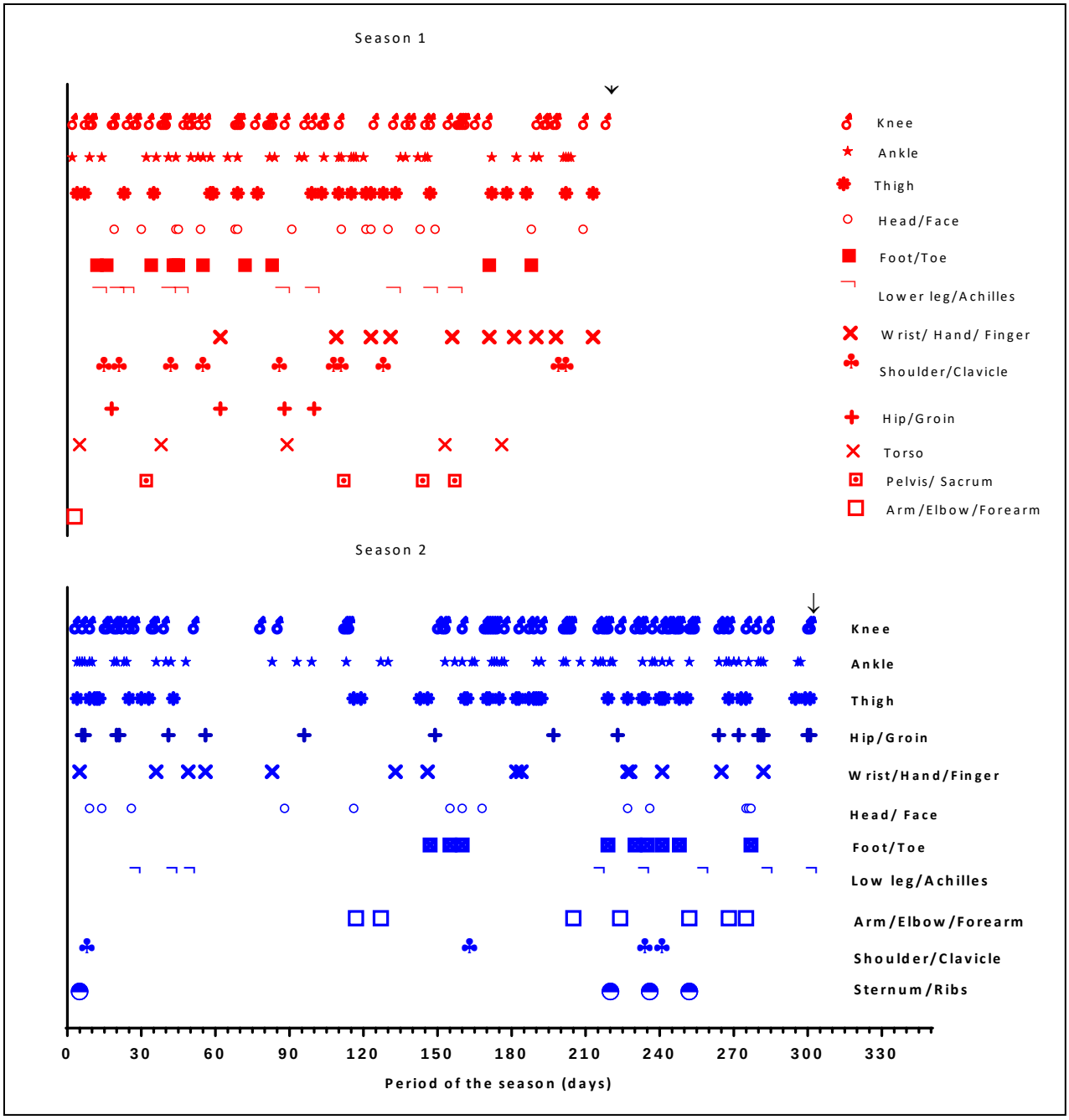


N=717 players, season one: n=194 injuries, season two: n=261injuries
The middle values represent the incidence of injuries per 1000 hours of exposure; error bars represent 95% confidence intervals.

Figure 4-6:Comparison of the incidence of training, match and overall injuries for season one and season two.

4.3.5.3 Injuries according to body location

The lower extremities were the most frequently affected by injury (n=364; 80% of all injuries), with the incidence rate of 1.9 (95% CI: 1.7-2.1) injuries per 1000 hours. The knee (n=127, 28% of all injuries) was found to be the most commonly injured body part across both seasons (incidence = 0.7; 95% CI= 0.6-0.8 per 1000 hours of exposure). The ankle joint was the second most common injured body part (n=112; 25% of all injuries), with an injury incidence of 0.6 (95% CI: 0.5-0.7) followed by the thigh (n=65; 14%; incidence = 0.3 (95% CI: 0.3-0.4). The head and face were the fourth most common injured body parts during the season one, while the hip and groin were the fourth highest injured body part during season two. Figure 4-7 shows the distribution of all injuries according to the body parts, and indicates when during the cycle the injury occurred during both seasons.



Season one: n=194injuries, Season two: n=261 injuries. Each body part on the right side of the figure is represented by a symbol. Red for season one and Blue for season two. The arrow (↓) represents the end of the season.

Figure 4-7: Distribution of injuries presented according to body part.

4.3.5.4 Injured structure and nature of injury

Fifty per cent of all injuries over the two seasons were joint and ligament sprains (n=272), followed by muscle strains (n=106; 20%), contusions (n=77; 14%) and lacerations/abrasions (n=23; 4%). Concussion injuries accounted for 3% of all injuries. Table 4-10 displays the frequency and percentages of the types of injuries reported during both seasons.

Table 4-10: Frequency of injured structure and nature of injury according to training and match injuries for each season.

Types of injuries	Season 1 (n=194)		Season 2 (n=261)	
	Match Frequency (%)	Training Frequency (%)	Match Frequency (%)	Training Frequency (%)
Contusion	17 (8.8)	14 (7.2)	10 (3.8)	9 (3.4)
Laceration/ Abrasion	5 (2.6)	3 (1.5)	3 (1.1)	1 (0.4)
Fracture and bone stress				
Fracture	0	1 (0.5)	2 (0.8)	1 (0.4)
Joint and ligaments				
Sprain	25 (12.9)	61 (31.4)	69 (26.4)	75 (28.7)
Lesion of meniscus	0	6 (3.1)	1 (0.4)	0
Ligament rupture	3 (1.5)	2 (1)	1 (0.4)	3 (1.1)
Dislocation	1 (0.5)	5 (2.6)	3 (1.1)	1 (0.4)
Nervous system				
Concussion	4 (2.1)	3 (1.5)	5 (1.9)	3 (1.1)
Muscle and tendon				
Strain	7 (3.6)	21 (10.8)	43 (16.5)	31 (11.9)
Muscle fibre rupture	2 (1)	2 (1)	0	1 (0.4)
Tendinosis	2 (1)	5 (2.6)	0	1 (0.4)
Tendon rupture	0	2 (1)	0	0
Others	1 (0.5)	2 (1)	2 (0.8)	1 (0.4)

Season one: n=194injuries, Seasontwo: n=261 injuries. Note that the figures reflect absolute numbers and not incidence. Red colour represents the highest proportion and the green colour the lowest.

4.3.5.5 Mechanism of injury

The majority of injuries were traumatic in nature (n=444, 98%), whereas overuse injuries accounted for 2% (n=12) over both seasons. Less than a third of injuries (n=145, 32%) resulted in the players being obliged to discontinue playing activity. Two-thirds of injuries (n=285, 63%) were due to contact (Table 4-11).

Table 4-11: Frequency and incidence of the underlying cause of injury per season

Patterns of injuries		Season 1		Season 2	
		N (%)	Incidence* (95% CI)	N (%)	Incidence* (95% CI)
Mechanism of injury					
	Trauma	186 (95.9)	2.3 (2.0-2.6)	258 (98.9)	2.3 (2.0-2.6)
	Overuse	8 (4.1)	0.1 (0.0-0.2)	3 (1.1)	0.0 (0.0-0.1)
New or recurrent					
	New	182 (93.8)	2.2 (1.9-2.6)	246 (94.3)	2.2 (1.9-2.5)
	Recurrent	12 (6.2)	0.1 (0.1-0.3)	15 (5.7)	0.1 (0.1-0.2)
Circumstance					
	Contact	114 (58.8)	1.4 (1.2-1.7)	171 (65.5)	1.5 (1.3-1.8)
	Non-contact	80 (41.2)	1.0 (0.8-1.2)	90 (24.5)	0.8 (0.6-1.0)
Discontinuation of play during the game					
	Yes	48 (24.7)	0.6 (0.4-0.8)	97 (37.2)	0.9 (0.7-1.0)
	No	146 (75.3)	1.8 (1.5-2.1)	164 (62.8)	1.5 (1.2-1.7)
Consequence					
	Foul	77 (39.7)	0.9 (0.8-1.2)	119 (45.6)	1.1 (0.9-1.3)
	No foul	37 (19.1)	0.5 (0.3-0.6)	52 (19.9)	0.5 (0.4-0.6)
	Not applicable	80 (41.2)	1.0 (0.8-1.2)	90 (34.5)	0.8 (0.6-1.0)

Season one: n=194injuries, Season two: n=261 injuries.
**per 1000 hours*

Table 4-12 lists the causes and mechanisms of the reported injuries and indicates that a collision with another player was the most common mechanism of injury (22%), followed by receiving a tackle (19%). More than half of these tackles were received during a match. Running and landing resulted in 11% of injuries.

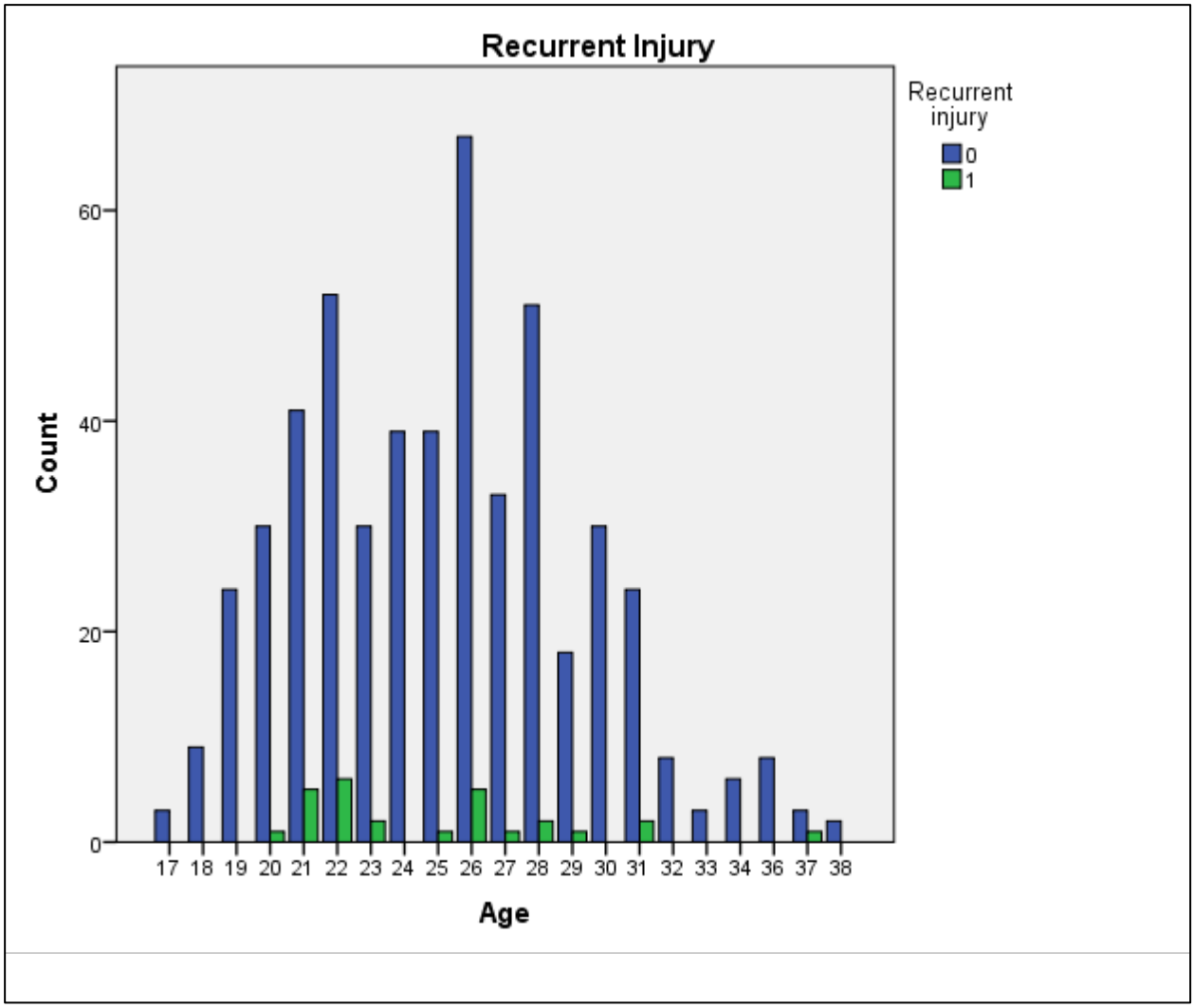
Table 4-12: Mechanisms leading to match and training injuries according to contact or non-contact situation.

Variables	Match		Training		Total
	Contact	No contact	Contact	No contact	Frequency (%)
Collision with player	43	0	59	0	102 (22)
Receive a tackle	48	1	36	1	86 (19)
Running	4	17	1	28	50 (11)
Landing	9	10	7	23	49 (11)
Kicking the ball	14	12	8	9	43 (9)
Tackle	10	3	10	7	30 (7)
Turning	1	6	2	13	22 (5)
Jumping	2	2	3	13	20 (4)
Elbow to head	9	0	3	0	12 (3)
Overuse	0	3	0	8	11 (2)
Heading the ball	4	0	4	0	8 (2)
Catching the ball*	0	0	4	3	7 (2)
Other	1	4	3	7	15 (3)
Total	145	58	140	112	455 (100)

The individual values are presented as frequency while the total values are frequency and percentages of the total number of injuries for both seasons (N=455).
Red colour represents the highest frequency and the green colour the lowest.
**Mechanism related to goalkeeping position.*

4.3.5.6 Recurrent injuries

There were in total 27 recurrent injuries; 12 in season one and 15 in season two. In season one, six players sustained a recurrent injury, while one players suffered from two recurrent injuries and one suffered four recurrent injuries. In season two, 15 players sustained one recurrent injury. The occurrence of recurrent injuries was not associated with seasons (Chi-sq=0.038, p=0.845). There was no significant difference in the mean age of players who suffered recurrent injuries (mean=24.8, SD=4.0) compared to players who did not have recurrent injuries (mean=25.3, SD=4.1) (t (29)=-0.618, p=0.541), tested with separate variances. Figure 4-8 shows the frequency of first time and recurrent injuries according to age.



N=547 players, 22 injured players with recurrent injuries
Bars represent the frequency of injuries.
Blue bars: represent no recurrent injuries; green bars represent recurrent injuries

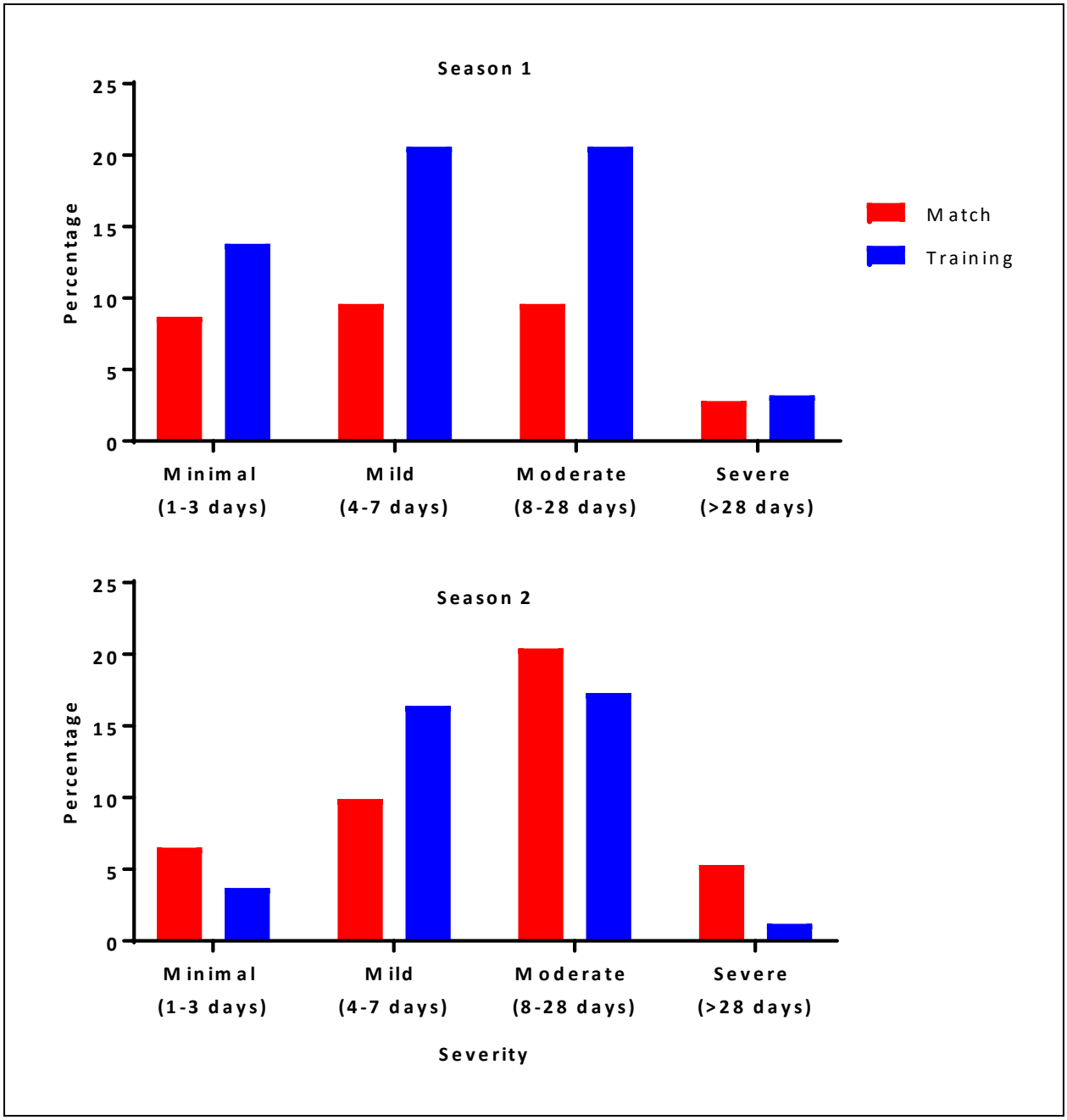
Figure 4-8: Recurrent injuries by age of the player.

Recurrent injuries caused players to be absent for an average period of 13 days (SD: 13.7; median=9; IQR=57). Out of the 27 recurrent injuries, 11 (40.8%) were moderate, eight were considered mild injuries (29.6%), and four were considered as minimal (14.8%) and severe (14.8%) injuries. The part of the body that sustained most recurrent injuries was the ankle joint (n=10; 37.0% of recurrent injuries), followed by the knee (n=9; 33.3%). Strains were the most common type of injury (n=17; 63.0% of recurrent injuries). Recurrent injuries to the muscles and tendons resulted in severe types of injuries. The median time to recurrent injury after resuming full soccer participation was equal to 16 days.

Most injuries were classified as early recurrent (n=22; 81.5% of all recurrent injuries), occurring within less than two months after resuming full participation from the index injury. Recurrent injuries resulted in longer periods of absence (median=9; IQR=57) compared to the index injury (median=6; IQR=24). However, the difference was not statistically significant (U = 5114.5, Z = -1.003, p=0.310). Two players who had concussion were reported to have continued playing immediately after the onset. Five players with concussions resumed playing within three days, while 11 out of 15 concussions resumed play within seven days.

4.3.5.7 Severity of injuries

As shown in Figure 4-9, most injuries were either mild (n=151, 33% of all injuries) or moderate (n=188, 41%) as defined by the length of time away from training or match playing. The severity of injury increased from season one to season two for minimal, mild, moderate and severe match injuries (Chi-sq (10)=45.704, p<0.001). Mild injuries decreased by almost half from season one to the season two; while moderate injuries increased from 34% in season one to 46% in season two.



Season one (n=194) and season two (n=261) injuries.
Percentage refers to % of injuries in that Season.

Figure 4-9: Comparison of training and match injury severity across the seasons.

4.3.5.8 Lower limb injuries by types, pattern and severity

The majority of the knee (102 out of 127) and ankle injuries (104 out of 112) were sprains. Of the 65 thigh injuries, 46 were strains and 13 were contusions. Table 4-13 provides the details of the different types of lower limb injuries.

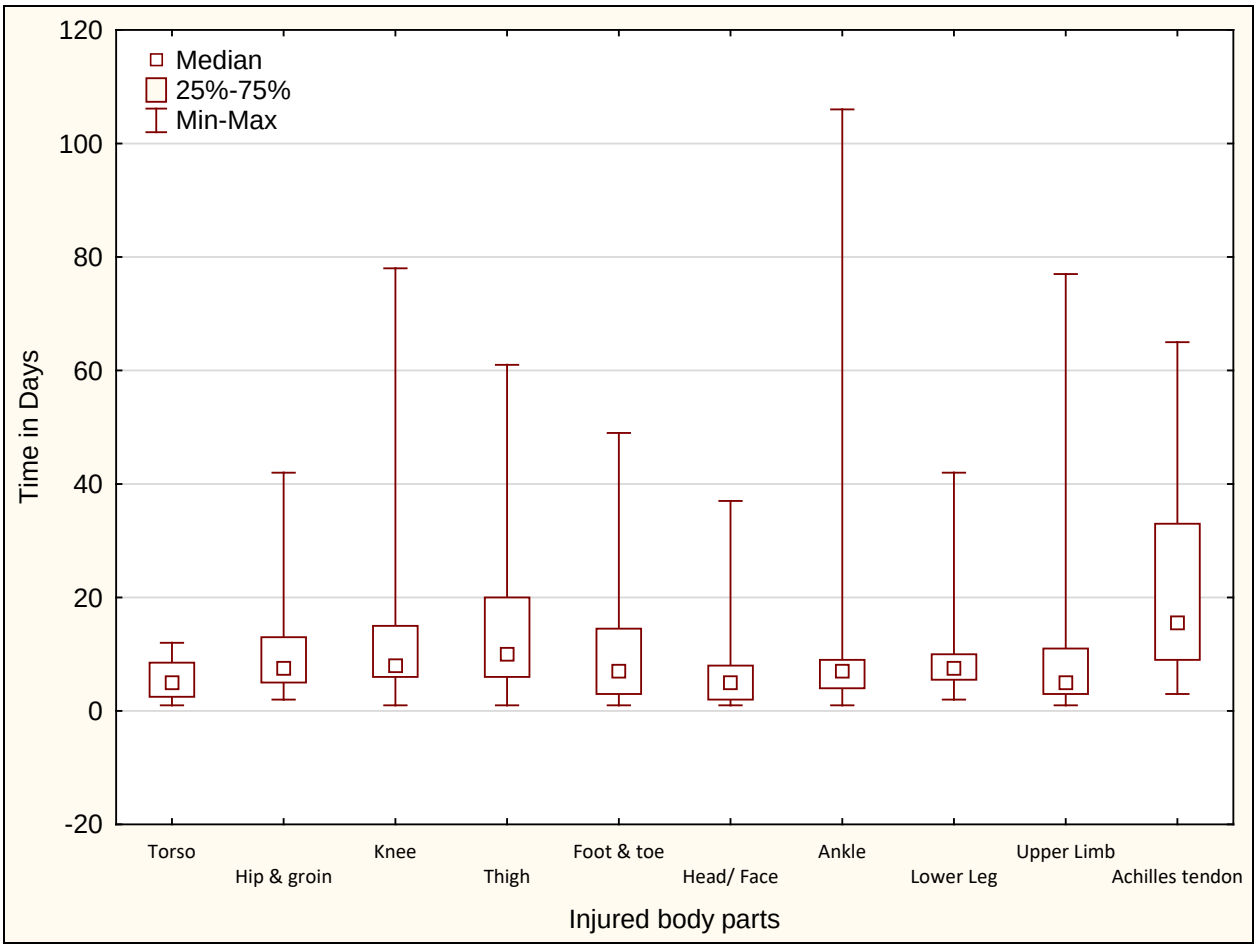
Table 4-13: Lower limb injuries covering the three most affected body parts according to the types, patterns and severity.

	Lower limb location	Hip/groin	Thigh	Knee	Lower leg/ Achilles	Ankle	Foot and toe
Types of injuries							
	Sprain	3	0	102	1	104	7
	Lesion of meniscus	0	0	7	0	0	0
	Ligament rupture	0	0	7	0	0	0
	Dislocation	0	0	1	0	0	1
	Strain	17	46	1	7	3	3
	Muscle fibre rupture	0	0	0	0	0	0
	Tendinosis	0	0	0	1	3	4
	Tendon rupture	0	0	0	2	0	0
	Contusion	1	13	7	7	1	3
	Fracture	0	0	0	0	1	1
	Other	1	2	2	0	0	1
Patterns of injuries							
	Trauma	20	65	124	18	109	17
	Overuse	2	0	3	0	3	3
	Contact	7	22	86	10	76	15
	Non-contact	15	43	41	8	36	5
	New	20	62	118	17	102	20
	Recurrent	2	3	9	1	10	0
	Foul	4	11	58	6	53	10
	No foul	3	11	28	4	23	5
	Continued playing	9	17	40	5	40	7
	Discontinued playing	13	48	87	13	72	13
Severity (Days of absence)							
	Minimal (1-3)	3	7	14	3	18	6
	Mild (4-7)	8	18	42	4	44	5
	Moderate (8-28)	9	33	59	8	48	8
	Severe (>28)	2	7	12	3	2	1
	Total	22	65	127	18	112	20

n=364 lower limb injuries
Red colour represents the highest values and the green colour the lowest.

4.3.5.9 Time lost due to injury according to injury location

Injuries resulted in a loss of 5069 days over both seasons (range 1-106 days). Injuries from season one (n=194) caused 1923 days of absence while the season two injuries (n=267) caused players to miss 3146 days. Injuries to the Achilles tendon resulted in the longest lay off time followed by injuries to the thigh. Figure 4-10 shows the layoff time of injuries according to the body parts. There was a significant difference in the time lost according to the injured body part (H (9, 455)= 35.265, p=0.001).



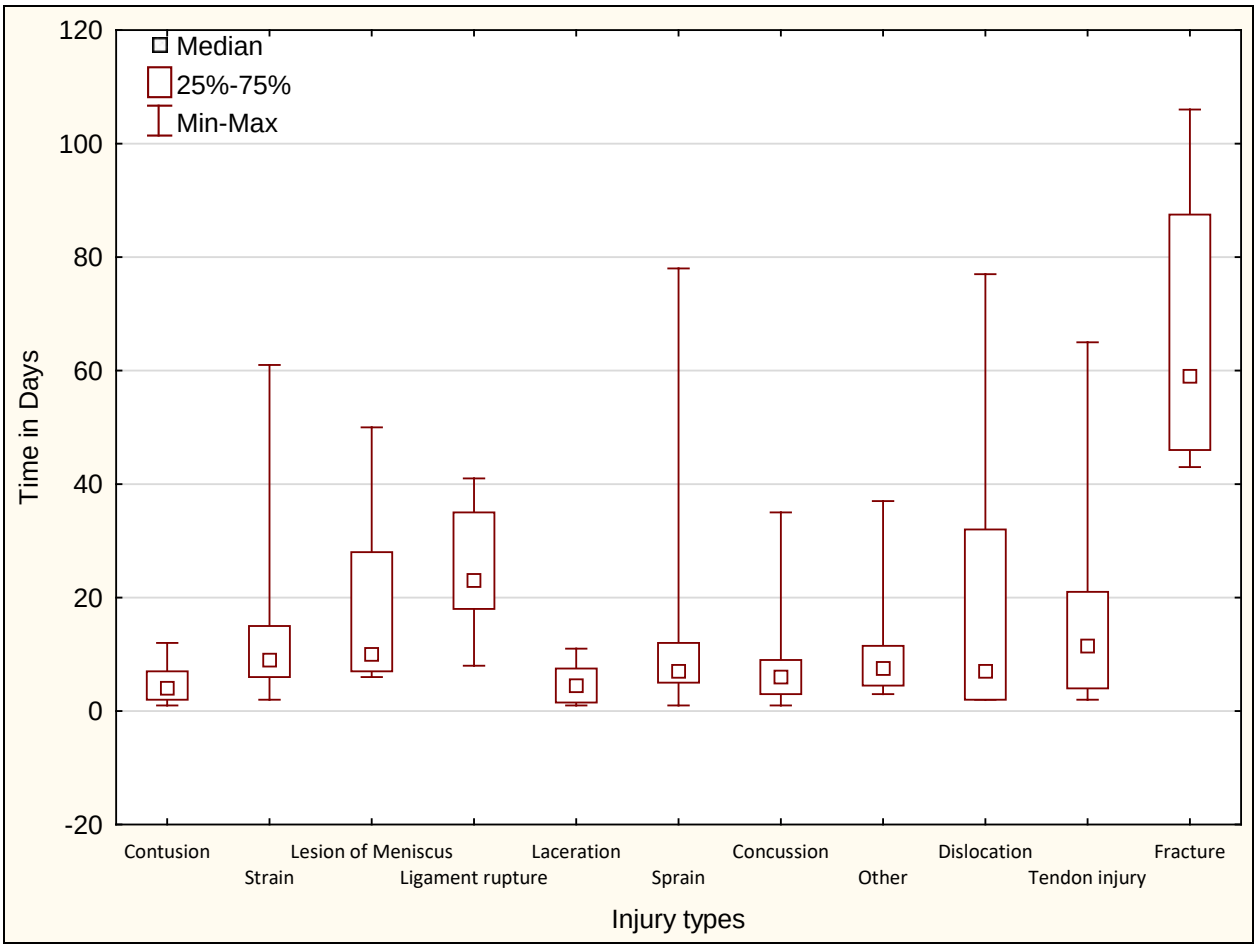
n=455 injuries

Inside box represents the median values, the outside box represents 25th and 75th percentiles while the error bars represent the minimum and the maximum.

Figure 4-10: Injury lay off time according to injurylocation.

4.3.5.10 Time lost according to the types of injury

There was a significant difference in time lost according to the type of injuries (H (10, 455)= 69.021, p<0.001). Fractures led to the longest lay-off period, followed by ligament ruptures and tendon injuries (Figure 4-11). Ankle fracture was the most serious injury in terms of time loss, with a lay-off period of 106 days.



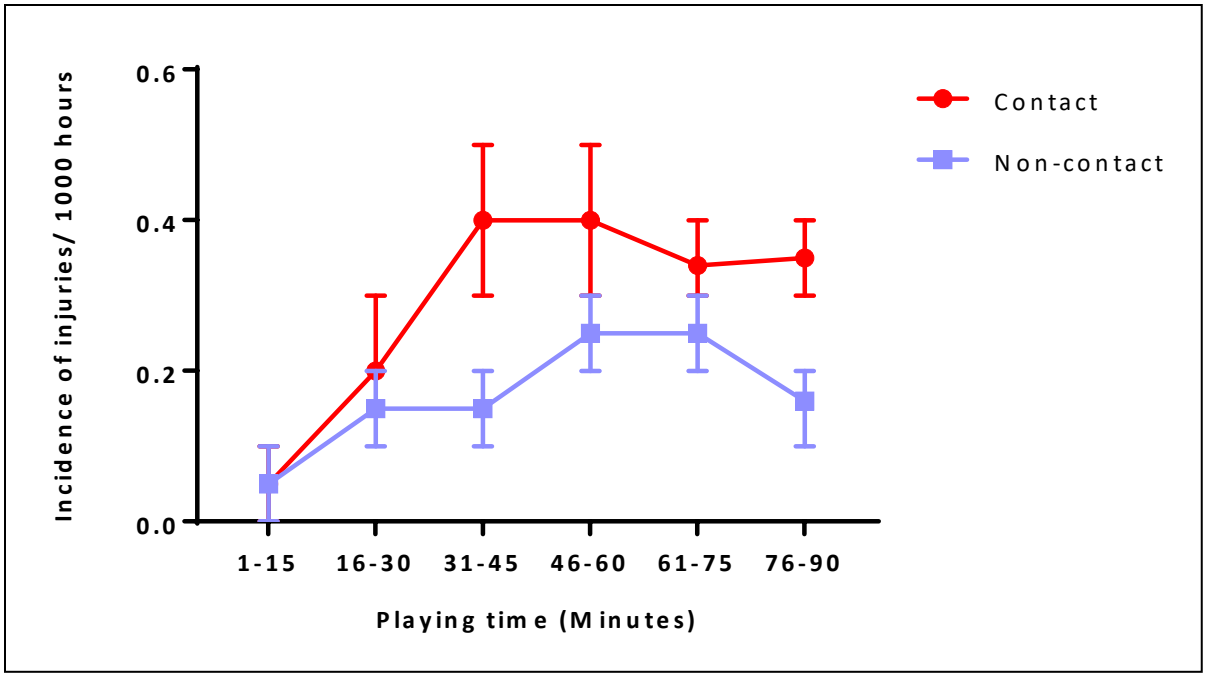
n=455 injuries

Inside box represents the median values; the outside box represents 25th and 75th percentiles while the error bars represent the minimum and the maximum.

Figure 4-11: Lay off time according to the types of injuries.

4.3.5.11 Distribution of contact and non-contact injury incidenceaccording to the time of play

There was an increased incidence of injuries in the second half of the playing time with the highest incidence of all injuries observed from 46 to 60 minutes into match time (Figure 4-12). There were 107 (24% of all injuries) contact and 64 (14% of all injuries) non-contact injuries that occurred in the first 45 minutes of playing time. A higher frequency of contact (n=178, 39%) and non-contact injuries (n=106, 23%) happened in the second half of the playing time. Considering the exposure time, the incidence of contact injuries per 1000 hours (0.6, 95% CI: 0.5-0.7) in the first half of play was lower compared to the incidence of contact injuries per 1000 hours (0.9, 95% CI: 0.8-1.1) in the second half of play (IRR: 1.7, 95% CI: 1.3-2.1). Similarly, the incidence of non-contact injuries per 1000 hours (0.3, 95% CI: 0.3-0.4) in the first half of play was lower compared to the incidence of non-contact injuries per 1000 hours (0.6, 95% CI: 0.5-0.7) in the second half (IRR: 1.7, 95% CI: 1.2-2.3).



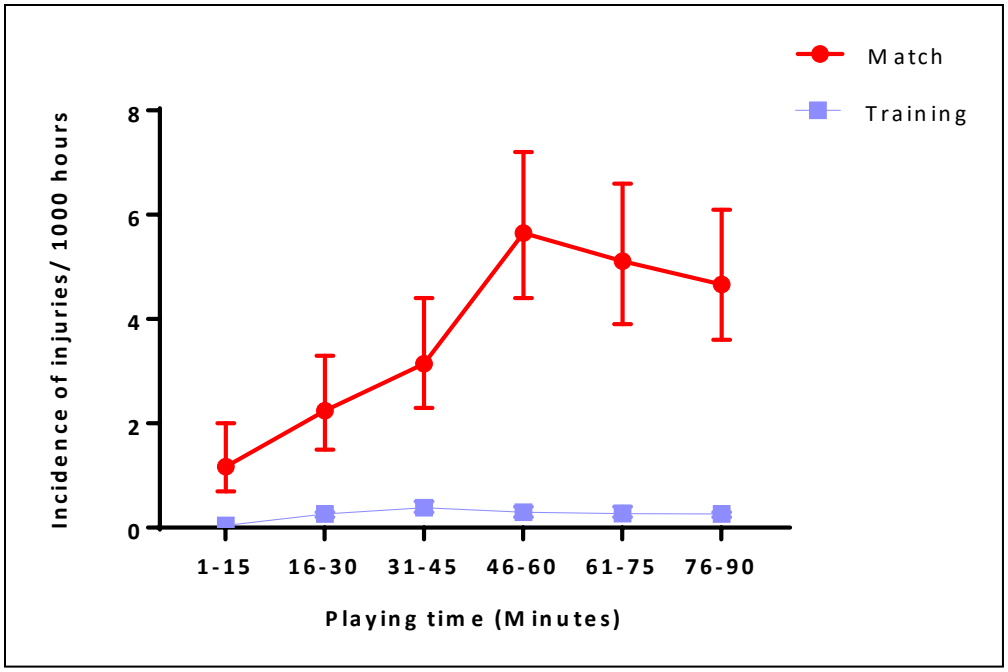
n= 455 injuries

Data are presented as injury incidence per 1000 hours of exposure; error bars represent 95% confidence intervals.

Figure 4-12: Contact and non-contact injuries according to the playing time.

4.3.5.12 Distribution of training and match injury incidence according to the duration of play

Figure 4-13 shows that match injuries were significantly higher than training injuries. The incidence of match injuries increased with time, peaking between 45-60 minutes, and reducing thereafter until the end of the match. There were no significant variations in the incidence of training injuries according the playing time.



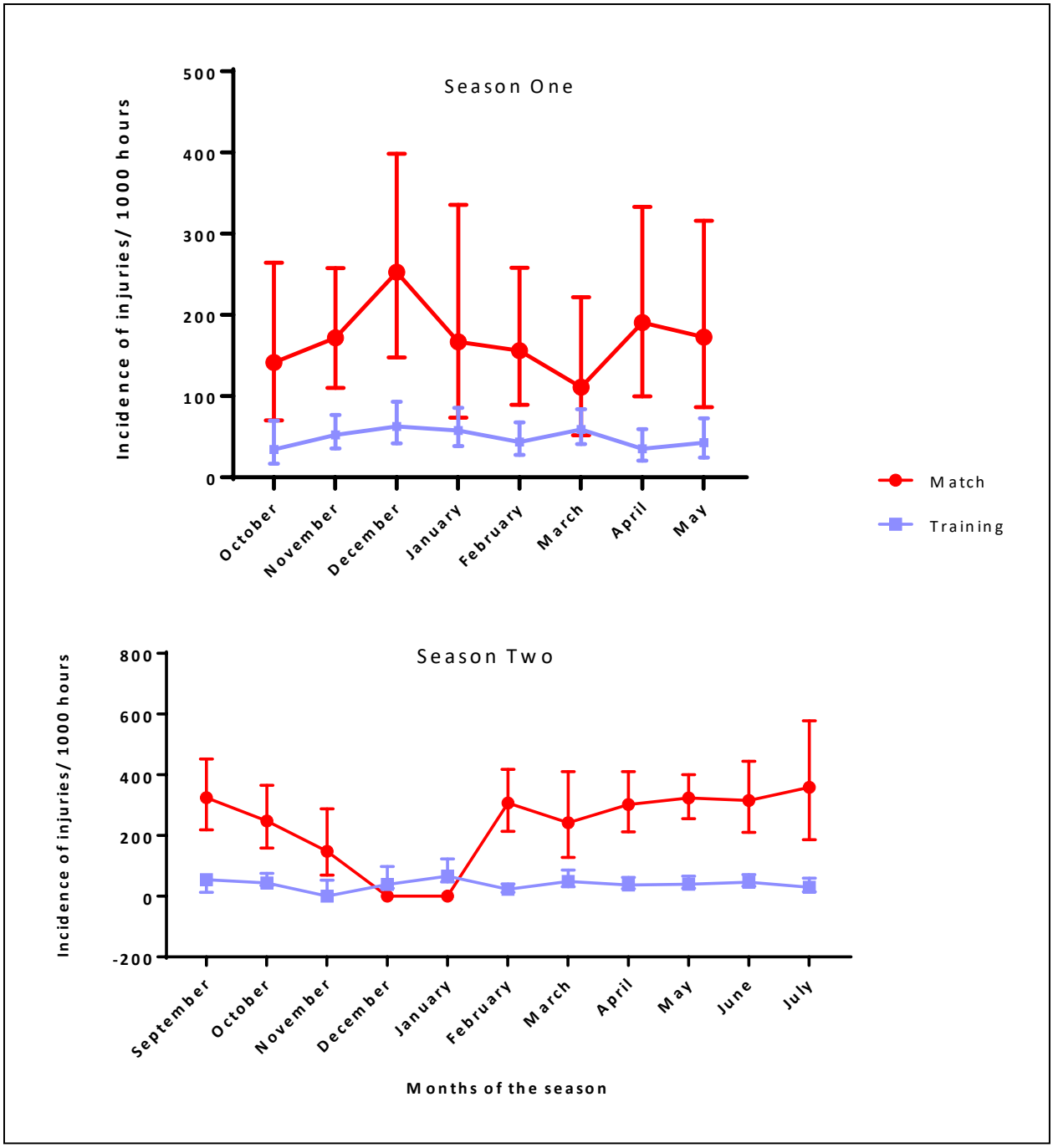
n= 455 injuries

Data are presented as injury incidence per 1000 hours of exposure; error bars represent 95% confidence intervals.

Figure 4-13: The incidence of training and match injuries according to training and match duration.

4.3.5.13 Monthly variations in training and match injury incidence over both seasons

The highest match injury incidence (252.9/1000 hours) was during December for season one, and during July (359.0/1000 hours) for season two. The match injury rates were significantly higher throughout season two compared to season one, except for the December and January period. The variations in the rate of training injuries were similar during both seasons. Furthermore, no statistically significant differences were observed between the monthly variation of training ($t(17)=1.053$, $p=0.307$) or match injuries ($t(17)=-1.333$, $p=0.200$) across both seasons (Figure 3-14).



n=455 injuries

Data are presented as injury incidence per 1000 hours of training or match exposure; error bars represent 95% confidence intervals.

Note that no match was played in December and January in season two but some teams conducted a number of training sessions.

Figure 4-14: Monthly variations in training and match injuries over season one and season two.

4.3.6 Intrinsic risk factors for injuries

Factors associated with injuries were further analysed. An analysis of the occurrence of injuries was conducted among the individual 502 players that participated in either season of the study. The results indicated that 263 (52%) players incurred an injury while 239 (48%) players were not injured. Univariate analyses were conducted to examine the relationship between the potential risk factors and the outcome variable of sustaining an injury. Risk factors for all injuries were examined, including lower limb injuries. Risk factors with a p-value of less than 0.05 were further analysed using a Multivariate model. The decision tree model was used to identify the demographic and functional variables associated with injuries using the Chi-square Automatic Interaction Detector(CHAID) method. "*At each step, CHAID chooses the independent (predictor) variable that has the strongest interaction with the dependent variable. Categories of each predictor are merged if they are not significantly different with respect to the dependent variable*[401].

4.3.6.1 Risk factors for all injuries

Univariate analysis indicated that demographic and anthropometric characteristics (age, number of years playing soccer, first division experience, number of year playing in the current club and body mass) was significantly different between those who sustained any injury and those that did not. In addition, Sit and Reach, timed hop and lower extremity function test results were significantly associated with sustaining injuries (Table 4-14). These variables were suitablefor multivariate analyses and were included in the CHAID analysis. However, as age and soccer experience were highly correlated, age was entered as an independent variable.

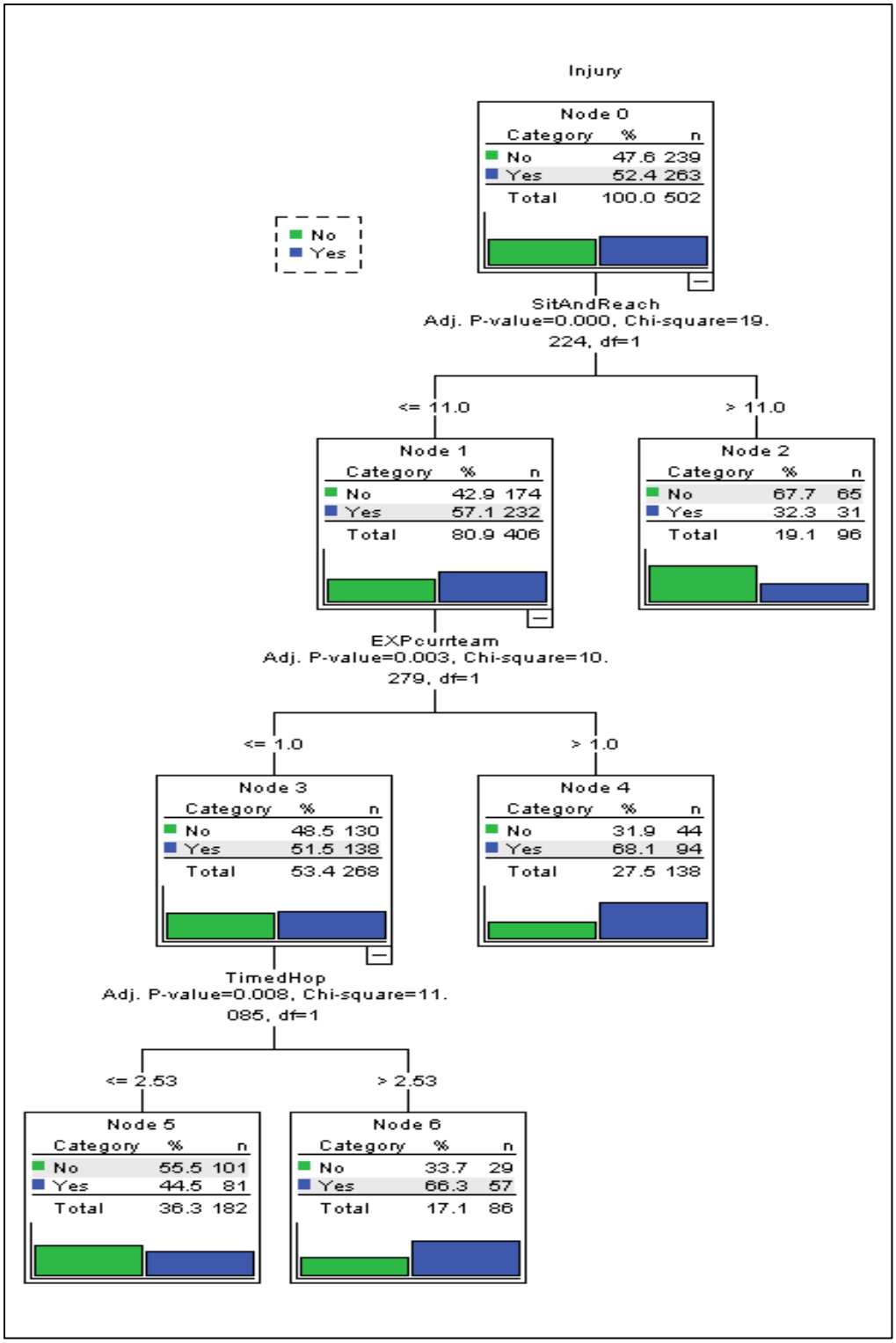
Table 4-14: Univariate risk factor analysis for all injuries.

Variables/ tests	Injured (N=263)	Uninjured (N=239)	Statistics		
	Mean (SD)	Mean (SD)	t-value	df	p-value
Age (years)	25(4.1)	24.2(3.9)	2.280	500	***0.023***
Soccer experience (years)*	5.3(2.6)	4.5(2.1)	3.645	494	***<0.001***
1st Division experience (years)*	3.3(2.1)	2.7(1.8)	3.860	497	***<0.001***
Current team experience (years) *	1.7(1)	1.4(0.8)	2.840	487	***0.005***
Body mass (kg)	74(8.8)	71.8(10)	2.688	500	***0.007***
Stature (cm)	174.6(9.5)	173.2(10.1)	1.666	500	0.096
Ankle dorsiflexion lounge (cm)	15.3(3.7)	15.1(3.7)	0.575	500	0.566
Sit and Reach (cm)	3.5(7)	6.5(6.8)	-4.805	500	***<0.001***
Four-point hold (sec)	156.9(37)	162.7(35.6)	-1.802	500	0.072
Calf endurance test, Left (n)	37.4(7.1)	36.7(7.2)	1.107	500	0.269
Calf endurance test, Right (n)	40.1(7.1)	30(7)	1.715	500	0.087
Active knee extension (°)	10.6(8.1)	9.9(8.4)	0.952	500	0.342
Thomas test hip (°)	-0.6(6.4)	-1.1(6.4)	0.963	500	0.336
Thomas test knee (°)	65.1(7.4)	65.9(7.5)	-1.194	500	0.233
Active hip Internal rotation (°)	25.1(5.2)	26.3(5.6)	-0.543	500	0.587
Active hip external rotation (°)	28.5(5.6)	27.9(5.5)	1.270	500	0.205
Hip abduction (°)	44.1(4.1)	44.3(5.1)	-0.379	500	0.705
Active slump test (°)	8.9(4.7)	8.6(4.9)	0.662	500	0.508
Y-Balance Anterior, Left (cm)	80(10)	80.8(9.8)	-0.930	500	0.353
Y-Balance Anterior, Right (cm)	83.5(9.7)	80.8(9.8)	-0.751	500	0.453
Y-Balance Posteromedial, Left (cm)	88.6(10.7)	90.1(11.6)	-1.511	500	0.131
Y-Balance Posteromedial, Right (cm)	92.2(10.6)	93.3(10.7)	-1.164	500	0.131
Y-Balance Posterolateral, Left (cm)*	92.8(9.9)	93.1(11.2)	-0.376	477	0.707
Y-Balance Posterolateral, Right (cm)	97.4(11.2)	98.1(11.6)	-0.619	500	0.536
Single hop (cm)	256.4(19.1)	255.8(21.6)	0.325	500	0.745
Triple hop, Left (cm)	753.4(46.3)	752.7(46.6)	0.174	500	0.862
Triple hop, Right (cm)	761.4(43.1)	760.2(46.5)	0.284	500	0.777
Cross over hop (cm)	716.9(57.3)	713.7(60.2)	0.613	500	0.540
Timed hop (sec)	2.4(0.3)	2.4(0.3)	2.164	500	***0.031***
Lower Extremity Function Test (sec)*	104.2(10.4)	106.6(11.4)	-2.444	484	***0.015***

**Tested with separate variances*.
n=502 players

Figure 4-15 demonstrates that, of the eight variables entered into the model, a Sit and Reach score of less than or equal to 11 was strongly associated with sustaining an injury. A larger proportion of the players with low flexibility sustained injuries (57%) compared to those with high flexibility (32%).

In those with limited flexibility, players who had been with their current club for a period of one year or longer were associated with injury (52% as compare to 69%) than those who had spent less than one year with their current club. A timed hop of more than 2.53 was associated with injury (44.5% for shorter and 66% for longer time hop). The model correctly placed 57% and 69.5% of players in the injured and non-injured categories respectively.



Variables entered: age, years playing soccer, first division experience, year playing in the current club, body mass, Sit and Reach, timed hop and lower extremity function tests.The model does not display non-significant variables.

Figure 4-15: CHAID decision tree of associations between injury and demographic and functional variables.

4.3.6.2 Risk factors for Lower limb injuries

Univariate analysis revealed that the variables age, number of year playing soccer, first division and for the current club were statistically significant and eligible for multivariate analysis. In addition, the Sit and Reach, four-point hold, and lower extremity function tests results were significantly associated with injuries. Therefore, these variables were also eligible for multivariate analysis (Table 4-15).

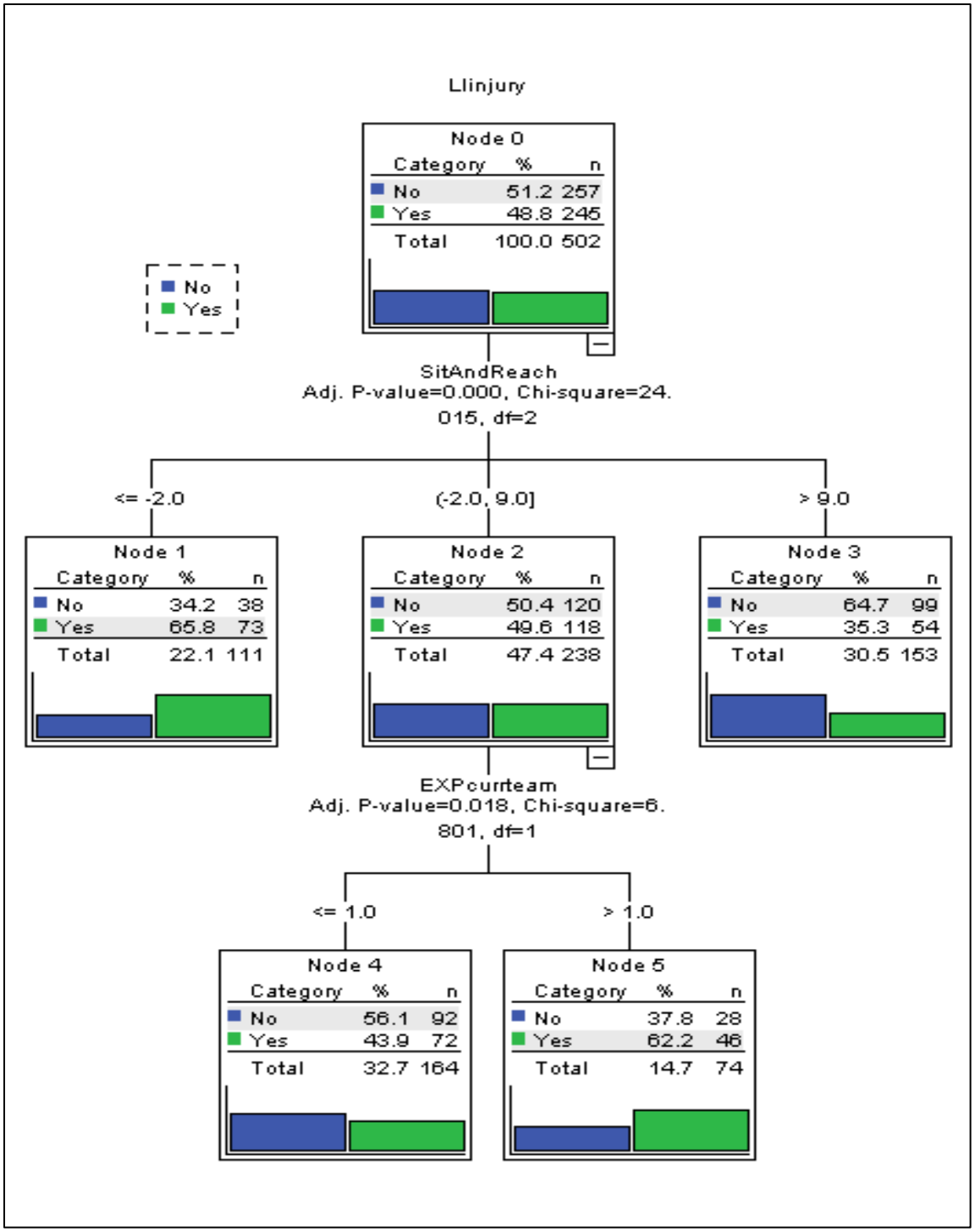
Table 4-15: Univariate risk factor analysis for lower limb injuries.

	Injured/ Uninjured		Statistics		
Variables	Injured (N=245)	Uninjured (N=257)	t-value	df	p-value
	Mean (SD)	Mean(SD)			
Age (years)	25.1(4.1)	24.2(4)	2.566	500	***0.011***
Soccer experience (years) *	5.2(2.7)	4.6(2.2)	2.950	472	***0.003***
1st Division experience (years) *	3.3(2.2)	2.7(1.8)	3.363	477	***0.001***
Current team experience (years) *	1.7(1.1)	1.4(0.8)	3.048	451	***0.002***
Body mass (kg)	73.4(9.2)	72.5(9.6)	1.072	500	0.284
Stature(cm) *	174(9)	173.8(10.4)	0.248	496	0.804
Ankle dorsiflexion lounge (cm)	15.4(3.7)	15(3.6)	1.394	500	0.164
Sit and Reach (cm)	3.4(7)	6.3(6.9)	-4.583	500	***<0.001***
Four-point hold (sec)	155.3(35.6)	163.9(36.7)	-2.661	500	***0.008***
Calf endurance test, Left (n)	37.3(7)	36.9(7.2)	0.614	500	0.539
Calf endurance test, Right (n)	40(6.9)	39.2(7.1)	1.317	500	0.188
Active knee extension (°)*	10.6(7.9)	9.9(8.5)	0.936	499	0.349
Thomas test hip (°)	-0.4(6.6)	-1.3(6.2)	-1.683	500	0.093
Thomas test knee (°)	65.1(7.5)	65.8(7.4)	1.059	500	0.290
Active hip Internal rotation (°)	26.3(5.4)	26.2(5.4)	-0.091	500	0.928
Active hip external rotation (°)	28.6(5.7)	27.9(5.4)	-1.236	500	0.217
Hip abduction (°)*	44.2(3.9)	44.3(5.2)	0.343	475	0.732
Active slump test (°)	9(4.8)	8.5(4.9)	-1.126	500	0.261
Y-Balance Anterior, Left (cm)	80.1(9.9)	80.6(9.9)	-0.540	500	0.589
Y-Balance Anterior, Right (cm)	83.5(10.7)	84.1(9.4)	-0.719	500	0.472
Y-Balance Posteromedial, Left (cm)	88.8(11.3)	89.9(10.9)	-1.090	500	0.276
Y-Balance Posteromedial, Right (cm)	92.3(10.9)	93.1(10.4)	-0.763	500	0.446
Y-Balance Posterolateral, Left (cm)*	92.9(10.4)	93(10.7)	-0.088	500	0.930
Y-Balance Posterolateral, Right (cm)	97.9(11.5)	97.6(11.3)	0.215	500	0.830
Single hop (cm)	256.8(19.2)	255.5(21.3)	0.736	500	0.462
Triple hop, Left (cm)	753.5(46.2)	752.6(46.7)	0.220	500	0.826
Triple hop, Right (cm)	761.7(42.9)	760(46.4)	0.403	500	0.687
Cross over hop (cm)	717.1(55.4)	713.7(61.7)	0.656	500	0.512
Timed hop (sec)	2.4(0.3)	2.4(0.3)	1.047	500	0.296
Lower Extremity Function Test (sec)	104.2()10.6	106.5(11.2)	-2.309	500	***0.022***

**Tested with separate variances, n=502 players*

Mean and standard deviation ofinjured and uninjured players are presented as well as the test statistics.

Out of a total of 502 players, 245 (49%) sustained lower limb injuries. The Sit and Reach test was most strongly associated with injury. The proportion of players who were injured was 66% for those with a range 2cm or less, 50% for those with a range of 2.9cm and 35% for those with a range of 9cm or greater (Figure 4-16). In players with medium flexibility, length of time playing for the current team was associated with injury, with 43.5% of those with one or less years of injury, compared to 62.2% of those who had been in their current team for longer than a year. The model correctly classified 49% of those with injuries and 79% of those with no reported injuries. As seen in Section 3.3.6, the CHAID automatically categorises the variables and the percentages displayed are calculated according to each cell node. The sum of the percentages does not nessesarity need to be equal to 100%.



N=502

Variables entered: age, years playing soccer, first division experience, year playing in the current club, body mass, Sit and Reach, timed hop, four point hold and lower extremity function test. The model does not display non-significant variables.

Figure 4-16: CHAID results decision tree for relationship between demographic characteristics and functional tests and lower limb injuries.

4.3.7 Summary of results

In summary, the present study, based on a sample of 717 player seasons, revealed the following: The average player was approximately 25 years old, with about five years of soccer experience, three of which were at first division level. An important difference between the two seasons was the 13-week match interruption during season two due to the African Championship Cup and subsequent extension of the season to 44 weeks (compared to 33 weeks in season one). However, several teams conducted trainings during the interruption period. Although there was no significant difference in the overall and training exposure time per player, match exposure time of two more hours was significantly higher during season two (14 hours in season one, compared to 16 hours in season two).

Approximately 46% of the players were injured in each of the two seasons. There were 455 reported injuries, 57% of which occurred during the longer season. However, the incidence was similar, approximately 2.4 injuries per 1000 hours of soccer play. The incidence of injuries during training was 1.7, compared to 22 per 1000 hours of play. Incidence of training injuries was similar across both seasons, whereas the incidence of match injuries was significantly higher during season two. There was increased injury incidence with increased acute: chronic training and match workload ratios.

Lower extremities were the most frequently affected over the two seasons, with the knee joint most commonly injured followed by the ankle joint. Ligament strains were the most common form of injury followed by muscle strains and contusions. Over 90% of reported injuries were new injuries. Similarly, over 90% of injuries were due to trauma and over half were contact injuries. Approximately one quarter of injuries lead to a discontinuation of play, whereas 40% were associated with fouls. The most common mechanisms of injury were collisions between players and receiving a tackle. About three quarters of the reported injuries were mild or moderate in severity and injuries to the Achilles tendon lead to the longest median lay-off time. Fractures resulted in a median lay-off time of two months whereas ligament ruptures lead to a median lay-off time of approximately three weeks. The greatest incidence of injuries was sustained between the 46^{th} and 60^{th} minute of match play.

CHAID indicated that a score of 11cm or less on the Sit and Reach test, more than one year in the current club and a timed hop of more than 2.5 seconds were all associated with injury. Lower limb injury was also associated with a smaller range in the Sit and Reach test and those with a range of 2cm or less were particularly at risk. A duration of more than one year playing in the current team was also associated with a greater incidence of lower limb injury.

4.4 Discussion

The aim of the present study was to determine the incidence rate and nature of injuries sustained by first division soccer players in Rwanda according to their nature, severity, location and playing situation. This was achieved with a representative sample of first division players and it was possible to identify certain intrinsic risk factors associated with injury. The first section of this discussion focuses on the study sample and the extent to which the results are generalisable. The overall, training and match injury rates are then compared to those published in the literature, and, as they are generally lower, the reasons for this are examined. The impact of the interruptions during season two is also discussed in this section. The discussion then compares the injury patterns found in this study to published literature, the reasons for these similarities and differences are considered. Finally, the study limitations are presented; and based on conclusions that we drew from the results, recommendations for future practice are presented.

4.4.1 Generalisability of the study results

The above average team participation rate of 80% was encouraging and may be indicative of the coaches' recognition of the importance of understanding and reducing the injury burden. It was unclear why three teams declined to participate. Nevertheless, as their positions were spread across the log, their exclusion is unlikely to introduce any noticeable bias. As all the players in each of the teams voluntarily consented to participate in the study, it is suggested that results are generalisable to all Rwandan male soccer first division teams. However, the exposure of the players that were involved in the national team was not recorded in this study as there were only nine players were involved. The Rwanda national team involves mostly foreign-based players. The injury rate of players engaged in different competitions including national team duties may therefore be different[216;225].

A total number of 502 individual players participated in the study. Analysis techniques for demographic details and risk factors using CHAID analysis utilised each player as the unit of analysis. However, following the recommendations from the consensus statement of epidemiological studies in soccer, each player is counted as a unit of analysis while participating indifferent seasons[80]. Therefore, 717 players-seasons were used in the analysis to allow for harmonisation and comparison with other studies. The high player-season participation rate (87%) appeared to be representative of the male first division players and could portray the general situation of Rwandan soccer. The results also add to the scarce longitudinal cohort studies that include African players.

Similar to a number of studies conducted in adult soccer leagues[116;121;117], the average age of the players in this study was 25 years old. A younger mean age has been found in amateur[402], professional players in England[25], Argentina[26] and Nigeria[35]. This implies that by 25 years of age, players are physically strong and mature enough to play soccer at First Division level. However, the histogram of ages was bimodal, where 25% of players were under the age of 21 years and 75% of players were under 27 years of age. The peak at 21 years of age indicates that many of the players are still young which concurs with the report of the National Institute of Statistics Rwanda which indicates that 54% of the population was 19 years of age or younger in 2011[61].

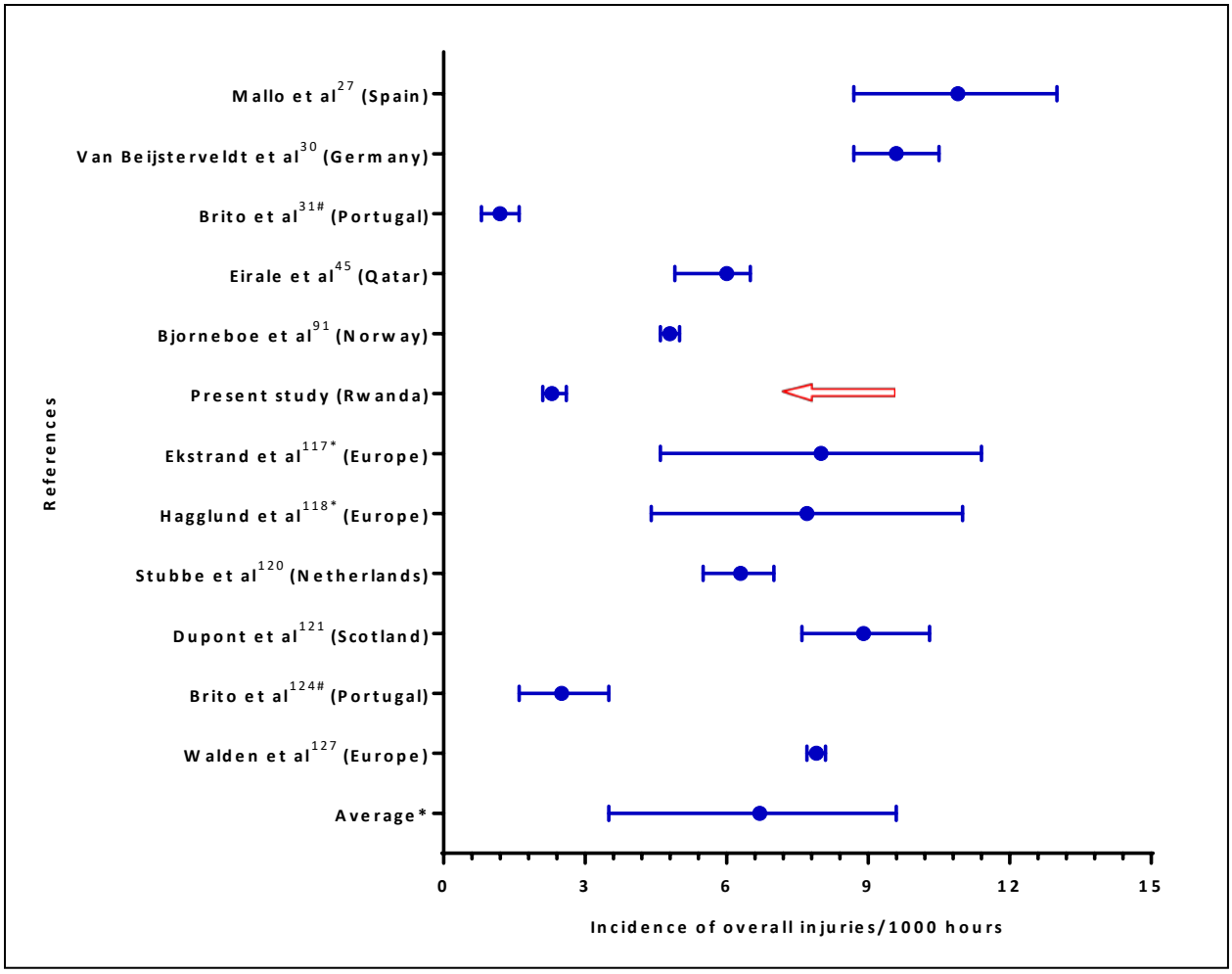
An explanation of the peak at 21 years may be that before the 2015-2016 season, FERWAFA together with the Rwanda National Identification Agency(NIDA) reviewed the certification of all players. This decision was taken after the elimination of the Rwanda national team in the qualification of the Africa Cup of Nations as a direct result of one player used double identification. The national team was disqualified due to a mismatch of the name and date of birth of a player from his team license and passport. Many experienced players were barred from participation in the league until cleared. Teams were therefore obliged to buy new, mostly younger players, to fill the gap. As will be discussed below, a shorter time in the current team was associated with less injury, which may be due to older players being more utilised and therefore more susceptible to injury. Collecting information regarding the playing experience of the players may be significant in understanding the relationship between experience and injuries.

Players had a slightly lower average stature (171 cm) compared to soccer players from Europe and the Americas which ranged between 173cm and 183cm[29;24;116;119]. Similarly, their average body mass (65kg) was comparatively lower than players from elsewhere (72-79kg)[21;24;29;35;116;119]. The resulting lower BMI of players in Rwanda is, however, unlikely to have had an impact on their injury rate. Anthropometric characteristics are not given much consideration as they are not regarded as vital in adult soccer compared to other sports such as rugby[403]. This may be an explanation as to why they are only descriptively presented in many studies. In the present study, the weight of those players with an injury was higher than those without, but on multivariate analysis, this relationship was not borne out. Similarly, the few studies that analysed the contribution of weight, height and BMIdid not find any association between these variables and injuries[18;44;177].

The consensus statement explaining data collection procedures in soccer recommends following up players for the full season or competition[4] as this allows for an in-depth understanding of exposure factors, which was also carried out in the present study. In addition, the present study followed up with players for two consecutive seasons, as did several other studies aiming at identifying the burden of injuries[28;30;116;119;120;404]. The length of the season was similar to other studies conducted among amateur and sub-elite level players, with an average duration of 33 weeks[30;119;404] although a lengthier duration has been reported in professional players ranging from 36 to 45 weeks[28;116;120]. This allowed for the results of the present study to be compared to other studies.

4.4.2 Injury incidence

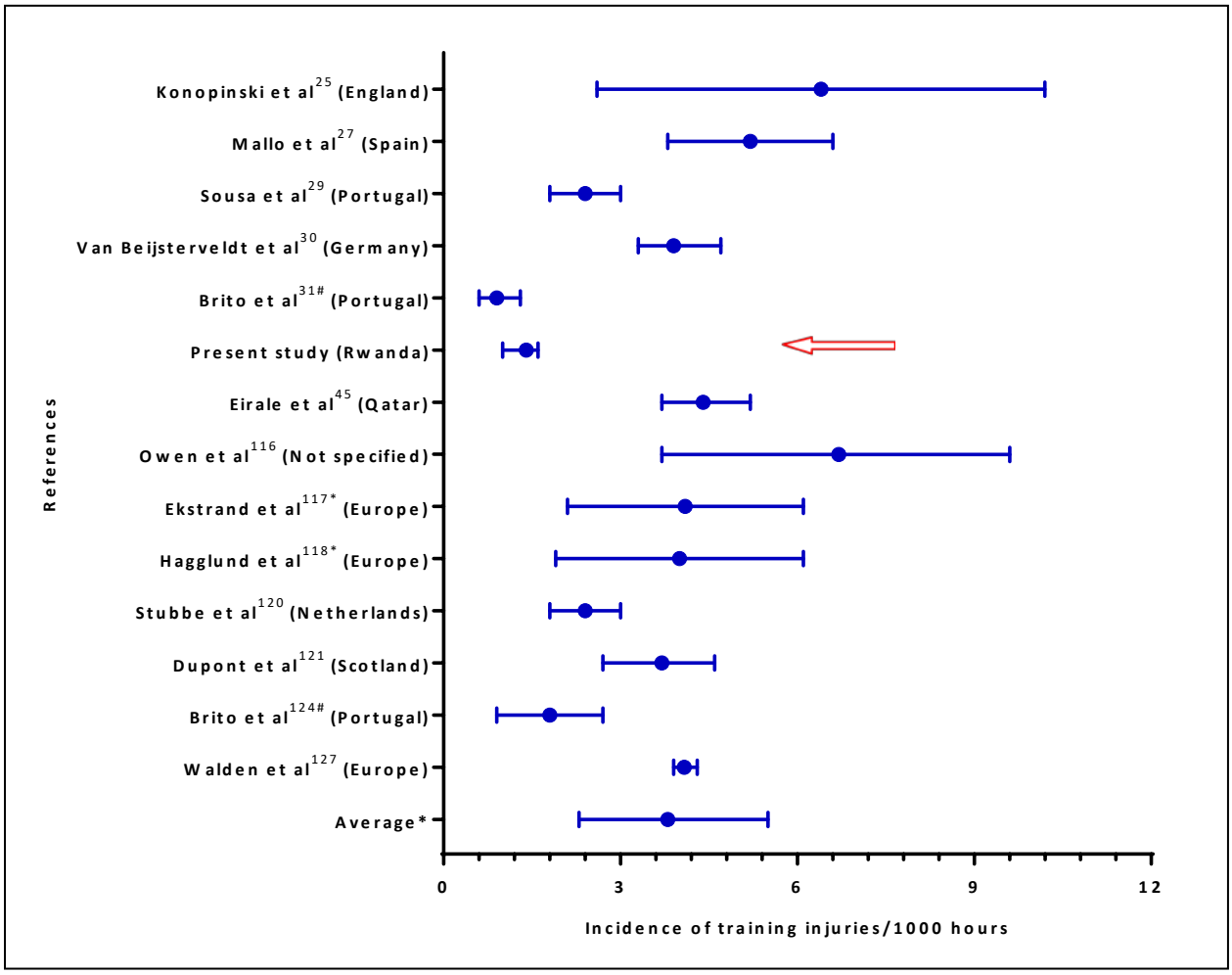
The results from the present study found that nearly half of the players sustained at least one injury and that in a team of 30 players, 14 players sustained an injury. Additionally, six players suffered from two injuries, while two players sustained three injuries during the season. However, the incidence rate of time loss injuries was lower than expected compared to those reported in international literature on injuries in adult males at either professional or amateur level. (A time loss injury rate is used in this discussion as previous studies all report time loss injury rather than overall incidence rate). The overall incidence rate for the two seasons was 2.3 (95% CI: 2.1-2.6) injuries per 1000 hours of soccer play compared to international studies that have reported incidence ranges from 4.7 to 21.8 injuries per 1000 hours of soccer play[25;26]. The weighted average incidence rate computed from the present study, represented in Figure 3-17, was equal to 6.7 (SD=2.9) overall injuries per 1000 hours. The weighted average reflects the means and standard deviations of the incidence rates reported in the studies included in the figure below. The lower rate of injuries found in this study may be due to several factors, which are discussed below.



*Dots present injury incidence per 1000 hours while error bars represent the 95% confidence intervals, *error bars represent confidence intervals, # Studies conducted in youth*

Figure 3-17: Incidence of overall injuries in selected studies and the present study.

The incidence rate of training injuries found in the present study was 1.4 per 1000 playing hours. This rate was lower than most other studies reporting injuries in professional[27;106;128], amateur[29;30] and youth[84;123] soccer players. However, the incidence of training injuries found in this study exceeded the rate of 0.9 (95% CI: 0.8-1.6) reported among 674 youth players in Portugal, all of whom were younger than 19 years of age[31] (Figure 4-18). The authors[31] found that non-injured players were younger than injured players.Therefore, age could partially account for the lower rate in Portugal. The Rwandan players were also young, with 25% of players under the age of 21. This could have contributed to the lower incidence rate compared to international studies. However, age was not found to be a significant predictor of injury in the multivariate analysis.



*Dots present injury incidence per 1000 hours while error bars represent the 95% confidence intervals, *error bars represent confidence intervals, # Studies conducted in youth*

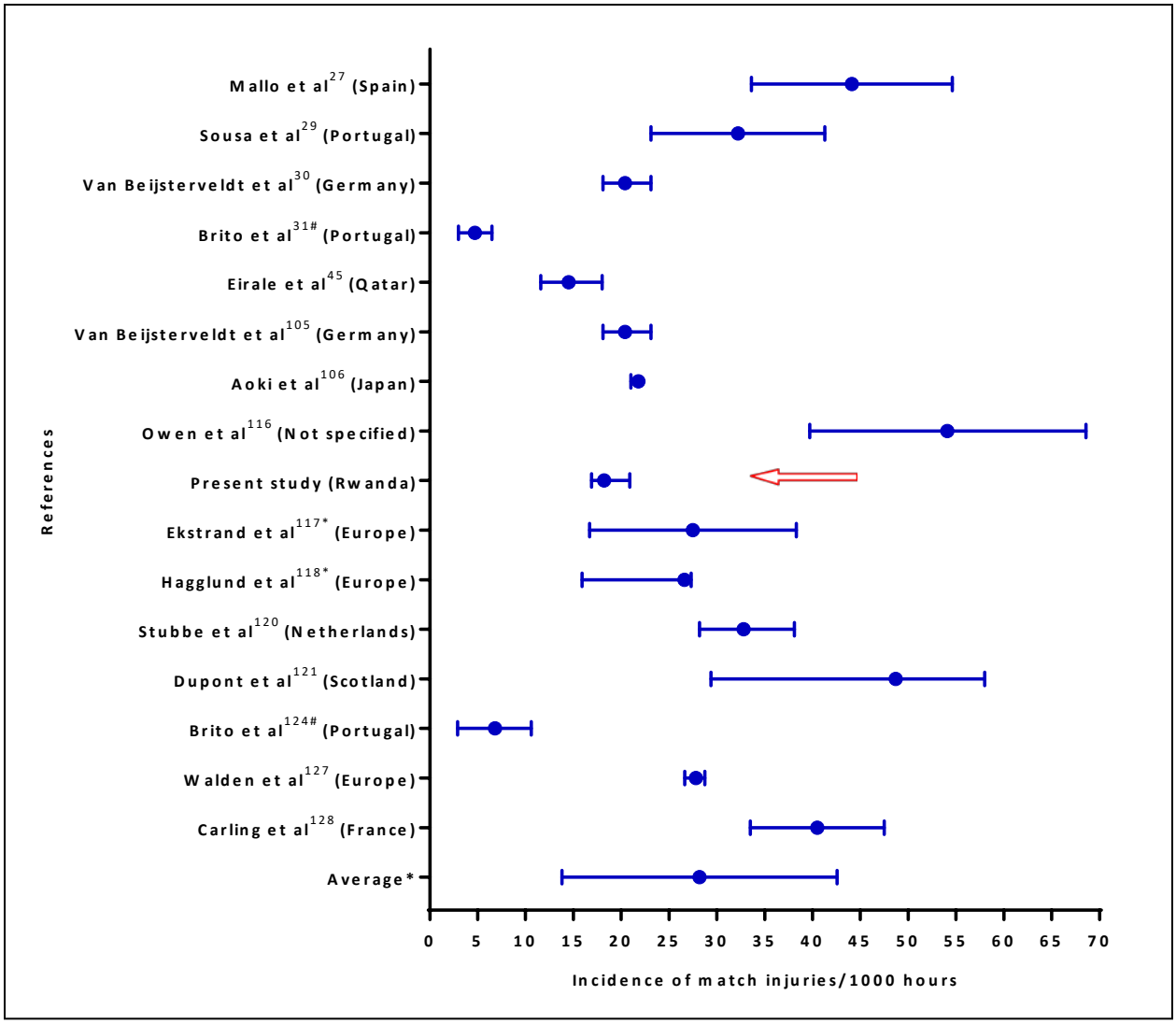
Figure 4-18: Incidence of training injuries in selected studies and the present study.

The duration of training may have influenced the incidence of injuries. Several international studies reported a higher training exposure (315-335 hours)[28;90], while others reported a lower training exposure (123-167 hours)[24;29;405] than the training exposure hours reported in the present study. Interestingly, the mean training exposure hours reported in the top 25 European teams were less (213 hours per player per season) compared to the findings of the present study (256 hours per player per season)[406]. This indicates that soccer players in Rwanda are exposed to a similar number of training hours as soccer players worldwide and this may indicate that the duration of training is not associated with the risk of injuries.

This was supported by our finding that the weekly training acute:chronic workload ratio was not associated with the incidence of injuries. Figure 3-15 depicted an increased injury incidence in the weeks following those with a higher acute:chronic workload ratio.

Owen[116] indicated that the intensity of the training, as measured by heart rate, had an impact on the incidence of injuries in soccer. In addition, high training load has been found to be a risk factor for training injuries in rugby[407] when measured in terms of training time and rating of perceived exertion for intensity. It is thus clear that intensity of training does impact training injuries specially when using heart rate measurements[222]. Rwandan teams may not train at the same intensity levels when compared to the European teams. This cannot be tested, as the specificity of the training programmes was not assessed in this study. Further studies are needed to investigate the influence of these training characteristics on injury incidence.

The incidence of match injuries reported in the literature varies widely. The rate calculated in the present study (18.2 match injuries per 1000 hours) is lower compared to a weighted average from international studies (28.2, SD=14.4 match injuries per 1000 hours), however the confidence intervals do overlap (Figure 4-19).



*Dots present injury incidence per 1000 hours while error bars represent the 95% confidence intervals, *error bars represent confidence intervals, # Studies conducted in youth*

Figure 4-19: Incidence of match injuries in selected studies and the present study.

A lower rate of 14.5 (Cis11.6-18.00) per 1000 hours match exposure was reported in 230 Qatari players over a season[24]. As in Rwanda, the Qatari teams participated in fewer matches per season compared to the Western teams that play almost double the number of matches per season. The Rwandan league is relatively small. There are a fewer number of matches and consequently less match exposure, a mean of 16 hours, compared to 21-51 hours reported in published literature[90;405;406]. This indicates that soccer players in Rwanda have less match exposure than their international counterparts.

This may explain why FERWAFA increased the number of teams in the first division to provide greater match exposure to the players. FERWAFA believes that an increase in match exposure hours will allow players to accumulate experience that would help them to compete internationally. However, the increase in exposure may also predispose players to injuries[92;219;408]. Therefore, assessing the occurrence of injuries is important to understand the risks associated with increased soccer participation.

The lower rates of match play exposure is likely to be a contributing factor to lower injury incidence rates in the present study, as increased match exposure hours have been found to be associated with an increase in the occurrence of injuries[92;219;408] . This is in accordance with the findings of the present study which found a significant increase in the match injury incidence rate with an increased match acute:chronic workload ratio. However, no significant relationship was found during season two, perhaps because of the 13-week period of interruption. (Note that the incidence rate is per 1000 hours, and is therefore standardised, regardless of the amount of playing time).

Similar to other investigations[91;106;114;116;121;124;128], the incidence of match injuries was considerably higher than training injuries (by more than ten times). This finding may be explained by the observation that match play consists of high intensity play with greater incidences of physical contacts when compared to training sessions, particularly as 98% of the injuries were traumatic in nature and more than half were due to contact. The intensity levels observed are driven by the motivation to win, which may lead to undisciplined playing behaviour[91]. For many teams in Rwanda, it is not compulsory for the medical personnel to be present during training sessions as there is inadequate funding to retain the services of the medical practitioners on a permanent basis. Therefore, despite the training given to all team members for the present study, the medical personnel may have missed certain injuries that occurred in their absence during training sessions. Under-reporting of training injuries has been highlighted elsewhere[409]. The authors[409] found underestimation of the injuries reported by medical teams compared to player interviews. The present study relied on the medical staff reports due to limited financial and technological resources for both the researcher and the teams. The results of this study would serve as the basis for future studies that would use player interview and other communication technologies for accuracy of the data collection.

With regards to severity of injury, which is measured as time loss, moderate injuries are reported to be the most common severity level of injuries[127;30], which was supported in the presented study where 41% of all injuries were classified as moderate. Severe injuries were reported in 7% of all injuries.

The overall distribution of injury severity was similar to those reported elsewhere[127;27;29;30;121;120], however the proportion of moderate injuries, which increased from 34% to 46%, in the second season was mostly observed during matches. Evidently, fractures resulted in the longest period of absence with a median time of 59 days. In the present study, four fractures (0.9%) were reported across both seasons. Two fractures affected the upper limbs while the other two affected the lower limbs. Three of the four fractures were sustained as a result of receiving a tackle from an opponent while one resulted from a collision with an opponent. An ankle fracture was the most severe injury with 106 days of absence.

A further analysis indicated that 23 out of the 35 severe injuries occurred during match play, 12 of which resulted from contacts. Eleven out of the twelve contact injuries were judged as fouls. This may indicate the aggressiveness of the players towards their opponents during matches. Therefore, fair play needs to be emphasised in Rwandan soccer leagues. Ryynanen et al[410] did not find any association between foul play injury incidence. The severity of injuries is discussed further in the following section.

4.4.3 Location and types of injuries

As predicted, the present study found that the majority of injuries (80%) were sustained in the lower limbs. This proportion fell within the upper range when compared to published literature reporting on adults (66-89%)[28;91;45] and youth (47-90%)[31;84;94;129]. The patterns of injury predominance varies widely in previously published research, while the proportion of knee injuries (28%) found in the present study was higher compared to previous studies reporting injuries in adults (16-21 years of age)[120;150] and youth (9-15 years of age)[31;129].

Knee injuries caused a median absence of eight days, however severe knee injuries were also reported to affect the ligaments and menisci. Knee ligament ruptures restricted players from participation for a median period of 23 days, with a maximum period of 41 days. The results of the present study are in accordance with a study conducted among soccer players in Czech Republic which reported that the knee constituted an above average percentage of severe injuries (30%)[169]. The authors reported that nearly a quarter of severe knee injuries reported in their study were caused by a partial or total tear of the ACL and a fifth were caused by a meniscal tear. Similarly, Darrow et al[42] reported that the knee constituted 23.3% of severe injuries in high school soccer in the United States of America[42]. However, a further study analysing severe injuries in soccer players in Luxembourg found that the knee was only the second most prevalent injury (14.6%) following thigh injuries (29.3%)[260].

Eighty per cent of knee injuries comprised of sprains with meniscal lesions and ligament ruptures each constituting 6% (12% in total). The elevated number of sprains observed in the present study may have resulted from the nature of the study. The study injury data were recorded by the medical personnel from their observation and examinations. The study did not rely on orthopaedic examinations or radiological investigations as they were not available for all the teams. Hence, the diagnoses recorded by the medical personnel may not be correct in all cases as sprains and strains may be over-reported as they are the simplest classification terms. Of the seven ligament ruptures (1.5% of injuries), three were associated with knee instability. Although the type of ligaments ruptured were not reported, it could be hypothesized that the ACL constituted a large majority. The proportion of ligament ruptures reported in this study is within the range of ACL injuries reported among male soccer players in previous studies (0.7-2%)[22;90;144].

Furthermore, PCL and MCL may have also contributed to ligament ruptures as it was reported that a non-negligible number of ruptures often occurs in the sport of soccer[90;99;406]. The results of the present study provide a basis for further investigations that could more accurately diagnose different types of sprain injuries and identify the specific ligaments affected by conducting clinical investigations.

More than two-thirds of knee injuries were caused by contact, which represents 19% of all injuries. These results are slightly lower compared to 25-29% reported by several studies[7;411], however they are comparable to the 12-19% reported by other studies[121;169]. As 67% of these injuries resulted from foul play and 55% of the cases of foul play caused knee injuries during matches, this result may indicate a lack of fair play in Rwandan soccer players. It may be suggested that the greater number of younger players in the Rwandan soccer leagues do not have the match experience or maturity to prevent foul play. Therefore, coaches need to instil a greater respect for safety and fair play in their players. Increased discipline and strict refereeing are required to minimise the number of fouls and to thus reduce injuries in the future[412].

The ankle joint was the second most affected body part comprising of a quarter of all injuries (25%), which is a higher than those rates reported in a number of published studies in adult[30;91;128] and youth soccer[31;85;114;165]. Sprains constituted the majority (93%) of ankle injuries, which was greater than the 51-81% range reported in the above-mentioned studies.

In an 11-year time trend study conducted by Lundblad et al[99] in European soccer teams, results indicated that half of the ankle injuries reported affected the lateral ligament. Other studies reported that lateral ligament injuries represented more than a quarter of ankle injuries[100;413]. Considering the results of the previous studies, 46% of all ankle injuries reported in the present study could be ligament sprains. However, details of the area of the symptoms, type of structure affected and precise diagnoses were not gathered which is considered as a limitation to the current study. An injury to the Achilles tendon caused the longest lay off time (median=15.5) apart from fractures. This indicates that muscles and tendon injuries are considered a burden to the players as they cause longer absences from soccer participation. The results of the present study suggest that almost all the Achilles tendon injuries are related overuse. Occasionally players may delay reporting injuries that have a gradual onset and does not restrict them from playing as they may judge these injuries to be minor and would not be aware of the importance of reporting as these types injuries. Players may only report these minor injuries as the symptoms worsen with time. Alternatively, the management of overuse injuries in soccer in Rwanda may not be adequate. Therefore, players may experience difficulties in returning to play once sustaining an overuse injury.

Ankle joints are vulnerable as their closeness to the ball and activities such as dribbling, tackling and shooting are high risk mechanisms[414]. Several authors have reported that ankle injuries occur as a result of contact[415;416]. Andersen et al[416] utilised video analysis andreported that more than half of ankle injuries occur as a result of tackling. Other mechanisms included shooting, running and landing. A further study that utilized video to analyse foot and ankle injuries that took place over four FIFA World Cup tournaments reported similar findings[415]. The authors found that receiving the tackle from the medial or lateral side of the leg that causes excessive ankle inversion or eversion respectively produced the highest proportion of ankle injuries. Receiving a tackle was the second most reported mechanism of injury, therefore it could be hypothesized that the same mechanism caused the high number of ankle injuries in soccer players in Rwanda, as more than two-thirds of ankle injuries were caused by contacts and nearly half of them resulted from foul play. As with knee injuries, interventions directed towards the reinforcement of the rules are urgently required in Rwandan soccer to reduce the incidence of ankle injuries resulting from tackling. Players should also be educated regarding the rules of the game as many players have limited experience playing soccer. Players may not be aware of all the rules of the game or their role in preventing injuries[417].

Landing and running were also mechanisms reported to cause ankle injuries in soccer[415;416]. A high proportion of ankle injuries in Rwandan soccer player may be caused by the same mechanisms when considering that five teams train on grass pitches that are not well managed. Several playing surfaces are half grass, half ground and their conditions are worsened during periods of rain[418]. Contextual factors could thus be a contributing factor to the high rate of ankle injuries seen in the present study compared to the rates reported in published literature[26;82;106;116;117;120], many of which originates from high-income countries.

The thigh region was the third most affected body part comprising of 18% of all lower limb injuries and 14% of all reported injuries. These injuries accounted for the second longest lay-off time (median=10). The findings of the present study are similar to the results in a study conducted by Owen et al[116] which reported a thigh injury rate of 14.3%. A number of studies presented the details of the area of the thigh that was affected as anterior to describe the quadriceps or posterior to describe the hamstrings[185;280]. In the present study however, such details were not provided according to the standardized injury report form from FIFA (Appendix VI). Ekstrand et al[406] reported that anterior quadriceps represented 5% of all the thigh injuries among European players. Gallo et al[26] identified that 14% of injuries in Argentinean players were to the anterior thigh injuries. Following these results, around 4-10 out of 65 thigh injuries would beanteriorly located. Posterior thigh or the hamstring area has been reported to contribute to 11-28% of all injuries[26]. Cloke et al[126] also found that 34% of thigh injuries were located on the posterior hamstring. Using the same proportions, players in the present study would have suffered from 22 hamstring injuries.

Running and high speed sprinting were reported to be the mechanisms leading to the hamstring injuries in previous studies[181;372]. Askling et al[130;131;132] described that running at high speed constituted the causing mechanism of the biceps biceps femoris area of the hamstring. Another mechanism causing hamstring muscle injury was any activity that required excessive lengthening of the muscle. These movements caused injuries of the semimembranosus tendon. Conflicting results were found as to the aetiology of muscle injuries in soccer. Certain evidence indicates that age[221], poor flexibility, quadriceps-hamstring strength imbalance, muscle weakness[182], and previous injury[28;117;120;170;161] has been found to increase the risk of muscle injuries in soccer. In the present study, reduced flexibility, as measured by Sit and Reach test was the significant predictor for all lower limb injuries. A more detailed discussion on the risk factors for injuries can be found in Section 4.4.6.

The fourth most commonly affected body part was the head and face which comprised on 7% (n=30) of all time loss injuries. The results of the present study are within the range reported in the reviewed studies (4-22%)[23;26;27;30;84;419]. As with knee and ankle injuries, the majority of injuries that affected the head (n=28) occurred due to contacts, all of which resulted from foul play and more than half took place during the matches. In a study conducted by Andersen et al[419] in Iceland and Norway using video viewing reported three main head injury actions for the field players. These mechanisms include dead to head collisions, upper limb to head, and foot to head contacts. Goalkeeping activities an additional detected mechanism[419]. Twelve injuries occurred as a result of elbow to head contact. Andersen et al[419] reported that it was the typical mechanism that resulted from head injuries. In a heading duel situation, a player deliberately uses the upper limb to prevent the opponent from heading the ball. The use of the arms above shoulder level is considered illegal play and among serious fouls that result in the guilty player being sent off the field with a red card[420]. Andersen et al[419] were able rewind, pause and replay their videotapes while analysing the each mechanism. The availability of such a facility would be of great benefit to future research, as well as for advocacy. The encouragement fair play among players and reinforcement of the rules of the game among referees would be important to reduce the occurrence of head injuries[419].

Half of the injuries affecting the head were reported to be concussions with or without loss of consciousness. Twelve of the injuries that affected the head and face were lacerations or abrasions while other injuries include contusions and dental injuries. The ratio of concussion injuries found in the presentstudy is higher compared to the study conducted by Andersen et al[419] which found a third of head injuries to be concussions. A lower percentage (1.3%) of concussion injuries out of all injuries was reported in the study conducted by Aus der Funten et al[89]. In the present study, these figures may have been underestimated as concussions do not only involve loss of consciousness[421]. Other concussion symptoms may not have been reported to the medical staff. Possibly, the remaining half of injuries may have been associated with concussion injuries.

Of concern is that two players who sustained concussions were reported to resume playing immediately after the onset. This is in contrast with the consensus recommendation on concussions in sport[422] which stipulates that a player should not be allowed to resume participation after suffering a concussion. It has been reported that the continuation of play results in more neuropsychological deficits that persist as well as other delayed symptoms[421]. In addition, in 11 out of the 15 concussion cases, the affected

players resumed play within seven days and five players resumed within three days. As previously mentioned, the expertise of the medical personnel may be limited due to cost considerations and the medical team, coaches and players may not be equipped with the necessary knowledge regarding concussions. Interventions targeting medical personnel and coaches in concussion management are needed. Players should also be targeted to raise awareness of concussion states to improve reporting and compliance along international guidelines regarding time off from play[421].

4.4.4 Recurrent injuries

The present study found that 22 players sustained at least one recurrent injury. The proportion (6%) of players with recurrent injuries was lower compared to the range (7-42 %) reported in studies conducted in adult soccer players[23;28;120;221;170]. This accords with the relatively low number of injuries reported to be overuse (4% in season one and 1% in season two), despite the training hours being comparable to those reported in other studies (Section 3.4.2). The present study explored the possibility that the age of the players maybe a possible explanation, however there was no significant difference in the mean age between those players who had sustained recurrent injuries and those who had not. A more likely explanation may be that players and medical personnel may not be under excessive pressure to allow the player to return to play before full recovery has taken place, as the league may not be as competitive as elsewhere. It was reported that early return to play and inadequate rehabilitation increases the risk for subsequent injuries. The reduced number of matches played throughout the season may provide enough time for full recovery after injury. In addition, the medical personnel may be cautious to allow the player to resume participation as a result of inadequate rehabilitation[38]. A further possibility is that those players who were prone to recurrent injuries were not chosen among the starters in their respective teams from the onset.

The ankle joint sustained the most recurrent injuries (n=10; 37.0% of recurrent injuries), followed by the knee (n=9; 33.3% of recurrent injuries). Sprains were the most common form (n=17; 63.0%) of recurrent injuries. Previous injury to the ankle has been reported to increase the risk of subsequent ankle injury by five times[18;157]. It has been reported that the use of ankle support and proprioception training prevents recurrent ankle injuries. A lack of protection of the ankle joints in cases of injuries may have contributed to the occurrence recurrent ankle injuries. Additionally, players may not receive the appropriate rehabilitation with proprioception exercises to prevent recurrence[423]. Further research is needed to examine techniques used to rehabilitate injured players.

Players sustained a recurrent injury at least three days after resuming full soccer participation and at most 141 days (median=16; IQR=27). The majority of injuries were classified as early recurrent (n=22; 81.5%) taking place within less than two months after resuming full participation from the index injury. According to Hagglund et al[424], early recurrent injuries may be an indication of premature return to play. Premature return to full soccer activity is mostly associated with overlooking the steps that guide return to play decision making described by Shier[425;426]. Although certain medical personnel may delay players in returning to full participation, many medical personnel may not be aware of the guidelines that could assist them making appropriate decisions. Lack of knowledge regarding the return to play decision-making guidelines may lead to unnecessary delays in allowing players to return to full participation. Therefore, there is a need for training to inform medical personnel of the guidelines on assess risks to allow for informed decision-making.

Several studies have reported that recurrent injuries were more severe than the index injury in terms of days of absence, which concords with the findings of the present study which found that recurrent injuries resulted in longer days of absence (median=9; IQR=57) compared to the index injury (median=6; IQR=24), however this difference was not statistically significant. The analysis of recurrent injuries was limited by the timeframe of the study, which has been the case for many previous studies[28;120;424]. Many of these studies presented only early recurrent injuries, while late and delayed recurrent injuries require more time[18;23;28;120;157;221;170]. There is a need of further research to investigate long-term recurrent injuries.

4.4.5 Timing of injuries during play

Consistent with many studies[7;86;170], a higher rate of injuries was observed in the second half of play compared to the first half. Match and training injuries increased during playing time with a significant increase in the incidence of match injuries during the first quarter of the second half.

The large proportion of second half and last quarter injuries may be due to local muscle fatigue and central brain fatigue[427]. Delay in muscle reaction and anterior tibiofemoral displacement have been suggested as potential factors for increased risk of injury, particular during the latter stages of playing activity[427]. Gleeson et al[428] examined the effect of injuries on endurance training of the neuro-musculoskeletal system and reported that anterior tibiofemoral displacement constituted a risk for injuries in fatigued players. The authors also found that fatigue resulted in an electromechanical delay.

Rahnama[429] and Small et al[430] indicated that muscle fatigue would predispose players to muscle strains, particularly strains of the hamstrings. This usually occurs in the latter stages of soccer activity due to time dependent decrease in eccentric knee flexor strength. The authors found that fatigue affected the ratio of eccentric hamstring contraction to quadriceps concentric contraction, which increased the risk of hamstring injuries consistent with Mair et al[431] reports that eccentric contractions of fatigued muscles are more susceptible to stretch injury. In addition, muscle strength deficiency, a reduction in the capacity to absorb energy and a corresponding decrease in muscle force as a result of fatigue, can increase the potential for injury[432]. Subsequently, there is a decrease in the functional eccentric hamstrings to concentric quadriceps ratio. Consistently, many studies have reported an increased rate of injuries towards the end of the match[23;121;410].

Surprisingly, the present study found that the incidence of match injuries reduced from the 61st to the 90th minute. It is unclear why this is the case. It may indicate that coaches are aware of the increased predisposition to injuries towards the end of the match. Therefore, coaches may have used substitutions to replace players showing signs of fatigue. From the researcher's experience, other than injuries that require the player to be substituted, coaches usually opt for replacements in cases of fatigue or tactical changes. Coaches also begin substitutions around the 60th minute of the game. This hypothesis needs to be tested.

There was no significant difference in the occurrence of injuries throughout each training period. This may be explained by the lower intensity levels during training session than matches as discussed previously. During training, the level of intensity is controlled by the coaches, while during matches it is determined by the game situation. In the previous section, it was reported that the incidence of match injuries was higher than training injuries. Consistent results were also found where match injuries were higher compared to training injuries across each month of the season.

4.4.6 Intrinsic risk factors for injuries

The results from the univariate analyses found that those who were injured were older and had more years of soccer, first division and current team experience as well as a poorer performance on the Sit and Reach, four-point hold and LEFT tests.

From the multivariate analyses, decreased flexibility as measured by the Sit and Reach test, consistently emerged as the primary risk factor for all injuries and lower limb injuries in every model. An extended time playing for the current team was also associated with injury, as was a longer timed hop.

It is widely believed that good flexibility improves joint movement and subsequently appropriate motor performance and skill execution[433]. Poor flexibility has been thought to be associated with poor performance in certain sports and may be a risk factor for soft tissue injuries. For example, a study conducted among soccer coaches in Mauritius found that 93% believed that stretching performed before training and matches would prevent hamstring strains. These coaches suggested that players should regularly perform stretching during warming up and at the end of every practice session[433]. A study conducted by Witvrouw at al[179] in Belgian soccer players found that an increase in the tightness of quadriceps and hamstring muscles resulted in an increased risk of suffering from musculoskeletal injuries. In the present study, reduced flexibility as measured by The Sit and Reach test was the primary predictor for all injuries and lower limb injuries. Sit and Reach test has been found to simultaneously measure hip and back flexibility[284]. During the screening of the players, additional flexibility measurements were conducted namely the hip abduction, internal and external rotation and hip flexor measurements. Hamstring flexibility was also performed. As none of these tests appeared to contribute to injuries, it could be suggested that the flexibility of the back was more influential. Therefore, an investigation of the contribution of the back flexibility to injuries would be valuable.

Functional tests have been widely used to measure pre competition state as well as to assess recovery during rehabilitation, especially after ACL reconstruction[364;365;366;369]. In the present study, hop tests were included in the risk factor analysis model. The timed hop test emerged as one of the predictors of injuries. Players with poor performance on the timed hop test had an increased risk of injury. In contrast, a study conducted among volleyball and basketball players found an increased risk of injuries among those who performed better on the timed hop test[382]. Association of jump performance and injuries have been explained to originate from increased reaction forces at the time of contact with the ground[382;434]. The analysis of the ground impact pressure requires state of the art equipment that is expensive and largely unaffordable by anyone. This might be the reason why the association between the jump tests and injuries have not been extensively studied. The association between time playing with their current team and injury is more difficult to explain. It may reflect the increased age of the injured players as this was found to be significantly greater in univariate analysis.

Arnason et al[181] reported that knee joint laxity highly predisposed Icelandic soccer players to injuries. Knee injuries may occur as a result of joint laxity which is occasionally associated with muscle weakness or imbalance[20;176;184]. From the researcher's observation as the physiotherapist for the national team, lack of muscular control may also contribute to knee injuries in soccer players in Rwanda, as many coaches do not concentrate on the musculoskeletal conditioning of the players. Greater emphasis is often placed on technical and tactical trainings as they believe it would improve results. The analysis of additional risk factors for knee injuries among soccer players in Rwanda would assist with planning for injury prevention interventions targeting both players' match behaviour and the type of training organized by the coaches.

4.4.7 Strengths and limitations of the study

The present study followed theprotocols outlined in the consensus statements on injury definition and data collection procedures in soccer[4]. The recruitment was satisfactory and there was considerable co-operation from the players, coaches and medical personnel. The need to manage soccer injuries was clearly perceived as important and all were very much willing to offer their support. A prospective study was undertaken over two seasons, which allowed for the collection of a large amount of data and minimised recall bias. Injury epidemiology consensus recommends a prospective follow up and reporting of exposure of the players for full-time participation in soccer. The prospective follow up of players is important as it will reveal the patterns of injuries over time. The follow up methods utilised in this study was more extensive than those used in many other studies[120;264;435]. However, a longer follow up period for a number of seasons was also reported[97;99;106;118;133]. Therefore, the present study provided useful information on the incidence of injuries in soccer players in Rwanda with a two season follow up. It has been reported that injuries also occur during the pre-season period[124;436]. However, the pre-season periods were not included in the present study as ethical approval was only obtained after the pre-season had already commenced. Further studies are needed to analyse the characteristics of the training sessions and matches and their contribution to injuries.

Training of the research assistants, coaches and medical personnel was undertaken to improve the reliability of the data. Standardised tests were used throughout the study to assess for functional capacity and standardised data collection forms were used.

Both a strength and a weakness of the study was that the two seasons during which data collection took place differed in length as well as in the patterns of training and matches. This allowed for an analysis of the change in injury patterns, which may be associated with the extended break in the season. On the other hand, this did reduce the description of injury of a typical soccer player to a single season.

The present study relied mainly on reports from the coaches and medical personnel as recommended. Although training was carried out and the forms were collected regularly, there may still have been inaccuracies in reporting, particularly regarding the reporting of the nature and location of injuries as not all teams had medical practitioners that were able to make definitive diagnoses based on clinical or orthopaedic examinations. In addition, the grading and categorization of injuries might have differed due to the varied professional backgrounds of the medical personnel. In addition, there may have been underreporting of training injuries, as the medical personnel do not attend every training session. This concern is not unique to the present study as Bjorneboe et al[409] reported that medical staff underestimated the frequency of injuries compared to retrospective interviews of the players. However, there was no evidence of underreporting in the present study and the research team collected the completed forms every two weeks rather than at the end of the season. More investigations are also needed to analyse individual injury using diagnostic investigations to understand the patterns of specific types of injuries.

A number of studies reported that at elite professional level, approximately half of the players in a team play for their national teams[225]. In the present study, there were a few players that were called up for national team duties; therefore, data for these players were not included in the study. The data for these players were not taken into consideration to avoid an underestimation of national team risk exposure, which would result in the findings not being able to be generalised to elite professional players.

4.5 Conclusions and Recommendations

In conclusion, the present study adds to the body of knowledge of soccer injuries sustained in a low- to middle-income country. The injury incidence rate was generally lower than those rates reported in other studies, which was unexpected.

Possible reasons for this difference are that the Rwandan players are younger and that their training and match intensity may be less than in more competitive high-income country environments. As the number of matches is due to increase as additional teams, join the league, the impact of more match time on injuries needs to be closely monitored in the future. In contrast, the proportion of ankle injuries was higher than those rates reported in the literature and was the most common recurrent injury type. Prevention is paramount as injuries constitute a burden to teams and players. The following chapter (Chapter Five) reviews the available literature that examines the effectiveness of preventive measures in reducing injuries in male soccer players.

The considerable number of match and contact injuries is of concern, particularly as many were associated with fouls. The need for adequate refereeing and inculcation of better discipline in the players has been highlighted by these findings.

The flexibility of the back structures and the hamstring muscles (Sit and Reach test) as well as balance and co-ordination (hop test) emerged as being significant predictors of an increased risk of injury. Coaches should be aware of the need to target these areas. In addition, the impact of age on flexibility should be monitored and older players specifically need to maintain muscle length and strength. This indicates the need for injury prevention interventions to reduce the risk for injuries. Additionally, Chapter Five presents the results of the intervention study conducted among second division male soccer players. The recommendations for practice, policy and research are discussed in more detail in Section 6.2, together with the recommendations arising out of the intervention study.

CHAPTER 5. LITERATURE REVIEW: INJURY PREVENTION STRATEGIES IN MALE SOCCER PLAYERS

5.1 Introduction

The literature review reported in Chapter Two indicated that the incidence of injuries was higher at all the levels of play with consistently greater levels of match injuries compared to injuries sustained during training[23;26;27;124;128;120;129]. Most soccer injuries affected the lower extremities with the dominance on the knee, thigh and ankle joint[30;84;91;106;114;116;121]. The prospective study conducted among first division soccer players in Rwanda found that the incidence of injuries was generally lower than injury incidence levels reported in other studies (Section 3.4.2). Although Rwandan soccer players sustained fewer injuries, several of these injuries could have been avoided.

A detraining effect is one of the resulting burdens of injuries, along with a loss of fitness. The loss of physiological adaptations may result in psychological distress for the affected players[48]. Occasionally, players develop early degenerative diseases such as osteoarthritis[48]. The treatment and rehabilitation of soccer injuries is more demanding on players, therapists and teams as it is both time consuming and expensive[45]. Injury prevention interventions have been advocated to reduce the high injury incidence and associated complications for maximal performance and benefits[439].

A review conducted by Klügl et al[48] indicated that sports injury prevention investigations have increased in the last decade and the number of randomized controlled trials have almost doubled between 2000 to 2005[48;49]. Randomized controlled trials have often been used to investigate the effect of numerous injury preventive measures in various sports[48;441;48;443;48]. However, it is not known whether the knowledge gained from studies investigating injury prevention in other sports can be transferred to soccer. Therefore, the aim of this review is to evaluate the existing injury prevention research and present the effectiveness of different types of prevention methods in soccer.

5.2 Literature Search

5.2.1 Literature sources and searches

A computer-based search was conducted using the University of Cape Town's open access databases. Original research articles published in English or French were searched for using Medical Subject Heading (MeSH) terms in Pubmed, including Medline (Table 5-1).

Related terms were also used in an additional search conducted in Scopus and Web of Science databases using various combinations. Simultaneous searches were conducted in EBSCOhost for CINAHL as well as in Academic Search Premier. The list of study titles and their abstracts generated by the search were assessed for eligibility. Following, full-text copies were examined for relevancy. Pertinent studies were searched from the reference lists and a manual search was conducted for additional studies of interest.

Table 5-1: Key terms used in the search in Pubmed and other databases.

Key words	Search terms
Soccer	(("Soccer"[Mesh] OR ("soccer"[MeSH Terms] OR "soccer"[All Fields])) OR football[Title/Abstract]) OR "Sports"[Mesh]) OR ("sports"[MeSH Terms] OR "sports"[All Fields])) OR (team[All Fields] AND ("sports"[MeSH Terms] OR "sports"[All Fields]))) OR (("Contact"[Journal] OR "contact"[All Fields] OR "Contact"[Journal] OR "contact"[All Fields]) AND ("sports"[MeSH Terms] OR "sports"[All Fields]))) OR ("sports"[MeSH Terms] OR "sports"[All Fields] OR "athletics"[All Fields]))
Injury	((("Athletic Injuries"[Mesh] OR ("athletic injuries"[MeSH Terms] OR ("athletic"[All Fields] AND "injuries"[All Fields]) OR "athletic injuries"[All Fields])) OR (sports injured[All Fields] OR sports injures[All Fields] OR sports injuries[All Fields] OR sports injury[All Fields])) OR "Wounds and Injuries"[Mesh]) OR (injur*[All Fields])) OR (wound injuries[All Fields] OR wound injury[All Fields])) OR "Sprains and Strains"[Mesh]) OR (strain[All Fields] OR strain*[All Fields])) OR (sprain[All Fields] OR sprain*[All Fields])) OR "Contusions"[Mesh]) OR (contusion[All Fields] OR contusion*[All Fields])) OR ("brain concussion"[MeSH Terms] OR ("brain"[All Fields] AND "concussion"[All Fields]) OR "brain concussion"[All Fields] OR "concussion"[All Fields])) OR ("Brain Concussion"[Mesh] OR "Post-Concussion Syndrome"[Mesh]))))
Prevention	"Prevention"[All Fields] OR "Prevent*"[All Fields] OR "Reduce*"[All Fields] OR "Protect*"[All Fields] OR "Avoid*"[All Fields] OR "prevention and control"[Subheading] OR "Tertiary Prevention"[Mesh] OR "Secondary Prevention"[Mesh] OR "Primary Prevention"[Mesh]
Type of studies	((("cluster"[All Fields]) AND ("random allocation"[MeSH Terms] OR ("random"[All Fields] AND "allocation"[All Fields]) OR "random allocation"[All Fields] OR "randomized"[All Fields]) AND ("clinical trials as topic"[MeSH Terms] OR ("clinical"[All Fields] AND "trials"[All Fields] AND "topic"[All Fields]) OR "clinical trials as topic"[All Fields] OR "trial"[All Fields])) OR (("random allocation"[MeSH Terms] OR ("random"[All Fields] AND "allocation"[All Fields]) OR "random allocation"[All Fields] OR "randomized"[All Fields]) AND controlled[All Fields] AND study[All Fields])) OR ("randomized controlled trial"[Publication Type] OR "randomized controlled trials as topic"[MeSH Terms] OR "randomized controlled trial"[All Fields] OR "randomised controlled trial"[All Fields])
Population	Search limited to human, male at all levels (Adolescent, high school student, teenage, child, amateur, elite, professional, semi-professional)

5.2.2 Study selection

The review selected studies that assessed the effect of any form of preventive intervention on soccer injuries. Studies that used randomised, quasi or non-randomised controlled trials or prospective cohort studies with at least a comparison group or pre-post intervention analyses were included in the review. Articles published in a peer-reviewed journal written in English or French were included with no publication date restriction up to June 2017. The review also included studies that were conducted among male soccer players with no restriction on age. Studies that used mixed gender or sports population but provided specific results for males or soccer were also included. The outcome used in these studies should have included the incidence of one or more injuries. Studies that presented the incidence of injuries per unit of player time or the proportion of injured players divided by players at risk were also included.

5.2.3 Search results

5.2.3.1 Description of reviewed study

The search of injury prevention studies identified 45 publications that included soccer players. Twenty-six studies were conducted using male participants, 16 studies used female participants and three studies used both male and female participants. The full text version of one study could not be found, therefore it will not be discussed in the subsequent review[437]. Of the 44 remaining studies, 28 were RCTs, 15 were prospective cohort studies, and one was a non-randomised control trial. One of the 16 studies conducted among female participants also included basketball players. The follow-up period differed according to the nature of the intervention, with the shortest follow-up period being six months[54;438;439] and the longest follow-up period being four years[440].

The majority of these studies investigated the effect of one or more prevention intervention strategies on the incidence of overall injuries in[5;55;58;373;399;438;439;440;441;442;443;444;445;446;447] , while other studies focussed on one or more injury types, such as ankle sprains[50;51;52;448], ACL sprains[142;449;450;451], MCL injuries[452], recurrent injuries[57;453], acute lower limb injuries[53;442;454;455], hamstring strains[54;56;184;456;457], noncontact injuries, groin strains[404] and Achilles as well as patellar tendon injuries[458].

The review focused on interventions among male soccer players to assess the extent of injury prevention research compared to the considerable amount of epidemiological studies available.

The types of the interventions used among males were to some extent similar to the interventions conducted among females; however, the studies in males outweighed those conducted in females. Based on the type of intervention employed, studies were grouped into four major categories: external support, training programmes, stretching and other interventions (Table 5-2).

Table 5-2: Characteristics of included studies in the review.

Reference Country	Gender Level Age	Design Follow up	Participants	Primary outcome (Type of injury studied)	Intervention	Dosage Compliance	Effect of intervention
External joint support							
Tropp et al[50] Sweden	Male Amateur Not reported	RCT 6 months	IG: Orthosis: 124 players, Ankle disc training: 144 players CG: 171 players	Ankle sprain	Ankle orthosis or balance training	10 minutes ankle disk exercises performed 5 times a week for 10 weeks and 5 minutes ankle disk training 3 times a week for the rest of season Not reported	Significantly lower injuries in players with a history of ankle sprain compared to the control group
Surve et al[51] South Africa	Male Elite & Amateur Not reported	RCT 1 Season	n= 504 IG: 117 players without a history of ankle sprain 127 players with a history of ankle sprain CG: 260 players	Ankle sprain	Semi rigid ankle orthosis	Instructed to wear the semi-rigid orthosis for every training and match Not reported	60% lower incidence of ankle sprains in the intervention group, no effect for players without previous ankle sprains
Mohammadi[57] Iran	Male First division 24.6±2.6 years	RCT 1 season	n=80 players IG1: n = 20 proprioceptive training IG 2: n = 20 strength training IG 3: n = 20 orthoses CG: n = 20	Recurrent ankle inversion sprains	Three interventionsprogrammes were conducted in intervention groups, proprioceptive, strength and orthoses	Progressive training conducted daily for 30 minutes Not reported	No significant difference in the recurrent ankle injuries between the orthoses group and the control group

Reference Country	Gender Level Age	Design Follow up	Participants	Primary outcome (Type of injury studied)	Intervention	Dosage Compliance	Effect of intervention
Multi-component intervention							
Ekstrand et al[438] Sweden	Male Amateur 17-37 Years	RCT 6 months	n= 180 players IG: 6 teams CG: 6 teams	All time-loss injuries	Multi-modal programme (training modification, strapping, training shoes, shin guards and controlled rehabilitation)	Delivered by team doctors and physiotherapists Not reported	75% fewer injuries in the intervention group
Junge et al[441] Switzerland	Male Youth amateur 14-19 Years	Prospective cohort 1 years	n= 194 IG: 101 CG: 93	All time-loss injury	A multi-modalintervention composed of warm-up, cool-down, taping of unstable ankles, rehabilitation as well as the FIFA 11+ programme	once a week supervised Not reported	No significant reduction of the incidence of injuries. Significant differences were found for number of injured players, mild overuse and noncontact injuries
Training programmes							
Balance and proprioceptive training							
Tropp et al[50] Sweden	Male Amateur Not reported	RCT 6 months	IG: 60 players without and 65 players with previous ankle injuries CG: 171 players	Ankle sprain	Ankle orthosis or balance training	10 minutes ankle disk exercises performed 5 times a week for 10 weeks and 5 minutes ankle disk training 3 times a week for the rest of season Not reported	71-82% fewer injuries in players with a history of ankle sprain
Mohammadi[57] Iran	Male First division 24.6±2.6years	RCT 1 season	n=80 players IG1: n = 20 proprioceptive training IG 2: n = 20 strength training IG 3: n = 20 orthoses CG: n = 20	Recurrent ankle inversion sprains	Three interventionsprogrammes were conducted in intervention groups, proprioceptive, strength and orthoses	Progressive training conducted daily for 30 minutes Not reported	Significant reduction of recurrent ankle sprains in proprioceptive training group compared to the control group.

Reference Country	Gender Level Age	Design Follow up	Participants	Primary outcome (Type of injury studied)	Intervention	Dosage Compliance	Effect of intervention
McGuine & Keene[448] USA	Male & Female High school Soccer & basket 16.4 ± 1.2	RCT 1 season	n=765 players IG:373 players CG:392 players	Ankle Sprains	Balance Training Program	5-phase balance training progressively performed for 5 sessions per week for 4 weeks in preseason and 3 sessions per week during in-season period. 30 seconds exercise with 30 seconds rest for 10 minutes 90% compliance	38% reduction of ankle sprains in players who experienced previous ankle sprain.
Caraffa et al[449] Italy	Male Elite & Amateur Unknown	Prospective controlled study 3 years	n= 600 players IG:300 players CG: 300 players	ACL injuries	Progressive Balance training	20 minutes 5-6 days a week Not reported	87% fewer ACL injuries per team in the intervention group
Warm-up programmes							
Van Beijsterveldt et al[55] Netherlands	Male Amateur 18-40 years	Cluster RCT 1 season of 9 months	n=556 Intervention: 223, Control: 233	All injuries	10 exercises targeting core stability, strengthening, plyometric, stabilisation and proprioception	Performed 2 to 3 times a week 71% player compliance	No significant differences in the overall incidence or severity of injuries between the intervention and control group
Owoeye et al[439] Nigeria	Male Youth 14 -19 years	Cluster RCT 6 months	n=416 players IG: 212 players CG: 204 players	All injuries	The FIFA 11+ soccer specific warm-up programme	3 times per week for the full season. Not reported	The FIFA 11+ pro gramme reduced the incidence of overall and lower limb injuries

Reference Country	Gender Level Age	Design Follow up	Participants	Primary outcome (Type of injury studied)	Intervention	Dosage Compliance	Effect of intervention
Silvers-granelli et al[445] USA	Male Collegiate > 14years	RCT 1 season	n=1525 players IG: 675 players, CG: 850 players	Time loss injuries	The FIFA 11+ soccer specific warm up	3 times per week for the full season Greater benefits of the prevention programme were achieved with increased compliance	46.1% reduction of overall injuries and 28.6% reduction in time lost due to injuries.
Hammes et al[446] Germany	Male Veteran 45 years	RCT 9 months	n= 265 players IG: 146 players CG: 119 players	All injuries	The FIFA 11+ soccer specific warm-up programme	20 min warm-up performed once a week Not reported	Other than severe injuries, no significant difference in the incidence of injuries was found between intervention and control group
Grooms et al[455] USA	Male Collegiate 18-25 years	Prospectiv e Cohort 2 seasons	n = 41 players	Lower extremity injury risk and time lost due to lower extremity injury	The soccer specific warm up programme	20 minutes exercises 5 to 6 times per week Not reported	72% reduction of of lower extremity injuries and associated time lost
Junge et al[459] Switzerland	Male Amateur Age not reported	Cohort 4 years	n=1000 Intervention : 737, Control: 755	All injuries	Countrywide campaign on the use of 11+ programme to prevent soccer injuries	Coaches decided when to conduct the programme Teams performed the exercises for 40% of the original exercises Less 50% of the teams performed the exercises 2 times or more per week.	11.5% reduced match injuries and 25.3% reduced training injuries
Farhan et al[460] Malaysia	Male Youth 13.3±0.4 years	RCT 1 year	N=50 players IG: 25 players CG:25 players	Lateral ankle sprain	warm-up program of 15-20 minutes per session	5 times per week for 12 weeks Not reported	55% reduction of ankle injuries

Reference Country	Gender Level Age	Design Follow up	Participants	Primary outcome (Type of injury studied)	Intervention	Dosage Compliance	Effect of intervention
Strength training							
Arnason et al[54] Norway	Male Elite & Amateur Not reported	Prospective cohort 2 seasons	n= 58 teams Iceland, 42 teams in Norway	Hamstring strains	eccentric hamstring training	12 repetitions of Nordic eccentric Hamstring strengthening exercises 48% compliance	35% fewer hamstring strains in the training group
Croisier et al[56] Belgium	Male Professional 26±6 years	Prospective Cohort 9 months	n=462	Hamstring injuries of players with strength imbalances	Hamstring strength conditioning programme	Manual, isotonic, or isokinetic strengthening exercises Not reported	Significant reduction of the risk of hamstring muscle injury
Askling et al[184] Sweden	Male Elite 24 years	RCT 11 months	n= 30 players IG: 15 players CG: 15 players	Hamstring Strain	Pre-season strength training using a special device providing eccentric overload of the hamstring	1-2 times a week for 10 weeks Not reported	Significant reduction in proportion of injured players in intervention compared to the control group
Hölmich et al[404] Denmark	Male Amateur Mean age: IG: 24 years; CG: 25 years	Cluster RCT 30 weeks	n=977 players IG: 524 players CG: 453 players	Groin injuries and associated pain	Six-exercises set including strengthening coordination and core stability targeting hip and pelvis muscles.	2-4 times a week Not reported	No significant reduction of groin injury thought reduced by 31%.
Lehnhard et al[440] USA	Male Youth/ college Not reported	Prospective cohort 4 years	1 team	All injuries	strengthening exercises for the upper and lower body	2 days a week during the season break and the preseason periods Not reported	47% fewer injuries in two years of strength training than two years without training
Zouita et al[447] Tunisia	Male Elite youth 13–14 years	RCT 1 season	n=32 teams IG: 26 teams CG: 26 teams	All	strength training	2 to 3 sessions of 90 minutes for 12 weeks (4 X 3 weeks separated by 1-week recovery) Not reported	The strength training programme reduced the rate of injuries

Reference Country	Gender Level Age	Design Follow up	Participants	Primary outcome (Type of injury studied)	Intervention	Dosage Compliance	Effect of intervention
Engebretsen et al[454] Norway	Male Elite & Amateur Not reported	RCT 7 months	n= 388 IG: 193 CG: 195	Ankle and knee sprains, hamstring and groin strains	Neuromuscular and/or strength training targeting ankle, knee, groin and/or hamstring	3 times a week for 10 weeks and once a week for the rest of the season 19-30% compliance during the preseason period	No effect of the intervention
Petersen et al[456] Denmark	Male Professional and amateur 23.5± 4 years	Cluster RCT 1 season of 12 months	n=942 players IG: 461 Players CG: 481 Players	Acute Hamstring Injuries	Eccentric Training/ Nordic hamstring exercises	10 weeks of progressive exercises followed by weekly programme 91% of the first 27 sessions	Additional eccentric hamstring exercise decreased the rate of hamstring injuries
Horst et al[457] Netherlands	Male Amateur 24.5+3.8 years	RCT 1 season	n=579 players IG: 292 players CG: 287 players	Incidence and severity of Hamstring Injuries	Nordic Hamstring Exercise	25 sessions performed for 13 weeks Compliance with the intervention was excellent	Significantly reduction of hamstring injury incidence, but no effect on severity
Fredberg et al[458] Denmark	Male Professional 17-37 years	RCT 12 months	n=209 IG: 98 players CG: 111 players	Achilles and patellar tendons injury	Prophylactic eccentric training and stretching	10 minutes exercises performed 3 times a week 2.25 times per week	Eccentric training did not reduce the risk of Achilles or patellar tendons injuries
Stretching exercises							
Arnason et al[54] Norway	Male Elite & Amateur Not reported	Prospective cohort 2 seasons	n= 58 teams Iceland, 42 teams in Norway	Hamstring strains	Stretching, Flexibility exercises of the hamstring	Hamstring stretches performed during warm-up prior every training session 39% compliance	No effect of flexibility training alone was observed in the reduction of hamstring injuries
Fredberg et al[458] Denmark	Male Professional 17-37 years	RCT 12 months	n=209 IG: 98 players CG: 111 players	Achilles and patellar tendons injury	Prophylactic eccentric training and stretching	10 minutes exercises performed 3 times a week 2.25 times per week	Eccentric training did not reduce the risk of Achilles or patellar tendons injuries

Reference Country	Gender Level Age	Design Follow up	Participants	Primary outcome (Type of injury studied)	Intervention	Dosage Compliance	Effect of intervention
Other interventions							
Johnson et al[5] Sweden	Male and Female Elite Female: 20.1 years Males: 22.9 years	RCT 6 months	Male: n=132 players IG: 16 teams CG: 16 teams Female: n=103 players IG: 16 teams CG: 16 teams	All injuries	Cognitive-behavioural training with relaxation and imagery training	6 to 8 sessions during 19 weeks of the competitive season Not reported	83% significantly lower injuries in the intervention group compared to the control group
Hägglund et al[453] Sweden	Male Amateur 15-46 years	RCT 1 season 10 Months	n=582 IG:282 CG:300	All Recurrent injuries	10-step progressive rehabilitation program including return to play criteria designed for coaches	Not reported 68% compliance with the recommended number of training sessions	66-75% reduction of recurrent injuries after a controlled rehabilitation program implemented by coaches
Arnason et al[461] Norway	Male Elite & Amateur Not reported	RCT 6 months	n= 271 IG: 127 CG: 144	All acute injuries	Injury prevention awareness raising programme	15 minutes presentation and video viewing Not reported	No effect of the video awareness programme on the incidence of injuries
Elias et al[462] USA	Male and female Youth Age not reported	Tournament of 4 day	4000 payers	Heat stroke	Educational intervention programme related to hot weather	Not reported Not reported	Fewer heat stroke cases, from 21 cases over two days, to 13 cases over four days

RCT: Randomised Controlled Trial; IG: intervention group; CG: Control group; n: number of participants

5.2.3.2 External protective joint support

Three studies investigating the effect of external joint supports focused on the ankle joint. An RCT conducted among Swedish soccer players investigated the effect of a semi-rigid ankle orthoses offered to 124 players with and without a history of ankle injuries[50]. The control group of 171 players did not wear any protective ankle equipment. After the six month follow up, ankle orthoses significantly reduced the number of ankle injuries among players with previous ankle sprains. However, the

intervention did not show any effect in players without prior ankle sprain injuries[50]. Similar findings were observed in an RCT that assessed the effect of a semi-rigid ankle orthoses on the incidence of ankle injuries in 504 amateur and elite South African male soccer players over one season[51]. The study demonstrated a significant reduction of recurrent ankle sprains in players who used the orthoses compared to the players who did not use them. However, the study did not find any differences in the in the incidence of ankle injuries in players without a history of ankle sprains[51].

Another RCT investigated the preventive effects of ankle braces on recurrent ankle inversion strains in first division Iranian soccer players over a full season[57]. The study found no significant difference in the incidence of recurrent ankle sprains among the 20 players that made use of an ankle brace compared to those who did not (n=20 players). Although the use of a brace may be recommended to prevent recurrent ankle injuries in soccer, the studies encountered a number of methodological limitations as highlighted in the systematic review on measures used to prevent ankle sprains in sports[463]. The studies did not report on the methods of randomisation of the participants. The type and texture of the orthoses used were not mentioned and differed across each study. The studies did not mention the degree of ankle sprains that were prevented by the external ankle orthoses. Furthermore, the studies did not mention how long the orthoses should be used to offer minimum protective outcome[50;51;57].

5.2.3.3 Multi-component injury prevention interventions

The first injury prevention study was published as early as 1983[438]. The study assessed the effect of a multi-component programme, delivered by the team technical and medical staff, on the reduction of injuries in 180 adult Swedish soccer players. The six-month intervention programme consisted of the correction of warm up and cool down sessions, the compulsory use of shin guards and appropriate shoes, prophylactic taping of unstable or previously injured ankles, suspension of player with knee instability, educating the players and coaches regarding fair play and injury risk, and finally the continued supervision of the intervention. The authors reported a 75% reduction of injuries in the intervention group compared to the control group. However, the study encountered a limitation in which participants did not follow the original design as planned[438]. In a systematic review conducted by Olsen et al[464], the study was rated poorly, with 40% on RCT quality assessment scores. Additionally, it may be difficult to ascertain the contribution of individual components in the reduction of injuries, as all components were used concurrently[464].

Nearly two decades later, Junge et al[441] published a study that examined the effect of a multi-component intervention on the reduction of injuries in youth amateur soccer players in Switzerland. Seven teams received the intervention composed of education and supervision of warm-up, cool down, ankle taping, appropriate rehabilitation, fair play and the execution of 10 sets of soccer specific exercises. Teams were supervised once a week for the duration of a season. Players in the intervention group sustained 21% fewer injuries than players in the control group[464]. Similar to the study described above[438], while implementing a multi-component programme, it is not possible to distinguish the relative contribution of each component in preventing injuries. Additionally, the implementation of each component requires close supervision by specialised personnel[438;464;441] that are not always available in teams with limited financial resources.

5.2.3.4 Training programmes

5.2.3.4.1 Balance and proprioceptive training

Tropp et al[50] indicated that ankle disk training performed during pre-season and in-season periods was effective in preventing recurrent ankle injuries in male amateur Swedish players[50]. Proprioceptive training has also been shown to significantly reduce the incidence of ankle recurrent sprains in first division male soccer players in Iran (RR:0.13; 95% CI: 0.003–0.93)[57].

In a three-year prospective controlled study, Caraffa et al[48] examined the effect of a 20-minute progressive balance training programme among 600 soccer amateur and elite soccer players. The intervention group (n=300 players) performed the balance training four to five days per week and were followed for three years, while the control group (n=300 players) trained as per usual. The intervention group had 87% fewer ACL injuries compared to the control group[48].

McGuire and Keene[448] evaluated the effect of a five-phase balance training programme on the incidence of ankle sprains in male and female high school athletes, where 242 athletes were male. The training consisted of single leg balance exercises performed with or without the balance board and the participants' eyes open or closed. The analysis found a significant reduction in ankle sprains in players with prior ankle sprain (RR: 2.14, 95% CI: 1.25-3.65). However, the study did not find any difference in the incidence of new ankle injuries between the intervention and control group[448].

The above-mentioned studies[57;48;448] highlighted the effects of balance and proprioception training in the prevention of recurrent ankle and ACL injuries. Balance and proprioceptive training is effective in reducing the risk of ankle sprains specifically. When incorporated into rehabilitation, balance and proprioceptive exercises train the neuromuscular system, which is the natural protective reflex of the joints. However, it requires eight to 10 weeks for the proprioceptive training to be effective[465]. Therefore, compliance to the programme is important to achieve the desired effect as reported by McGuire and Keene[448]. The main limitation found in these studies is that they made use of a combination of exercises, which made it difficult to measure the contribution of each individual exercise towards injury prevention.

5.2.3.4.2 Strength training

ARCT by Askling et al[184] assessed the effects of a pre-season eccentric overload strength training programme targeting the hamstring muscles on the reduction of injuries over the course of a season. The 15 players allocated to the intervention group sustained four hamstring strains throughout the season, which was significantly lower than the 15 players in the control group who sustained 10 hamstring strains. Specific hamstring training in addition to the standard conditioning programme was recommended during the preseason period for performance and injury prevention purposes[184].

Arnason et al[54] conducted a prospective cohort study in Iceland and Norway over four seasons to assess the effectiveness of Nordic hamstring strengthening and flexibility training on the rate of hamstring injuries. Teams in Iceland performed the Nordic hamstring strength exercises with warm-up stretches and flexibility training, while teams in Norway performed warm-up stretches and the flexibility training only. The incidence of hamstring strains was lower in the Icelandic teams compared to the baseline data (RR: 0.42, 95% CI: 0.21–0.84), and the Norwegian teams (RR: 0.43, 95% CI: 0.19–0.98). The authors concluded that the eccentric Nordic hamstring strength training combined with stretching exercises incorporated during the warm up could reduce the risk of hamstring strains[54]. The results should also be interpreted with caution as the study was not an RCT by design. The observational design used in this study could not allow for the testing of confounding factors such as competition, previous injury and country-related environmental factors.

In a cluster RCT, Petersen et al[456] examined the effect of the Nordic exercises on the incidence of acute hamstring injuries. The study was conducted in amateur and professional Danish soccer teams. The

intervention group performed the Nordic eccentric training for 10 weeks during the pre-season in addition to the in-season weekly programme of 12 months. The intervention group suffered significantly less acute (RR: 0.29, 95% CI: 0.15-0.57), new (RR: 0.41, 95% CI: 0.18-0.93) and recurrent (RR: 0.14, 95% CI, 0.04-0.51) hamstring injuries compared to the control group[456]. In a further RCT conducted in the Netherlands, Horst et al[48] assessed the effect of 25 sessions of Nordic exercises on the incidence and severity of hamstring strains in adult amateur soccer players . The intervention group performed Nordic hamstring exercises for 13 weeks, while the control group continued training as usual. Reduced risk of hamstring injuries was found in the intervention group compared to the control group (OR: 0.28 95% CI: 0.11-0.72). However, the intervention did not have any effect on the severity of hamstring injuries[48]. Thesestudies[456;457] complement Arnason et al's[54] recommendation to incorporate the Nordic hamstring strengthening exercises in the training routine of soccer players. Nordic hamstring strengthening is easy to perform as it does not require any equipment is less time consuming and can be performed on the field. Players with a history of hamstring strains may also perform the exercises to prevent the recurrence of injuries[54;456;457].

The effect of strength training in the reduction of injuries was also investigated in a time series study by Lehnhard et al[440]. Collegiate level soccer players were followed up for four years, with the first two years of data collection serving as a baseline.

During the final two years of the study, players performed strengthening exercises for the upper and lower body twice per week during the mid-season break and the pre-season periods. Strength training significantly reduced the incidence of injuries by 47% during the two-year intervention compared to the baseline period. However, the authors could not conclude that the reduction of injury occurrence were as a direct result from the intervention, as they recognized the effect of confounding factors related to the study design[440].

Another prospective cohort study examined the effect of a hamstring conditioning programme targeting professional players with muscle strength imbalances[56]. During the preseason period, 462 players performed manual, isotonic or isokinetic strength exercises to restore balance between hamstring and quadriceps muscle strength. Injuries were recorded during the full season of ninemonths. There was a significant reduction in injury risk after restoring muscle strength balance. The study observed an increased risk for injuries in players with untreated muscle imbalances compared to players with normal

strength profiles (RR: 4.66 95% CI: 2.01-10.8). It was therefore recommended that muscle strength should be tested during the preseason period. Furthermore, specialised strength training should be designed to restore the balance between the agonist and antagonist muscles to prevent injuries[56].

Zouita et al[447] examined the effect of a 12-week resistance training programme on the incidence of injuries in elite youth soccer players in Tunisia. Players in the intervention group (n=26) performed two to three 90-minute strength training sessions peer week for 12 weeks, with one week of recovery each month. Zouita et al[447] reported four injuries in the intervention group and 13 injuries in the control group. The study defined injuries as a grievance to the bodyresulting in more than three days absence from soccer participation[447]. The incidence of injuries in the intervention groupwas significantly lower than in the control group (RR: 300.7, 95% CI: 98.1-921.5)[447].

The studies discussed above indicate that strength training performed either during the pre-season period or throughout the season may reduce the incidence of injuries at all levels of soccer play[54;56;184;440;447;456;457]. However, an RCT conducted by Holmich et al[404] among 977 Danish amateur soccer players found conflicting results. The intervention group conducted strengthening exercises of the hip adductors, abdominal muscles, iliopsoas and core stability exercises two to four times per week for 30 weeks while the control group continued with their standard training programme.

There was 31% reduction in groin pain in the intervention group compared to the control group, however these results were not statistically significant (RR: 0.69, 95% CI: 0.40-1.19)[404]. Similarly, no effects of a strength training programme were observed in a study conducted by Engebretsen et al[454] among Norwegian amateur and elite players. The intervention group conducted a neuromuscular strength training programme targeting the ankle, knee, groin and hamstring three times per week for 10 weeks of the pre-season and once a week during the course of the season. The control group continued training as usual. No effects of the intervention was reported as the study suffered from low compliance to the programme, specifically during the pre-season period[454].

In 2010, Kirkendall et al[466] reviewed studies that investigated the effect of exercise-based interventions in the reduction of the incidence of injuries. The review found that balance and proprioception training was effective in ankle injury reduction, and that strengthening exercises reduced the incidence of muscle injuries[466]. Conflicting results were found in a systematic review of randomised controlled clinical

trials on the evidence of preventive exercise interventions on injuries in soccer at all levels, ages and gender[467]. A possible reason for these findings is the methodological limitations found in these studies. Reviewed studies differed in the sample size, type, frequency and duration of exercises, as well as low compliance to the intervention programme[467]. Another systematic review reported poor quality and heterogonous types of the studies that investigated the effect of exercise-based internvetions[468]. The complexity of conducting high quality studies in the domain of sports,specificallyin team sports like soccer was acknowledged[464;466;467;468;469].

5.2.3.4.3 Soccer specific warm-up programme

The 10 sets of soccer specific exercises initially developed by the F-MARC were named the "FIFA 11" or "the 11"[55;459]. The programme comprised of 10 exercises and focused on the promotion of fair play. The exercises targeted the improvement in strength, balance and jumping/landing ability. The exercises were designed to be integrated in warm-up sessions to be effective in injury reduction. Only three studies examined the effect of "the 11" in the prevention of injuries[55;459;470]. Two were RCTs conducted in adult males[55] and female youths[470], while one study was a cohort study in male amateur players[459]. In 2004, Junge et al[459] disseminated the "the 11" warm up programme countrywide in Switzerland. After four years, the authors found a 17.2% reduction in the incidence of match injuries. Non-contact match injures were also 27% lower in teams that implemented "the 11" compared to those who did not. The incidence of training injuries was 25.3% lower compared to teams that did not perform the "the 11"[459]. However, the results should be interpreted with caution as the study had many methodological limitations. The studies did not conceal the allocation of the teams in the study groups during randomisation, and did not blind the outcome assessors. More importantly, the studies encountered limitations related to compliance to the intervention programme.

Two other RCTs did not find any preventive effects of the "the 11" warm up programme on the incidence of overall, training or match injuries, as well as in the severity, location and type of injuries[55;470]. The common limitation in these two studies was the low level of compliance among players. Studies also did not have enough statistical power to detect effects of the programmes on injury prevention[55;459;470].

In 2006, F-MARC revised and updated the warm up programme to the FIFA 11+, with the main adaptations being the inclusion of advanced techniques that increase the intensity and the addition of

running exercise[471]. The sequence of certain exercises was designed to be more dynamic to improve physical strength[471]. Using pre-post intervention designs, studies demonstrated that the FIFA 11+ programme increased proprioception, static and dynamic balance[472], functional balance[444] and concentric hamstring strength[472] in players.

Grooms et al[455] conducted an intervention cohort study among 41 male youth collegiate-level players. The authors examined the effect of the FIFA 11+ programme on the reduction of lower extremity injuries by comparing the incidence of injuries across two seasons. The incidence of injuries in the intervention season was lower compared to the season without an intervention (RR=0.28, 95% CI: 0.09-0.85). The intervention also decreased the incidence of severe injuries,with a 95% decrease in thigh muscle strains[455]. However, the findings of this study should be interpreted with caution as it was conducted in only one team and did not randomise the participants to obtain a high level of evidence.

In a study based in Germany, 20 teams with 265 male veteran players were randomised into two groups. The intervention group was offered the FIFA 11+ programme (10 teams with 146 players), while the control group continued with a standard warm up routine (10 teams with 119 players)[446]. Other than the reduction of severe injuries in the intervention group, no significant differences in the incidence of injuries were found between the intervention and control groups[446].

In Nigeria, a study randomised 20 youth teams into an intervention group that performed the FIFA 11+ warm-up programme (10 teams with 212 players) and a control group instructed to continue with their standard warm-up (10 teams with 204 players)[439]. A significant reduction in overall and lower extremity injuries was observed in the intervention group compared to the control group. However, the study did not find any significant difference in specific injuries such as in the thigh, knee, and ankle. Further, the study did not have any effect on the severity of injuries and did not reduce contact or non-contact injuries[439]. The study encountered certain limitations regarding the blinding of the data collection team. The study also encountered compliance limitations as the authors could not guarantee the appropriate implementation of the programme as prescribed[439].

Another RCT of 1525 collegiate male soccer players from the USA demonstrated the protective effects of the FIFA 11+ in reducing injuries[445]. The intervention group players (n=675 players) were instructed to perform the intervention three times per week for the full season. The control group players (n=850

players) used their standard warm-up routine. The intervention reduced overall injuries by 46% and significantly reduced time loss due to injuries. Although the study shows the effectiveness of the warm-up programme, collegiate level teams had less exposure instances as they only participated in 18 matches and completed 51 practice sessions[445]. In addition, the collegiate-level season was only five months in length, which is shorter compared to most professional seasons lasting eight to ten months[445]. The shorter duration of the season may have influenced the adequate compliance level achieved in this study. The type of the intervention mayhave alsohad an influence on the levels of compliance. Participating coaches consented to receiving training electronically, which indicates that the coaches that agreed to participate in the study and were conscious of their commitment to adhere to the study requirements. The study indicated that greater benefits of the prevention programme were achieved with more consistent use of the warm-up exercises[445].

A recent study conducted in Malaysia randomly selected 25 youth players to an intervention group that performed a soccer specific warm up programme and selected 25 players to a control group that warmed up as usual[460]. The study found that completing the training sessions five times a week over a 12-week period significantly lowered ankle injury incidence by 55% in the intervention group compared to the control group. However, the study could not control confounding factors such as the level of play, skill and fitness[460].

Systematic reviews that specifically evaluated the effect of the warm up injury prevention programme developed by F-MARC could not establish the effectiveness of the FIFA 11 programme[473;474;475]. However, the revised version, the FIFA 11+, was effective in reducing overall injuries[476;477;478]. Furthermore, the programme was effective in participants who performed the training programme at least twice per week. Therefore, the authors recommended the use of the FIFA 11+ injury prevention programme at all levels of soccer, and that well-designed RCTs specifically focussing on compliance are needed to update the existing body of knowledge[473;474;476;477;478].

5.2.3.4.4 Stretching and flexibility

Arnason et al[54] examined the effects of flexibility training with warm up stretches of the hamstring muscles in Norwegian teams over a four-year period. Fourteen Norwegian teams participated in the study. The incidence of injuries in the teams that incorporated flexibility stretches in their warm up was not significantly different from teams that performed a routine warm up (RR: 1.53, 95% CI: 0.76-3.08).

The authors recommended further well-designed RCTs to confirm the effect of flexibility exercises in the prevention of hamstring strains[54].

The effects of eccentric training and stretching to reduce Achilles and patella tendon injuries was investigated in 209 Danish professional players[458]. The RCT targeted players with abnormal ultrasounds of the Achilles and patella tendons. Players in the intervention group performed the eccentric training and stretching exercises for 10 minutes, three times per week for a period of 12 months. The control group teams continued with their usual training. There was no difference in injury incidence between the intervention and control groups in players with normal ultrasounds. On the contrary, there was an increased incidence of patella tendon injury in the intervention group for players with abnormal ultrasounds[458].

5.2.3.5 Other injury prevention interventions

A video-based injury prevention programme was tested in an RCT among elite soccer players in Iceland[461]. Players in the intervention group received an educational presentation of injury occurrence and risks, and an educational video on injury prevention. The intervention did not have any effect on the incidence of injuries[461].

Another RCT conducted by Johnson et al[5] examined the effect of a cognitive-behavioural intervention on the incidence of injuries in players identified to have a greater risk of sustaining injuries. Male and female players in the intervention group were exposed to six mental skills approaches. The incidence of injuries was significantly lower in the intervention group compared to the control group. The authors explained that the intervention helped the players to recognize and avoid stressful situations and equipped players with coping strategies. The authors recommended further research in this domain[5].

Elias et al[462] studied the effect of an educational intervention programme related to warm weather on the reduction of heat stroke during a youth soccer tournament. The intervention was targeted towards the team administration, coaches and referees to educate them regarding the appropriate behaviour in hot weather and emergency procedures after the onset of heat exhaustion. The authors reported fewer heat stroke cases, from 21 cases over two days, to 13 cases over four days[462]. However, the authors could not confidently conclude that the intervention was effective as the study posed several limitations. Inferential statistics were not performed as the number of cases was limited[462].

Hägglund et al[453] assessed the effectiveness of a coach controlled rehabilitation programme to reduce recurrent injuries in 15–46 year old male players in fourth division Swedish teams. Teams were randomly assigned to either the intervention (n=202 players) or control groups (n=300 players). Coaches of the teams allocated to the intervention group implemented the programme consisting of information regarding the incidence of recurrent injuries and their associated risk factors, as well as a 10-step programme that follows the principles of rehabilitation for return to play decision making. Coach-directed rehabilitation reduced recurrent injuries between 66-75%. The programme was advocated for teams that did not have appropriate medical support[453]. However, data pertaining to injuries was reported by the coaches and no medical assessment was conducted[453].

5.2.3.6 Compliance with injury prevention programmes

Compliance or uptake of the intervention plan was the key element underpinning the effectiveness of introduced injury prevention programmes. The majority of reviewed studies did not effectively document the participants' compliance to the intervention programme. Many studies did not report compliance[5;50;51;56;57;184;404;440;447;461], while others recognised its importance but did not document it[449]. Among the studies documenting compliance levels, a number of them[54;55;439;446;448;455;456;457;458] did not link its contribution to injury prevention, while very few[445;453;454] reported its contribution to the effectiveness of the prevention programmes.

Silvers-granelli et al[445] found that increased compliance was associated with additional benefits of the prevention programme in the reduction of injuries[445]. Studying the influence of compliance on injury incidence specifically, Soligard et al[479] found that highly compliant participants reduced their risk of injury by more than a third. Engebretsen et al[454] did not find any effect of the intervention many due to very low compliance (19-30%) rates[454]. It was therefore recommended that future studies should record compliance data and their association with injury incidence[454;479].

5.3 Summary of the Literature Review: Preventive Measures to Reduce the Risk of Injuries in Male Soccer Players

Studies have examined the effects of several interventions in preventing injuries in soccer using one or more strategies. Two studies reported a preventive effect of orthoses on previous ankle injuries but no effect on injuries without a history of ankle sprain[50;51], while another study did not find any significant difference[57]. There is a good evidence of balance and proprioceptive exercises in preventing recurrent

ankle sprains[50;57;448] and ACL injuries[449]. Stretching and flexibility exercises did not reduce the risk of muscle and tendon injuries[54;458]. Video-based awareness interventions did not have any effect in the reduction of soccer injuries[461].

Reliable evidence was found for the use of Nordic eccentric hamstring exercises in the prevention of hamstring injuries[54;184;456;457], although strengthening exercises were not effective in preventing overall soccer injuries[454]. Due to the complexity of the game and the multi-component aetiology of injuries, a multimodal intervention was recommended.

Multimodal interventions incorporating core strength, balance, coordination and plyometrics significantly reduced overall injuries[438;441]. As a result, F-MARC designed a set of exercises that could be integrated into a standard training programme, specifically during warm up[471]. Several studies indicated that the FIFA 11+ warm up programme was effective in reducing the risk of injuries[439;445,446;455;459]. Although the intervention was effective in preventing injuries, many studies reported limitations pertaining to the compliance to the programme[54;55;439;446;448;455;456;457;458]. It was found that for the FIFA 11+ to be effective, the exercise programmes hould be performed at least two to three times per week. Therefore, it was stressed that future research should emphasise compliance for the programme to be considered effective[55;439;446;448;455;456], which is the focus of the next chapter.

CHAPTER 6. THE IMPACT OF THE FIFA 11+ PROGRAMME: A RANDOMISED CONTROLLED TRIAL

6.1 Introduction

As reported in the literature and evidenced by the epidemiological study described in Chapter Three, participation in soccer constitutes a risk of injuries from elite professional, amateur and youth level (Section 4.3.5.1). We found that, for example, approximately half of the first division players suffered at least one injury per season and the incidence was considerably higher during matches than training (Section 4.3.5.2). Injuries may result in extended periods of absence from training and match participation and lead to medical and rehabilitation expenses[42;43]. Loss of key players due to injuries may also have an impact on the performance and success of teams[45]. For the individual soccer player, the loss of income due to injury may have severe consequences as alternative employment possibilities may be decreased, particularly in low-income countries[480]. Injury prevention through effective interventions is thus important to minimise the rate of injuries and the associated burden on individual players as well as teams.

As in much of the published literature, the prospective study found that lower limb injuries had the highest incidence, with an elevated frequency of knee, followed by ankle injuries (Section 4.3.5.3). Joint sprains and muscle strains were the most common types of injury. Clearly, the lower limbs should be a primary target for injury prevention strategies. Reduced flexibility, as measured by the Sit and Reach test, was the strongest predictor of overall and lower limb injuries (Section 4.3.6). In addition, poor performance on neuromuscular control tests related to coordination and dynamic stability, such as the timed hop and four-point hold tests, were associated with an increased risk for lower limb injuries. Thus, strategies to reinforce neuromuscular system performance may be an important component of injury prevention.

Recognising that the sport of soccer challenges the physical and the psychological robustness of the players and requires a large range of skills performed at the maximal levelof the neuromuscular system, FIFA developed a multi-component soccer specific intervention[471]. The prevention programme, FIFA 11+, targets improvement in strength, balance and coordination and includes a set of exercises that should be performed during warm up, at least three times per week[471]. As discussed in Chapter Four, the positive impact of the FIFA 11+ warm up in preventing injuries has not yet been fully established, as poor compliance to the programme has limited the conclusions drawn in several of the studies that examined its effectiveness[446;448;455;456;457;458;445;453;454].

Therefore, an examination of the implementation of the FIFA 11+ warm up programme in the reduction of injuries, with an emphasis on compliance, would be a useful complement to the existing body of knowledge.

The FIFA 11+ injury prevention programme can be managed by the staff of the teams (coaches, athletic trainers, physiotherapists); however as in other injury prevention programmes, it is often led by the coaching staff[54;55;439;455;456;457;458]. A recent extensive systematic review indicated that the effectiveness of coach-directed interventions was similar to interventions led by other team personnel[481]. As adherence to the programme has emerged in published studies as a challenge and coaches are the likely implementers of the programme; it is necessary to understand the coach-related factors that play a role in the uptake and adherence to the injury prevention programme. Previous studies on coach-related factors did not find any relationship between coaches' experiences, beliefs and attitudes on adherence to injury prevention programmes[482]. However, there is limited information on coach-related factors that may affect the implementation of injury prevention programmes in low-income countries.

Accordingly, the aim of this study was to determine the impact of a coach-led intervention on injury incidence and severity in second division soccer players in Rwanda. The specific objectivesof this study have been described in Chapter One, Section 1.5.

6.2 Research Setting

Second division players were recruited for the intervention study. In Rwanda, the second division championship is predominantly played by team members younger than first division players. At this level, players may engage in soccer with an inadequate conditioning of their neuromuscular system. In addition, certain players may incur injuries as their bodies are not adequately mature due to varied growth patterns[84;167;166].

The second division players are generally younger than the first division players. Players in the second division may be at risk for injuries, as they may not have received appropriate training in preparation for the game. Therefore, injury prevention in the form of neuromuscular training would be important to prevent injuries. There are more resources available in terms of medical support, coach expertise and access to safe, appropriate playing facilities for first division players than for the second division players.

Players in second division may also be at a greater risk of injury if they are not familiar with the regulations, or where the quality of refereeing are poor compared to the first division. It was hypothesised that there would be an increased incidence of injury in second division players. Accordingly, there would not only be a greater need for intervention, but that the intervention may result in a greater reduction of these injuries than in first division players.

During the study period (2016), there were 24 teams competing in the second division[63]. Unlike in the first division, the second division teams do not play every other team, as this would require them to play 44 games. Therefore, the teams are randomly divided into two groups, namely Group A and Group B, comprised of 12 teams each. The teams in each group play each other and accumulate points according to the win or draw rules. The two teams that accumulate the most points in each group progress to the semi-final round where they play each of the teams from the other group. The winners of the semi-final stage qualify for the final and are automatically promoted to the first division.

6.3 Methods

A cluster-randomized controlled experimental trial design was used for this study, with the teams as the unit of randomization. This method was used as players were naturally grouped into teams/clusters and implementation of the programme was at the team/cluster level, with the coaches instructing players. It was not possible to randomise individual players from a single team into different groups, as the risk of contamination would be very high. There were 25 teams registered to participate in the 2016 season, however one team withdrew from the competition due to financial reasons prior to recruitment and therefore was not included. Each team was regarded as a cluster for randomisation. The internvetion group was required to undergo the 11+ programme; while the control group received training on first aid only.

6.3.1 Participants

All teams enrolled in the second division competition were eligible and the coaches and players of the 24 teams were invited to participate in the study. There were 630 players who were eligible for recruitment and the teams had registered a mean of 26 (SD=3) players (Table 6-1). One team in the intervention group was allowed to register additional players by FERWAFA as it was regarded as an exemplary academy that promoted more young players.

Table 6-1: Distribution of teams and the respective number of players in the intervention and control groups.

Study group	Intervention group		Control group	
Number	Team name	Number of players	Team name	Number of players
1	ASPOR FC	25	Akagera FC	28
2	Esperance FC	37	Etoile de l'Est FC	27
3	Giticyinyoni FC	22	Gasabo United FC	27
4	Hope FC	29	Heroes FC	27
5	Intare FC	28	Isonga FC	24
6	Interforce FC	25	Kirehe FC	22
7	La Jeunesse FC	26	Nyagatare FC	30
8	Miroplast FC	25	Rugende FC	26
9	Pepiniere FC	28	SEC FC	29
10	Sorwathe FC	21	Unity FC	27
11	United Stars FC	24	UR-Huye FC	22
12	Vision JN FC	22	Vision FC	29
Total		312		318
Mean (SD)		26 (4)		27 (3)

FC: Football club, JN: Jeunesse Nouvelle, SD : Standard Deviation
Intervention group: 12 teams, 312 players; Control group: 12 teams, 318 players

The intervention was to be taught to the coaches. Therefore, head coaches of the teams participating in the second division league were included in the study. Players who had contracts and licenses from the teams enrolled to play in the second division were also included in the study. Players presenting injury at the beginning of the study were included oncethey were completely able to train with the team and play matches. Their pre-existing injuries were not included in data analysis.

6.3.2 Sample size calculation

Based on the study conducted by Twizere[38], about 70% of soccer players in Rwanda sustained injuries (not only the first division, as in the prospective study). To obtain a 20% reduction of injuries with the implementation of the FIFA 11+ warm up programme with a power of 90% and alpha of 5%, a sample size of 125 wasrequiredin each group (intervention and control). Statistica data analysis software, version 13.2, Dell Inc. was used to compute the sample size. Taking the design effect of two for cluster randomization into consideration, the minimum number of players required to participate in this study was 217 in each group. As the sample pool was comprised of approximately 600 players, it was anticipated that the study would be adequately powered. A random sampling method was used to allocate the teams into either the intervention or control groups.

6.3.3 Randomisation and blinding

Twenty-four teams were randomised into the intervention and control groups with an equal number of teams in each group. The names of the 24 teams were placed in a pool where each team had an equal opportunity of being selected. A research assistant randomly selected the teams for both groups drawing the names of the teams one by one.

The coaches are generally responsible for planning all player activities and were responsible for the implementation of the intervention programme. It was thus impossible to blind assignment of the coaches or players to group allocation. However, the medical personnel recording the injuries sustained by the players were blinded. The researcher was fully aware of the club allocationbut was not involved with any of the testing. Research assistants were blinded as they were assigned to teams without knowing whether the team allocated to is in internvetion group or the control group. Research assistants were not aware of the content of the training that coaches had and had no information that coaches were required to implement the 11+ in the teams during training and matches. Although six teams from the intervention group and five teams from the control group were located in Kigali city, contamination could be very minimal as the teams were separated by their geographical location.

6.3.4 Instrumentation

6.3.4.1 Intervention content: the FIFA 11+ injury prevention programme

The intervention group coaches and teams were required to undergo training and perform the FIFA 11+ injury prevention programme. The FIFA 11+ injury prevention programme is a set of 15 exercises developed by FIFA medical experts to reduce the risk of injury[471], as discussed in Section 5.2.3.4.3. The exercises are performed following a specified sequence during warm up and are composed of three major sections[471] (Appendix XIV). The first section involves slow speed runs combined with dynamic stretches; the second section involves exercises designed to strengthen the trunk muscles and balance exercises targeting the lower limbs; and finally the third section involves running at an increased speed including different manoeuvres. The F-MARC has been notified about the study (Appendix XV). The exercises are described in Table 6-2.

Table 6-2: Instructions on the type of exercise, important points to observe with repetitions and time as described in the FIFA Manual[471].

Part 1: Running exercises			
1	*Straight ahead*	*Jog straight to the last cone. Run slightly more quickly on the way back. Make sure you keep your upper body straight. Your hips, knees and feet should be aligned. Do not let your knees buckle inwards.*	*Repeat 2 times*
2	*Hip out*	*Jog to the first cone. Stop and lift your knee forwards. Rotate your knee to the side and put your foot down. Jog to the cone and do the exercise on the other leg. When you have finished the course, jog back. Make sure that you keep your pelvis horizontal and your core still. The hip, knee and foot of the supporting leg should be aligned. Do not let the knee of the supporting leg buckle inwards.*	*Repeat 2 times*
3	*Hip in*	*Jog to the first cone. Stop and lift your knee to the side. Rotate your knee forwards and put your foot down. Jog to the next cone and do the exercise on the other leg. When you have finished the course, jog back. Make sure that you keep your pelvis horizontal and your core still. The hip, knee and foot of the supporting leg should be aligned. Do not let the knee of the supporting leg buckle inwards.*	*Repeat 2 times*
4	*Circling partner*	*jog forwards to the first cone. Shuffle sideways at a 90-degree angle towards your partner, shuffle an entire circle around one other (without changing the direction you are looking in) and back to the first cone.jog to the next cone and repeat the exercise. When you have finished the course, jog back. Bend your hips and knees slightly and carry your body weight on the balls of your feet. Do not let your knees buckle inwards.*	*Repeat 2 times*
5	*Jumping with shoulder contacts*	*jog to the first cone. Shuffle sideways at a 90-degree angle towards your partner. In the middle, jump sideways towards each other to make shoulder-to-shoulder contact. Shuffle back to the first cone. Then jog to the next cone and repeat the exercise. When you have finished the course, jog back. Land on both feet with your hips and knees bent. Do not let your knees buckle inwards.*	*Repeat 2 times*
6	*Quick forwards and backwards sprints*	*Run quickly to the second cone then run backwards quickly to the first cone, keeping your hips and knees slightly bent. Repeat, running two cones forwards and one cone backwards. When you have finished the course, jog back. Make sure you keep your upper body straight. Your hips, knees and feet should be aligned. Do not let your knees buckle inwards.*	*Repeat 2 times*
Part 2: Strength, plyometrics and balance exercises			
7	*The plank with one leg lift and hold*	***Starting position:** Lie on your front, supporting yourself on your forearms and feet. Your elbows should be directly under your shoulders.* ***Exercise:** Lift your body up, supported on your forearms, and pull your stomach in. Lift one leg about 10-15 centimetres off the ground, and hold the position for 20-30 sec. Your body should be straight. Do not let your opposite hip dip down and do not sway or arch your lower back. Take a short break, change legs*	*3 sets (20 – 30 sec. each)*
8	*Sideways bench with leg lift*	***Starting position:** Lie on your side with both legs straight. Lean on your forearm and the side of your foot so that your body is in a straight line from shoulder to foot. The elbow of your supporting arm should be directly beneath your shoulder.* ***Exercise:** Lift your uppermost leg up and slowly lower it down again. Repeat for 20-30 sec. Take a short break, change sides and repeat. Do not rest your head on your shoulder. Keep your pelvis stable and do not let it tilt downwards. Do not tilt your shoulders, pelvisor legs forwards or backwards.*	*3 sets (20 – 30 sec. on each side)*
9	*Hamstrings (Advanced)*	***Starting position:** Kneel on a soft surface. Ask your partner to hold your ankles down firmly.* ***Exercise:** Your body should be completely straight from the shoulder to the knee throughout the exercise. Lean forward as far as you can, controlling the movement with your hamstrings and your gluteal muscles. When you can no longer hold the position, gently take your weight on your hands, falling into a push-up position. Do not tilt your head backwards. Do not bend at your hips*	*1 set (minimum 12-15 repetitions) and/or 60 sec.*
10	*Single-leg stance (Testing partner)*	***Starting position:** Stand on one leg opposite your partner and at arm's' length apart.* ***Exercise:** Whilst you both try to keep your balance, each of you in turn tries to push the other off balance in different directions. Try to keep your weight on the ball of your foot and prevent your knee from buckling inwards. Continue for 30 sec. Do not let your knee buckle inwards. Do not let your pelvis tilt to the side.*	*2 sets (30 sec. on each leg)*
11	*One-leg squats*	***Starting position:** Stand on one leg, loosely holding onto your partner.* ***Exercise:** Slowly bend your knee as far as you can manage. Concentrate on preventing the knee from buckling inwards. Bend your knee slowly then straighten it slightly more quickly, keeping your hips and upper body in line. Do not let your knee buckle inwards. Your bent knee should not extend beyond your toes. Do not twist or tilt your pelvis to the side.*	*2 sets (10 on each side)*

12	*Box Jumps*	***Starting position:** Stand with your feet hip-width apart. Imagine that there is a cross marked on the ground and you are standing in the middle of it.* ***Exercise:** Alternate between jumping forwards and backwards, from side to side, and diagonally across the cross. Jump as quickly and explosively as possible. Your knees and hips should be slightly bent. Land softly on the balls of your feet. Do not let your knees buckle inwards. Do not let your knees buckle inwards. Do not land with extended knees or on your heels.*	*2 sets (30 sec.)*
Part 3: Running exercises			
13	*Across the pitch*	*Run approximately 40 metres across the pitch at 75 – 80% of maximum pace and then jog the rest of the way.jog back at an easy pace. Make sure you keep your upper body straight. Your hips, knees and feet should be aligned. Do not let your knees buckle inwards.*	*Do the exercise twice.*
14	*Bounding*	*Take a few warm-up steps then take 6 – 8 bounding steps with a high knee lift and jog the rest of the way. With each bound, try to lift the knee of the leading leg as high as possible and swing the opposite arm across the body. Jog back at an easy pace to recover.* *Keep your upper body straight. Land on the ball of the leading foot with the knee bent and spring. Do not let your knee buckle inwards.*	*Do the exercise twice.*
15	*Plant and cut*	*Jog four to five steps straight ahead. Then plant on the right leg and cut to change direction to the left and accelerate again. Sprint for 5 – 7 steps (at 80 – 90% of maximum pace) before you decelerate and plant on the left foot and cut to change direction to the right. Repeat the exercise until you reach the other side of the pitch, then jog back.* *Make sure you keep your upper body straight. Your hips, knees and feet should be aligned. Do not let your knees buckle inwards.*	*Do the exercise twice.*

The text is in italics as it is a direct quotation taken from the FIFA 11+ manual on page 15-69[471]*. The use of the internvetion programme was notified to the F-MARC.*

Coaches of the control group teams completed a one-day training on first aid and emergency procedures. They were informed to continue their usual plan and conduct of the components of training and matches. Injury and exposure data were obtained form the medical personnel and coaches respectively.

6.3.4.2 Study outcomes

There were two sets of outcome measures. The first measure determined the impact of the training on the behaviour of the coaches towards injury prevention practice. The other establishedthe effect of the implementation of the FIFA 11+ warm up on the incidence, location, type andseverity of injuries.

- **Coaches' injury prevention beliefs and practice readiness questionnaire**

Guided by previous studies[482], the coaches' beliefs and injury prevention practice readiness were assessed though paper based questionnaires (Appendix XIII). The questionnaire was comprised of two sections. Section A assessed the demographic characteristics of the coaches including their age, highest coaching qualification, highest academic qualification, number of years coaching, number of years coaching second division teams and number of years in the current team.

Section B incorporated the "*Readiness to Change"* questions to assess injury prevention belief and practice readiness in key areas such as "*planning injury prevention practice"," use of protective*

equipment", "checking playing field and facilities", and "checking up to date information"[482]. The various stages of readiness are defined as follows:

- *"Pre-contemplation - having no intention to start the behaviour in the next six months.*
- *Contemplation - considering starting the behaviour in the next six months on a regular basis.*
- *Preparation stage - performing the behaviour not regularly but occasionally.*
- *Action stage – performing the behaviour within the past six months on a regular basis.*
- *Maintenance stage -having done the behaviour for six months or more in a regular manner"*[482].

The above characteristics were essential in identifying any differences in the coaches from the intervention and control groups, as well as the influence of these variables on adherence.

The questionnaire used in this study was based on the Health Belief Model (HBM) and injury prevention literature to measure the beliefs, knowledge and readiness for injury prevention[483]. The questionnaire was considered as a useful tool to assess coaches' beliefs and readiness for injury prevention practice. No adaptations of the questionnaire were required, as injury prevention practices are similar irrespective of the context. Coaches usually supervise the players and hold a central role in injury prevention efforts. Irrespective of the country, coaches play a pivotal role in implementing injury prevention strategies in addition to their usual duties[484]. Sporting approaches and influencing factors towards injury prevention was found to be similar irrespective of the coaching context[485].

The validity and reliability of the questionnaire has been established in a study conducted among high school coaches in the USA[483]. The content validity was establishedby the review of a panel of experts including sports injury researchers. The validity of the questionnaire was established using the three-stage Delphi method. The questions included consistently received high mean scores across the three stages. The questionnaire was found to be reliable with the majority of the construct Cronbach's alpha reported at 70% and above[483]. No translation was required, as all the coaches were conversant in English.

- **Injuries and exposure**

The coaches recorded training exposure on the player exposure form (Appendix V). Training exposure was defined as any time that players undertook any form of physical activity designed by their coach[36]. The researcher recorded match exposure from the referees' report submitted to FERWAFA.

The time was recorded in minutes. Section 4.2.5.2, provides a detailed description of the methods of recording training and match exposures.

The team of medical personnel recorded injuries on the Injury Report Form (Appendix VI). Injury was defined as "*any physical complaint resulting from soccer participation*"[2]. Section 4.2.5.3 provides a detailed description of the methods of recording injuries during the study period.

6.3.5 Procedure

6.3.5.1 Preparation

Ethical approval and appropriate permissions to conduct the study were obtained. At the end of the 2014-2015 season, the teams that would compete in the 2015-2016 season were identified, and the teams were approached to participate in the study. During this period, the researcher had a series of meetings with the technical director of FERWAFA to plan for the training of coaches. The procedures of the study were explained and the content of the training was introduced. A CAF instructor who was knowledgeable about the FIFA 11+ was identified, approached and agreed to offer the training. The randomisation process took place in the technical directorate's office. During the pre-season period, coaches and players were invited to participate in the study. The medical personnel of all the second division teams were invited to attend the instructional meeting regarding the data collection. The purpose of the study as well as their roles were clarified. Discussions were held regarding the injury report form that would be used for collecting injury data. The demographic forms (Appendix I) and the medical forms (Appendix II) were also discussed during the meeting. The training procedure for research personned of the first division teams (Section 4.2.5.2) was used to train research personnel of this study. Medical personnel were requested to make use the injury report forms before the start of the league for familiarisation. The research team collected the necessary information required for the medical and the demographic form. The research assistants collected the completed daily injury report forms every two weeks.

6.3.5.2 Training

Team management and coaches of intervention group teams were contacted telephonically and invited to attend a three-day training programme.

On the first day of training for intervention group coaches, after introduction and explanation of the study and obtaining written informed consent for participation in the study, the coaches' injury prevention beliefs and readiness for practice questionnaires were distributed for pre-intervention testing. On completion of the pre-test, the CAF instructor introduced the concepts of injury prevention and the development and use of the FIFA 11+ injury prevention programme. Coaches were provided with copies of the FIFA 11+ manual and cards. A power point presentation was used to describe each exercise and in-depth explanations of the appropriate movements and positions were presented. On the second day, a video was presented which explained the types of exercises incorporated into the FIFA 11+. The video was paused after each exercise for the instructor to provide further explanations. Following, coaches took part in practical sessions on the FERWAFA training ground. The coaches performed each exercise while the instructor provided corrections. On the third day of the training, the coaches played the roles of both the instructor andthe player. For each day of the training programme, the morning sessions were held from 09:00 to 12:00, while the afternoon sessions were held from 14:00 to 16:00. On conclusion of the training programme, each coach was provided with a DVD of the FIFA 11+ programme. Coaches were requested to arrange FIFA11+ as a warm up for the players their teams at least three times a week to benefit from the intervention. Post-intervention questionnaires were completed by the intervention group coaches after the three-day training programme and again after a period of six months.

Control group coaches were invited by the technical director to attend a one day training programme held at the FERWAFA premises. The pre-intervention questionnaires were distributed to assess their beliefs and readiness for injury prevention practice. The coaches received training from the researcher on basic first aid and emergency procedures. The training covered topics relating to the occurrence of injuries, field assessments and phases of rehabilitation. First aid for injuries affecting specific body parts (ankle, knee, hip, groin, hamstring, hand and head) including concussion were also discussed. The discussion focused on specific conditions that affect players on the field such as nosebleeds, eye and dental injuries. The training programme was held from 09:00 to 17:00. Post-intervention questionnaires were completed by the control group coaches after the one day training programme and again after a period of six months. Coaches of the teams in the control group were instructed to continue their usual organisation of the training activities for the players.

In addition to group intervention training, coaches from both groups were taught to record exposure times on the specified forms (Appendix IV). Each intervention group coach also received training on the procedure of recording each warm up programme conducted by the teams (Appendix XVI). During this process, the coaches raised concerns regarding the burden that lies in the recording of each player's involvement in the warm up. It was therefore agreed that this information would not be recorded.
For the duration of the interventional training sessions, coaches residing outside Kigali were provided with meals and accommodation at the FERWAFA hostel . The coaches from Kigali were only provided with lunch.

6.3.5.3 Implementation and compliance

The CAF instructor and the researcher visited the intervention group coaches once per week for the first month of the season to foster the accurate implementation of the programme. For the remainder of the season, visits took place monthly. Additional instructions were provided where necessary in terms of repetition and duration of each exercise. The research assistants collected the completed forms twice per month.

6.3.6 Statistical analyses

Cluster sampling, as used in the present study, presents challenges for the conventional analysis of intervention data, since a design effect due to inter-cluster correlations is likely to exist. As pointed out by Sainani[486], the impact of analysing correlated data as individual data points can lead to incorrect conclusions. Therefore, Sainani[486] suggested that, if the sample size is large enough,the cluster is used as the unit of analysis rather than the individual. To account for this design effect, the incidence rates analysed used the team as the unit of analysis as, "*Reducing the data to independent observations is a valid approach to studying clustered data*"[487]. However, a disadvantage of this approach is that if the sample sizes are unequal in each team, the influence of larger samples is lost. Therefore, weighted means were compared using either a t-test or the Mann-Whitney U test. A table of complex sample functions in Epi-Info were used to analyse the proportions as this analysis considers the design effect.

A flow chart of the recruitment process was developed to account for follow-up loss. Normality tests were conducted for all continuous variables. Descriptive statistics were used to analyse the demographic characteristics of the coaches and players.

As the data were not normally distributed and the numbers were too small for the central limits theorem to apply (12 in each group of the study), players and their rank ordering were compared using a Mann-Whitney U test. The Chi-Squared test was used to assess whether the categorical data were associated with the study group. The stages of practice readiness were analysed using the six stages described above, and a Mann Whitney U test was used to compare behaviours at different intervals.

Player baseline characteristics were presented as means (SD) and a weighted independent t-test was used to assess the difference in the demographic characteristics of the players between the two groups at the team level. Injury rates were presented as the number of injuries per 1000 hours of exposure, with a 95% confidence interval for training, match and overall injuries between the intervention and control groups. As the data were not normally distributed, the weighted non-parametric Mann-Whitney U test was conducted to compare the rankings of all injuries, as well as training and match injuries. Furthermore, anodds ratios (OR) of the control/intervention groups sustaining injuries was computed using the Epi-Info complex tables function, using the team as the primary sampling unit. This function adjusts the OR for the cluster effect, which allows for ananalysis of the association between different variables with a binary dependent measure (injured/uninjured). A graphical representation was also prepared to indicate the comparison of injuries according to location and types between the intervention and control groups. Compliance was computed based on each team's implementation percentage of the FIFA 11+ sessions throughout the season. Teams that performed the injury prevention programme in 75% or more training or match sessions were classified as highly compliant. Teams that performed the programme between 50% to 75% of training or match sessions were considered to have medium compliance, while teams performing the programme for less than than 50% of training or match sessions were in the low compliance category. The influence of compliance on the injury outcome was also analysed.

6.3.7 Ethical considerations

The study received ethical approval from the Faculty of Health Sciences Human Research Ethics Committee at the University of Cape Town (HREC/REF: 683/2014) (Appendix VII). The trial was further registered in the Pan African Clinical Trial Registry (PACTR201505001045388) (Appendix XVII). The FERWAFA and the clubs consented to the researcher conducting the study.

6.3.7.1 Confidentiality and autonomy

The names of the participants were not included on any collected data and codes were used on data forms. The identity of the participants was protected to the maximum extent possible. Data obtained from the participants were protected with only the primary researcher having access to the raw data. The information obtained was retained with the strictest confidentiality and the maximum discretion of the players, coaches and teams was ensured when reporting the results.

The coaches and players received information (Appendix IX-Appendix XI) regarding the study as they were regarded as autonomous participants. The information letter explained in detail what participation would entail. For the coaches selected in the intervention group, this information included details relating to participating in the training programme, conducting the warm up sessions and completing the questionnaires and player exposure forms. The coaches and players were informed that their participation in the study was voluntary and had the right to withdraw from the study at any time without any consequences. The consent forms were signed by the coaches and players (parents or guardians of the under-18 players) indicating their agreement to voluntarily participate in the study (Appendix XII). Although the coaches and teams in general had agreed to participate in the study, players were free to decide whether to participate without any consequences.

6.3.7.2 Risk and benefits

Implementing the FIFA 11+ warm up programme involves physical exercises, which may have represented a risk of sustaining an injury, however this risk was minimal as the injury prevention programme was performed under close supervision and at minimal to moderate intensity. Players were requested to report any injury sustained during the implementation of the prevention programme. The information on coaches' low compliance with the programme, and poor coaches' beliefs and practice readiness once divulged could lead to devastating implications to the coaching career. This information was kept confidential and team managers were not informed of coach-specific findings. Data on players' injuries and their risks to recurrent injuries were not revealed to anyone in the teams to prevent any form of discrimination or disqualification from the team. Players with injuries that required further examinations, the researcher assisted the medical personnel to conduct thourought physical examination of the players and if necessary, they were referred to an orhtopedic surgeon.

The benefit of participating in the present study included gaining knowledge of injury prevention and first aid for coaches of the teams in the control group. The injury prevention programme was believed to

reduce the occurrence of injuries and their effects on players. Should the present study yield positive results, the researcher proposed to provide similar training to participants from the control group, which would be implemented in their teams on completion of the study.

6.3.7.3 Justice

All the teams were treated equally and had the same chance of being selected for either study group using a cluster randomised control trial design. Similar data collection methods were used for each of the teams. The training would also be organised for the control group teams as the intervention was effective. Coaches of the teams assigned to the control group received first aid training.

6.4 Results

The flow chart of the recruitment and randomisation processes are presented in Figure 5-1, using a CONSORT diagramme[488]. This section also presents the characteristics of the players in the intervention and the control group. The impact of the training on coaches' behaviour towards injury prevention practice is also presented. The effect of the implementation of the FIFA 11+ warm up on the incidence of time loss, lower limb, common types and severity of injuries is presented in different subsections. Implementation compliance and the relationship between the coaches' characteristics and compliance are presented. Finally, the effect of the team compliance level and the incidence of injuries are also presented.

6.4.1 Flowchart of recruitment

All the 25 teams that registered to participate in the 2016 second division league were eligible to participate in the study. Prior to randomisation, one team declined to participate in the study due to a lack of financial means to compete in the league. The remaining 24 teams (630 players) agreed to participate in the study. The teams were randomised into the intervention (12 teams, 312 players) and control (12 teams, 318 players) groups. Over the course of the study, four players from the intervention group were lost to follow up. Three of these players left to study, and one left due to the family relocation. A single player from the control group left for an unknown reason. No player was injured before the season began. The data of the players that left the study were included in the analysis (Figure 6-1). The study commenced on 1st February 2016 and concluded on 13th August 2016.

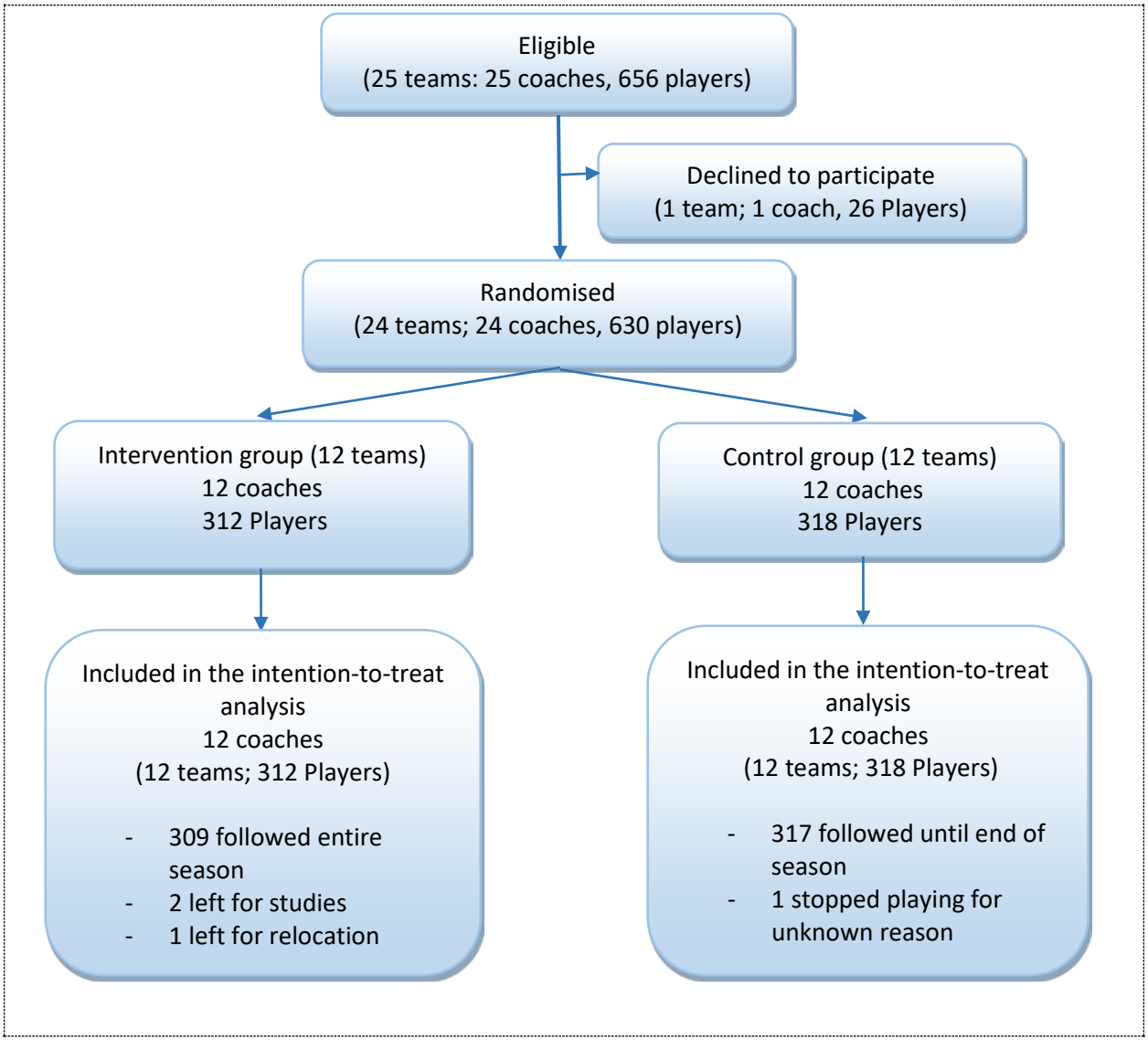


Figure 6-1: Flow chart for the study indicating teams and players in the intervention (12 teams, 312 players) and control (12 teams, 318 players) groups.

6.4.2 Characteristics of the participants

6.4.2.1 Characteristics of the coaches in the intervention and control groups

Twenty-four coaches participated in the study. The meanage of the coaches was 33 (SD=5) years (range 25-43 years). The mean years of experience was 8 (SD=5) years (range 3-25 years). There were no differences in the coaches' characteristicsbetween the intervention and control groups, apart from duration of experience of soccer coaching (U = 36.5, Z = -2.07, p=0.038) (Table 6-3).

Table 6-3: Demographic characteristics of the coaches in the intervention and control groups.

Variable		Intervention group	Control group	Statistics		
		Median (IQR)	Median (IQR)	Mann Whitney U	Z	p-value
Age (years)		31 (9)	34 (11)	54.5	-1.53	0.125
Coaching experience (years)		4 (6)	9 (7)	36.5	-2.07	***0.038***
Experience in coaching in the second division (years)		3 (1)	5 (6)	41.5	-1.83	0.067
Experience in coaching the current club (years)		3 (1)	4 (3)	65.0	-0.42	0.673
Level of education		n (%)	n (%)	Chi-square	Df	
	Primary	1 (4.1)	3 (12.5)	1.29	2	0.526
	Secondary	8 (33.3)	6 (25.0)			
	Tertiary	3 (12.5)	3 (12.5)			
Current licence level		N (%)	N (%)			
	B licence	0	3 (12.5)	3.43	2	0.180
	C licence	4 (16.7)	3 (12.5)			
	None	8 (33.3)	6 (25.0)			

SD: standard deviation *df: Degrees of freedom* *IQR: interquartile range*
Values are presented as median (IQR) of numerical variables as well as frequency (percentages) of categorical variables for coaches in intervention (n=12) and control group (n=12). The results of the test statistics comparing the characteristics of the coaches in both groups are also presented.

6.4.2.2 Stages of coaches' readiness for change in injury prevention practice

The results of coaches' stage of injury prevention practice for the intervention and control group are presented in Table 6-4. All the coaches were in the pre-contemplation phase and contemplation phase regarding the implementation of an injury prevention programme in their teams. Seven coaches in the intervention group and eight coaches in the control group did not have any intention to start the implementation of injury prevention within six months. The majority of coaches reported that they considered to begin checking protective equipment of the players within six months. Similarly, most coaches indicated that they considered checking the condition of the playing field and other facilities for safety purposes on a regular basis within six months. These behaviours were similar for coaches in both study groups, although one coach in the intervention group identified himself as being in the maintenance phase of regularly checking players' equipment over the previous six months. The majority of coaches were in the pre-contemplation and contemplation phases for both the methods of emergency planning and checking up to date information.

Table 6-4: Distribution of baselinestage of behaviour according to injury prevention practice for coaches in the intervention and control groups.

		Stage of current behaviour				
Prevention practice	Study groups	Pre-contemplation	Contemplation	Preparation	Action	Maintenance
Implementing injury prevention programme	Intervention	7	5	0	0	0
	Control	8	4	0	0	0
Checking protective equipment	Intervention	1	10	0	0	1
	Control	0	11	1	0	0
Checking safety of playing fields and facilities	Intervention	1	8	1	1	0
	Control	2	8	2	0	0
Having emergency care procedure	Intervention	6	6	0	0	0
	Control	6	6	0	0	0
checking up to-date injury prevention information	Intervention	1	9	2	0	0
	Control	4	6	2	0	0

Frequencies are presented for coaches in the intervention group (n=12) and control group (n=12).
Redcolour represents the highest frequency and greencolour the lowest.

6.4.2.3 Characteristics of the players in the intervention and control groups

The mean age of the players was 20 (SD=1) years (range 17-27 years). Players spent on average three years playing soccer, while the most experienced player had six years playing experience. Players had spent a mean of two (SD=1) years in the second division and the mean years of experience in the same team was two (SD=1) years. The mean body mass of the players was 65kgs (SD=4kgs, range 48-74kgs). Their mean stature was 169cm (SD=4cm, range 155-179cm). The mean body mass index (BMI) of the players was 22.6kg.m^{-2} (SD=0.9 kg.m^{-2}). There were no statistically significant differences in the demographic characteristics of the players from the intervention group or control groups (Table 6-5).

Table 6-5: Demographic characteristics of the players in the intervention and control groups.

Characteristics	Intervention group	Control group	Difference		Statistics		
	Mean (SD)	Mean (SD)	Coefficient	Robust Std. Err.	F (1, 23)	t-value	p-value
Age (years)	19.9(1.5)	19.7 (1.4)	0.280	0.158	3.15	1.78	0.089
Soccer experience (years)	2.9 (0.8)	3.0 (0.9)	-0.113	0.113	1.00	-1.00	0.328
Second division experience (years)	1.7 (0.7)	1.9 (1.0)	-0.164	0.105	2.46	-1.57	0.131
Current club experience (years)	1.5 (0.7)	1.7 (1.0)	-0.227	0.182	1.57	-1.25	0.223
Weight (kg) *	65.3 (3.5)	64.4 (4.6)	-0.943	0.725	1.69	-1.30	0.206
Height (cm)	169.5 (3.5)	169.2 (4.0)	-0.260	0.368	0.50	-0.71	0.486
Body Mass Index ($kg.m^{-2}$)	22.7 (0.8)	22.5 (1.0)	-0.273	0.201	1.84	-1.36	0.188

Std. Err.: Standard Error *: tested with separate variances

Intervention group: n=12 teams, 312 players Control group: n=12 teams, 318 players

Values are presented as mean ± standard deviation (SD) of the demographics of the players in the intervention and control groups as well as the results of the regression analysis adjusted for clustered teams and the estimates of robust standard errors.

6.4.3 Effect of the intervention on coaches' behaviour towards injury prevention practice

Table 6-6 indicates that the practice behaviour of all the coaches in both groups shifted to the contemplation stage immediately after interventional training. However, after six months, the majority of coaches in the control group were still in the pre-contemplation and contemplation phases for injury prevention implementation. In contrast, the behaviours of the coaches in the intervention group and control group similarly shifted towards action and maintenance stage for checking protective equipment and playing fields for preventive purposes. Subsequent to the training, all of the coaches had the intention to set up an emergency care procedure within six months. After the six-month follow up, eight coaches in the intervention group and seven coaches in the control group indicated that they no longer had the intention to have an emergency care procedure in their teams.

Table 6-6: Comparison of the changes in coaches' stage of behaviours according to injury prevention practice readiness from baseline to six months post-test.

		Stages of change														
		Pre-test					Post-test					6 months post-test				
	Injury prevention behaviour	Pre-contemplation	Contemplation	Preparation	Action	Maintenance	Pre-contemplation	Contemplation	Preparation	Action	Maintenance	Pre-contemplation	Contemplation	Preparation	Action	Maintenance
Intervention group	Implementing injury prevention programme	7	5	0	0	0	0	12	0	0	0	0	0	0	0	12
	Checking protective equipment	1	10	0	0	1	0	11	0	0	1	0	0	3	5	4
	Checking safety of playing fields and facilities	1	8	1	1	0	0	9	1	1	0	0	0	2	7	3
	Having emergency care procedure	6	6	0	0	0	0	12	0	0	0	8	4	0	0	0
	Checking up-to-date injury prevention information	1	9	2	0	0	0	10	2	0	0	0	5	7	0	0
Control group	Implementing injury prevention programme	8	4	0	0	0	0	12	0	0	0	1	8	3	0	0
	Checking protective equipment	0	11	1	0	0	0	11	1	0	0	0	0	4	5	3
	Checking safety of playing fields and facilities	2	8	2	0	0	0	11	1	0	0	0	1	3	6	2
	Having emergency care procedure	6	6	0	0	0	0	12	0	0	0	7	5	0	0	0
	Checking up-to-date injury prevention information	4	6	2	0	0	0	10	2	0	0	0	6	4	2	0

Values are presented as frequencies of coaches in the intervention group (n=12) and control group (n=12).
Redcolour represents the highest frequency and greencolour the lowest.

A Mann-Whitney U test indicated that there were no significant differences in the rank order of any behaviours between the coaches of the two groups at any time point, apart from the six-month post-test stage of behaviour in implementing an injury prevention programme (Table 6-7).

Table 6-7: Comparison of the changes in coaches' injury prevention practice readiness from baseline to six months post-test.

	Control	Intervention	Statistics		
IPP readiness	Rank Sum	Rank Sum	Z-adjusted	p-value	2*1sidedexact p
Pre-test	144.0	156.0	-0.38	0.705	0.755
Post-test	150.0	150.0			
6 months post-test	78.0	222.0	-4.51	0.000	<0.001

Intervention group: n=12 Control group: n=12
IPP: Injury prevention practice
Post-test statistical analysis was not applicable as the rank sum of the intervention and the control group were equal.

6.4.4 Effects of the intervention on injuries at team level

The impact of the training was first examined using the teams as the unit of analysis. As can be seen in Table 6-8, there were 363 players who sustained injuries, 163 (52%) in the intervention group and 200 (62.9%) in the control group. The percentage of injuries sustained per team ranged from 32.4% to 86.4%. In each group there was a single team where over 80.0% of players reported injuries. There was a negative correlation between the mean number of hours played and the percentage of injuries, however this was non-significant (r=-0.38, p=0.064).

Table 6-8: Number of injured playersper team.

Study group	Team code	Number of players injured	Total number of players	% Players injured	Total hours exposure	Mean hours exposure
Intervention	Int1	17	21	81.0	4260	202.8
Intervention	Int2	14	22	63.6	4504	204.7
Intervention	Int3	15	28	53.6	5601	200.0
Intervention	Int4	14	24	58.3	5028	209.5
Intervention	Int5	17	29	58.6	6202	213.9
Intervention	Int6	14	25	56.0	5367	214.7
Intervention	Int7	13	25	52.0	4443	177.7
Intervention	Int8	11	26	42.3	5811	223.5
Intervention	Int9	15	28	53.6	6100	217.9
Intervention	Int10	12	22	54.5	4385	199.3
Intervention	Int11	12	37	32.4	7412	200.3
Intervention	Int12	9	25	36.0	6220	248.8
Total Intervention		163	312	52	65333	209.4
Control	Cont1	19	22	86.4	4525	205.7
Control	Cont2	16	26	61.5	5431	208.9
Control	Cont3	18	27	66.7	5467	202.5
Control	Cont4	15	27	55.6	5504	203.9
Control	Cont5	14	27	51.9	5164	191.3
Control	Cont6	20	27	74.1	5169	191.4
Control	Cont7	16	24	66.7	4519	188.3
Control	Cont8	17	29	58.6	5801	200.0
Control	Cont9	19	30	63.3	5814	193.8
Control	Cont10	11	22	50.0	5205	236.6
Control	Cont11	19	28	67.9	5330	190.4
Control	Cont12	16	29	55.2	5460	188.2
Total Control		200	318	62.9	63389	199.3
Total participants		363	630	57.6	12820	204.3

Values are presented as frequencies of coaches in the intervention group (n=12) and control group (n=12).
Redcolour represents the highest frequency and greencolour the lowest.
Note that this table refers to number of injured players and not number of injuries.

Players in the intervention group were exposed to 61043 hours of training and 4290 match hours, with 65333 total exposure hours. Players in the control group were exposed to 59165 hours of training and 4224 match hours, with 63389 total exposure hours.

Table 6-9: Mean overall, training and match exposure hours and frequency of injuries per team.

Group	Team	Overall injuries				Training injuries				Match injuries			
		Exposure hours				Exposure hours				Exposure hours			
		Sum	Mean	SD	Freq. Injury	Sum	Mean	SD	Freq. Injury	Sum	Mean	SD	Freq. injury
Intervention	Int1	4259.5	202.8	19.1	15	3896.5	185.5	11.5	4	363.0	17.3	11.2	11
Intervention	Int2	4504.2	204.7	20.4	15	4157.7	189	16.7	5	346.5	15.8	9.1	10
Intervention	Int3	5600.7	200	12.7	17	5237.7	187.1	8.9	6	363.0	13	7.9	11
Intervention	Int4	5028.1	209.5	11.7	15	4698.1	195.8	6.1	6	330.0	13.8	11.5	9
Intervention	Int5	6202.2	213.9	18.3	18	5855.7	201.9	12.5	6	346.5	11.9	12.2	12
Intervention	Int6	5367.3	214.7	24.3	15	5004.3	200.2	19.3	6	363.0	14.5	9.2	9
Intervention	Int7	4443.0	177.7	12.9	12	4080.0	163.2	3.8	6	363.0	14.5	11.9	6
Intervention	Int8	5811.1	223.5	20.2	15	5464.6	210.2	16.1	6	346.5	13.3	11.8	9
Intervention	Int9	6099.9	217.9	32.1	14	5736.9	204.9	27.2	4	363.0	13	9.8	10
Intervention	Int10	4385.0	199.3	18.6	10	4022.0	182.8	11.8	6	363.0	16.5	11.0	4
Intervention	Int11	7411.9	200.3	17.3	12	7065.4	191	14.2	6	346.5	9.4	8.5	6
Intervention	Int12	6219.8	248.8	10.7	10	5823.8	233	3.7	3	396.0	15.8	11.1	7
Total intervention		65332.7	236.6	17.1	168	61042.7	218.6	17.1	64	4290	18	2.2	104
Control	Cont1	4525.4	205.7	30.5	24	4178.9	189.9	25.6	10	346.5	15.8	9.0	14
Control	Cont2	5430.9	193.8	26.8	24	5067.9	182.3	24.2	9	363.0	11.6	9.0	15
Control	Cont3	5466.7	188.3	21.2	24	5120.2	173.9	19.2	8	346.5	14.4	10.5	16
Control	Cont4	5504.2	200	42.8	23	5190.7	188.1	40.0	9	313.5	11.9	9.4	14
Control	Cont5	5169.1	205.7	30.4	21	4806.1	178	25.0	9	363.0	15.8	11.4	12
Control	Cont6	5801.3	208.9	17.7	22	5454.8	194.9	15.2	8	346.5	14	8.0	14
Control	Cont7	5814.3	202.5	26.2	21	5467.8	189.6	22.8	5	346.5	12.8	10.6	16
Control	Cont8	5164.0	188.3	26.5	21	4801.0	176.3	21.4	5	363.0	11.9	11.3	16
Control	Cont9	4519.1	190.3	21.2	18	4172.6	178	16.0	9	346.5	12.4	10.7	9
Control	Cont10	5204.7	191.3	24.3	18	4808.7	177.8	18.7	6	396.0	13.4	12.8	12
Control	Cont11	5329.5	191.4	23.0	18	4983.0	178	19.5	6	346.5	13.4	8.7	12
Control	Cont12	5460.0	203.9	21.8	18	5113.5	192.2	18.3	5	346.5	11.6	8.1	13
Total control		63389.2	200.1	13.6	252	59165.2	186.6	12.3	153	4224	13.4	1.9	163

freq=frequency
Values are presented as frequencies of coaches in the intervention group (n=12) and control group (n=12).
Redcolour represents the highest frequency and white colour the lowest.
Note that this table refers to number of injuries and not number of injured players.

In total, 420 injuries were sustained, 168 (40%) in the intervention group and 252 (60%) injuries in the control group. A one way ANOVA indicted that there was a significant difference in the means of the overall exposure hours ($F(22, 607)=11.425$, $p<0.001$), as well as in the training hours ($F(22, 607)=15.060$, $p<0.001$), but not in the match exposure hours ($F(22, 607)=1.077$, $p=0.367$)(Table 6-9) between the 24 teams.

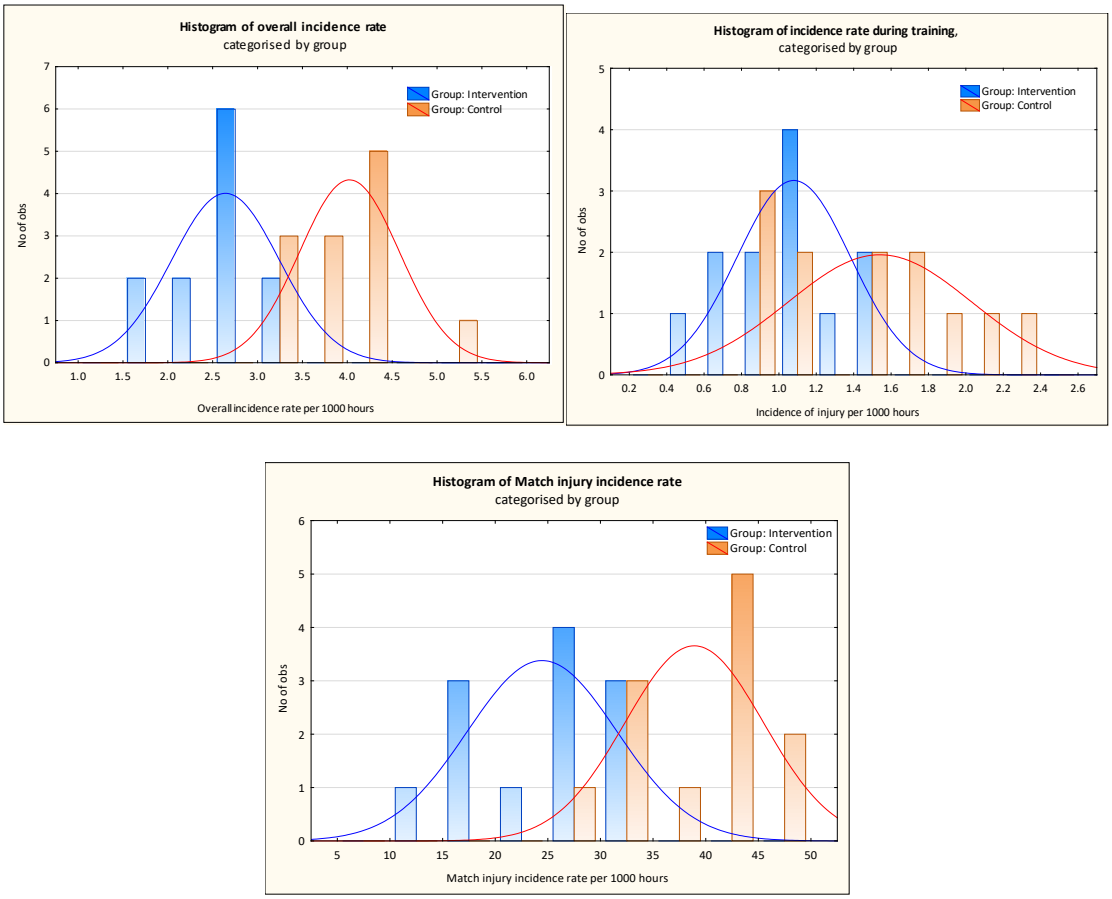
Table 6-10 lists the mean incidence of injury per 1000 hours at the team level of the team. The sum of the exposure hours per team and the number of injuries recorded in Table 6-9 were used to calculate the incidence rates in Table 6-10.

Table 6-10: Incidence of overall, training and match injuries per team.

	Overall		Training		Match		
Team code	Intervention	control	Intervention	control	Intervention	control	Team code
Int1	3.5 (2.1-5.8)	4.1(2.7-6.2)	1.0 (0.4-2.6)	1.9 (1.0-3.6)	30.3 (17.0-53.4)	33.1 (19.0-56.9)	Cont1
Int2	2.7 (1.5-4.7)	4.4 (3.0-6.5)	1.5 (0.7-3.2)	1.6 (0.8-3.1)	16.5 (7.6-35.6)	46.2 (28.6-73.7)	Cont2
Int3	2.3 (1.4-3.8)	3.6 (2.4-5.5)	0.7 (0.3-1.8)	0.9 (0.4-2.1)	27.5 (15.0-50.0)	46.2 (28.6-73.7)	Cont3
Int4	2.3 (1.2-4.2)	3.5 (2.2-5.5)	1.5 (0.7-3.3)	1.2 (0.6-2.7)	11.0 (4.3-28.0)	30.3 (17.4-52.2)	Cont4
Int5	2.6 (1.6-4.3)	4.2 (2.8-6.3)	1.1 (0.5-2.4)	1.7 (0.9-3.3)	26.0 (13.7-48.6)	44.7 (26.8-73.6)	Cont5
Int6	1.6 (0.9-3.0)	4.4 (3.0-6.6)	0.5 (0.2-1.5)	1.8 (0.9-3.4)	17.7 (8.6-36.0)	41.3 (25.2-67.1)	Cont6
Int7	3.3 (2.0-5.5)	4.1 (2.7-6.2)	1.2 (0.5-2.8)	1.0 (0.4-2.4)	28.9 (15.8-52.3)	44.1 (27.3-70.4)	Cont7
Int8	3.0 (1.8-4.9)	3.8 (2.5-5.7)	1.3 (0.6-2.8)	1.5 (0.7-2.9)	27.3 (14.4-51.0)	40.4 (24.2-66.7)	Cont8
Int9	2.9 (1.8-4.6)	3.4 (2.1-5.3)	1.0 (0.5-2.2)	1.2 (0.6-2.6)	34.6 (19.9-59.5)	34.6 (19.9-59.5)	Cont9
Int10	2.8 (1.7-6.6)	4.0 (2.5-6.3)	1.2 (0.5-2.6)	2.2 (1.1-4.1)	24.8 (13.1-46.4)	26.0 (13.7-48.6)	Cont10
Int11	1.6 (0.9-2.8)	5.3 (3.6-7.9)	0.8 (0.4-1.9)	2.4 (1.3-4.4)	17.3 (8.0-37.3)	40.4 (24.2-66.7)	Cont11
Int12	3.0 (1.9-4.7)	3.3 (2.1-5.2)	1.1 (0.5-2.5)	1.0 (0.4-2.3)	30.3 (17.0-53.4)	37.5 (22.1-63.1)	Cont12
Mean (SD)	2.63(0.60)	4.01(0.55)	1.08 (0.30)	1.53(0.49)	24.40(7.08)	38.73 (6.6)	

Int: intervention code Cont: control code Intervention group: n=12 teams Control group: n=12 teams
Values are presented as incidence (95% confidence interval) per 1000 hours of exposure as well as the mean (SD) incidence per 1000 hours of exposure.

As can be observed in the histogramsof incidence rates (Figure 6-2), apart from one team, the highest incidence rate in the intervention group was lower than the lowest rate in the control group for both overall and match incidence.



Intervention group: n=12 teams *Control group: n=12 teams*

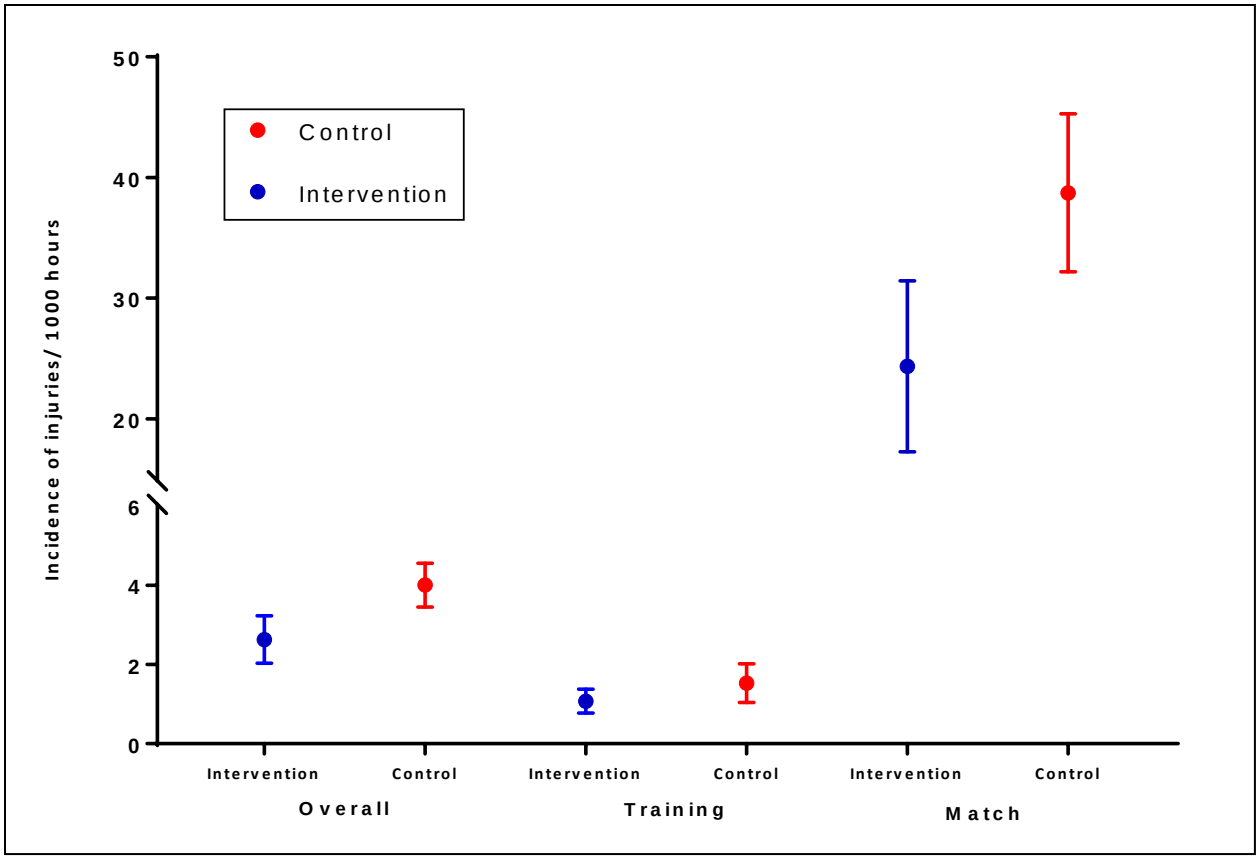
Figure 6-2: Histograms of the injury incidence rate per 1000 overall, training and match hours exposure, categorised by group.

As the data in each set were normally distributed within each group, a t-test was used to compare incidence rates. To control for the differences in the number of players in each team, the results were weighted according to number of players per team. The overall, training and the match incidence rates were all significantly lower in the experimental group ($p<0.001$)(Table 6-11). This is depicted graphically in Figure 6-3.

Table 6-11: Comparison of the weighted overall, training and match mean injury incidences of teams in the intervention and control groups.

Exposure	Mean Intervention	Mean Control	t-value	DF	P 2-sided	SD Intervention	SD Control	F-ratio Variances	p Variances
Overall*	2.59	4.02	-32.1	601.6	***<0.001***	0.587	0.511	1.321	***0.016***
Training*	1.07	1.54	-15.5	477.5	***<0.001***	0.274	0.458	2.789	***0.000***
Match	24.31	39.27	-28.5	606	***<0.001***	6.756	6.133	1.214	***0.093***

Intervention group: n=12 teams, 312 players *Control group: n=12 teams, 318 players*
Weighted by number of players in each team.
**tested with separate variances*



Intervention group: n=12 teams *Control group: n=12 teams*
The middle values representteam adjusted mean injury incidences per 1000 hours while the whiskers represent the standard deviation.

Figure 6-3: Mean overall, training and match injury incidences of teams in both studygroups.

6.4.5 Effects of the intervention at the level of individual players

6.4.5.1 Proportion of players who sustained injuries per group

Out of a total of 318 players in the control group, 200 (63%) players sustained injuries. In the intervention group, 163 out of 312 (52%) players incurred injuries.

The odds and risk ratios of players sustaining injuries in the control group were calculated considering the design effect due to the use of cluster sampling (Table 6-12), with the team as the primary sampling unit.

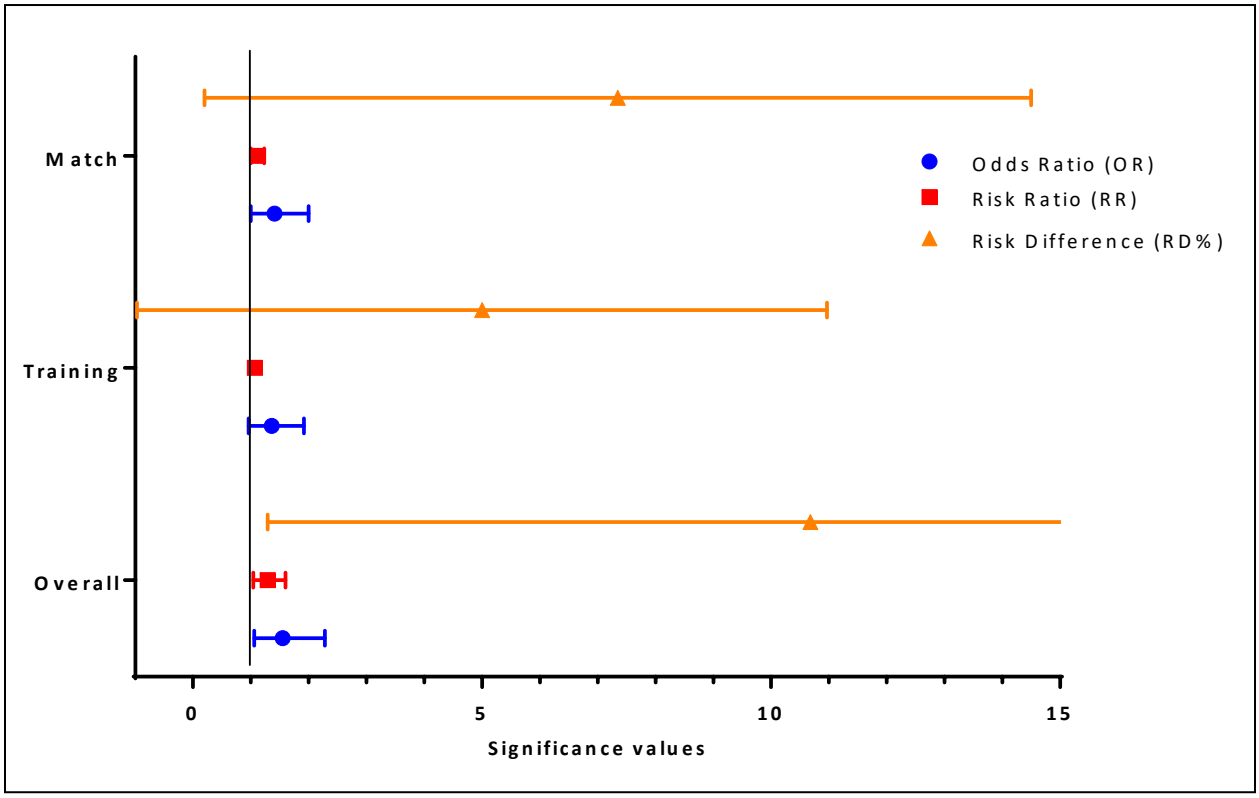
Table 6-12: Odds ratio of sustaining one or more injuries between the intervention and control group.

Study group	Overall Injury		Training Injury		Match Injury		
	No	Yes	No	Yes	No	Yes	TOTAL
Intervention	149	163	255	57	227	85	312
Row %	47.8	52.2	81.7	18.7	72.8	27.2	100
Standard Error %	3.682	3.682	1.228	1.228	2.9	2.9	
Lower confidence limits%	40.1	44.6	79.2	15.7	66.8	21.2	
Upper Confidence limits%	55.4	59.9	84.3	20.8	78.8	33.2	
Design Effect	1.69	1.69	0.314	0.314	1.319	1.319	
Control	118	200	244	74	208	110	318
Row %	37.1	62.9	76.7	23.3	65.4	34.6	100
Standard Error %	2.632	2.632	2.612	2.612	1.876	1.876	
Lower confidence limits%	31.7	57.4	71.3	17.8	61.5	30.7	
Upper Confidence limits%	42.6	68.3	82.1	28.7	69.3	38.5	
Design Effect	0.941	0.941	1.211	1.211	0.493	0.493	
TOTAL	267	363	499	131	435	195	630
Row %	42.4	57.6	79.2	20.8	69	31	100
Standard Error %	2.572	2.572	1.542	1.542	1.918	1.918	
Lower confidence limits%	37.1	52.3	76	17.6	65.1	27	
Upper Confidence limits%	47.7	62.9	82.4	24	73	34.9	
Design Effect	1.704	1.704	0.908	0.908	1.082	1.082	
Odds Ratio (OR)	1.55		1.36		1.41		
Standard Error (SE)	0.27		0.23		0.23		
95% Conf. Intervals	***(1.06-2.28)***		(0.96-1.92)		(1.00-2.00)		
Risk Ratio (RR)	1.29		1.07		1.11		
Standard Error (SE)	0.14		0.04		0.06		
95% Conf. Intervals	***(1.04-1.60)***		(0.99-1.150)		(1.00-1.23)		
RR = (Risk of Injury=Injured if Control)/(Risk of injury =Injured if Intervention)							
Risk Difference (RD%)	10.65		5.00		7.35		
Standard Error (SE)	4.56		2.886		3.454		
95% Conf. Intervals	***(1.29-20.01)***		(-0.97-10.972)		(0.20-14.492)		
RD = (Risk difference=Injured if Control)-(Risk of injury=injured in Intervention). This is equivalent to the absolute effect.							

Intervention group: n=312 players *Control group: n=318 players*

The odds and risk ratios for injuries were significantly higher in the control group for overall injuries, however the confidence intervals (CIs) included one for training and match injuries. The overall risk difference (the difference of the percentage injured in the control group and percentage of those

injured in the intervention group) was 10.7% and as the CIs did not include 1, this was a significant reduction (Figure 6-4).



Intervention group: n=312 players *Control group: n=318 players*
Values are Odds Ratio, Risk Ratio and Risk Difference with 95% confidence intervals.

Figure 6-4: Odds ratio, risk ratio and risk difference for overall, training and match injuries.

6.4.5.2 Number of injuries per player in each study group

Of those players who sustained injuries, the majority sustained only a single injury. Although the frequency of players sustaining one injury in either group was similar (109 in the intervention group compared to 98 in the control group), the control group saw more than twice the number of multiple injuries sustained by a single player (Table 6-13).

Table 6-13: The frequency of number of injuries sustained per player in each group.

		Number of injuries sustained				Total Injuries
Groups	Team Name	1	2	3	4	
Intervention	Int1	13	1	0	0	15
	Int2	10	1	1	0	15
	Int3	9	4	0	0	17
	Int4	9	3	0	0	15
	Int5	14	2	0	0	18
	Int6	9	3	0	0	15
	Int7	7	1	1	0	12
	Int8	7	1	2	0	15
	Int9	9	1	1	0	14
	Int10	8	1	0	0	10
	Int11	8	2	0	0	12
	Int12	6	2	0	0	10
	All teams	109	22	5	0	168
Control	Cont1	11	5	1	0	24
	Cont2	10	4	2	0	24
	Cont3	9	6	1	0	24
	Cont4	5	6	2	0	23
	Cont5	10	4	1	0	21
	Cont6	8	2	3	0	21
	Cont7	8	5	0	0	18
	Cont8	6	5	2	0	22
	Cont9	11	5	0	0	21
	Cont10	5	3	1	1	18
	Cont11	6	6	0	0	18
	Cont12	9	3	1	0	18
	All teams	98	54	14	1	252

N=420 injuries,
Intervention group: n=168 injuries *Control group: n=252 injuries*

6.4.5.3 Effect of the intervention on the patterns of injuries

Table 6-14 indicates that membership of the intervention group was associated with a greater risk of contact and non-recurrent injuries, compared to membership of the control group (Cluster adjusted OR: 1.40, 95% Confidence limits: 1.04-1.88) and sustained recurrent (Cluster adjusted OR: 26.94,95% Confidence limits: 3.57-205.46) injuries.

Table 6-14: Association between study group and circumstance, recurrence, overuse and training and match injuries.

STUDY GROUP	Circumstance		Injury recurrence		Overuse and Trauma		Training and Match		
	Non-contact	Contact	Recurrent	Non-recurrent	Overuse	Trauma	Match	Training	TOTAL
Intervention	42	126	1	167	8	160	104	64	168
Row %	25.0	75.0	0.6	99.4	4.8	95.2	61.9	38.1	100
SE %	1.706	1.706	0.579	0.579	1.282	1.282	2.430	2.430	
LCL %	21.5	71.5	-0.6	98.2	2.1	92.6	56.9	33.1	
UCL %	28.5	78.5	1.8	100.6	7.4	97.9	66.9	43.1	
Design Effect	0.259	0.259	0.947	0.947	0.605	0.605	0.418	0.418	
Control	80	172	35	217	15	237	163	89	252
Row %	31.7	68.3	13.9	86.1	6.0	94.0	64.7	35.3	100
SE %	2.410	2.410	0.975	0.975	1.556	1.556	2.103	2.103	
LCL %	26.8	63.3	11.9	84.1	2.7	90.8	60.3	31.0	
UCL %	36.7	73.2	15.9	88.1	9.2	97.3	69.0	39.7	
Design Effect	0.673	0.673	0.199	0.199	1.085	1.085	0.486	0.486	
TOTAL	122	298	36	384	23	397	267	153	420
Row %	29.0	71.0	8.6	91.4	5.5	94.5	63.6	36.4	100
SE %	1.743	1.743	1.497	1.497	1.07	1.07	1.604	1.604	
LCL %	25.4	67.3	5.5	88.3	3.3	92.3	60.3	33.1	
UCL %	32.7	74.6	11.7	94.5	7.7	96.7	66.9	39.8	
Design Effect	0.617	0.617	1.197	1.197	0.927	0.927	0.466	0.466	
Odds Ratio (OR)		***1.40***		***26.94***		1.27		1.13	
Standard Error (SE)		***0.21***		***26.98***		0.50		0.16	
95% Confidence Limits		***(1.04-1.88)***		***(3.57-205.46)***		(0.56-2.87)		(0.85-1.50)	

SE: Standard error, LCL: Lower confidence limits, UCL: Upper confidence limits

Data are presented as number out of total intervention (n=168) and control (n=252) injuries cluster-adjusted odds ratios (95% confidence limits) between the intervention and control groups.

6.4.5.4 Effects of the intervention on lower limb injuries

There were 135 lower limb injuries in the intervention group and 208 sustained in the control group. Team weighted incidence for lower limb injuries was 2.1 (95% CI: 1.7-2.5) per 1000 hours in the intervention and 3.3 (95% CI: 2.9-3.7) in the control group. Table 6-15 provides the details of injury incidence of lower limb injuries per team for both groups.

Table 6-15: Team level frequency and incidence of lower limb injuries.

Group	Team	Exposure hours	Number of injuries						Incidence of injuries per 1000 hours					
		Sum	Lower limb	Thigh & groin	Knee	Achilles & lower leg	Ankle	Foot	Lower limb	Thigh & groin	Knee	Achilles & lower leg	Ankle	Foot
Intervention	Int1	4260	13	5	4	1	3	0	3.1	1.2	0.9	0.2	0.7	0.0
	Int2	4504	12	3	4	0	5	0	2.7	0.7	0.9	0.0	1.1	0.0
	Int3	5601	14	5	3	1	5	0	2.5	0.9	0.5	0.2	0.9	0.0
	Int4	5028	13	5	4	1	3	0	2.6	1.0	0.8	0.2	0.6	0.0
	Int5	6202	12	2	3	2	3	2	1.9	0.3	0.5	0.3	0.5	0.3
	Int6	5367	11	4	3	3	1	0	2.0	0.7	0.6	0.6	0.2	0.0
	Int7	4443	11	5	3	0	2	1	2.5	1.1	0.7	0.0	0.5	0.2
	Int8	5811	13	6	5	0	2	0	2.2	1.0	0.9	0.0	0.3	0.0
	Int9	6100	9	2	3	1	3	0	1.5	0.3	0.5	0.2	0.5	0.0
	Int10	4385	9	5	3	1	0	0	2.1	1.1	0.7	0.2	0.0	0.0
	Int11	7412	10	5	2	0	2	1	1.3	0.7	0.3	0.0	0.3	0.1
	Int12	6220	8	2	3	1	2	0	1.3	0.3	0.5	0.2	0.3	0.0
Total		65333	135	49	40	11	31	4	2.1	0.8	0.6	0.2	0.5	0.1
Control	Cont1	4525	21	7	4	1	7	2	4.6	1.5	0.9	0.2	1.5	0.4
	Cont2	5431	20	8	5	1	5	1	3.7	1.5	0.9	0.2	0.9	0.2
	Cont3	5467	20	7	7	0	6	0	3.7	1.3	1.3	0.0	1.1	0.0
	Cont4	5504	18	4	4	1	8	1	3.3	0.7	0.7	0.2	1.5	0.2
	Cont5	5164	18	8	4	1	4	1	3.5	1.5	0.8	0.2	0.8	0.2
	Cont6	5169	16	4	4	1	7	0	3.1	0.8	0.8	0.2	1.4	0.0
	Cont7	4519	15	4	3	1	6	1	3.3	0.9	0.7	0.2	1.3	0.2
	Cont8	5801	15	7	4	0	1	3	2.6	1.2	0.7	0.0	0.2	0.5
	Cont9	5814	18	8	4	0	4	2	3.1	1.4	0.7	0.0	0.7	0.3
	Cont10	5205	17	7	4	2	4	0	3.3	1.3	0.8	0.4	0.8	0.0
	Cont11	5330	17	7	5	1	4	0	3.2	1.3	0.9	0.2	0.8	0.0
	Cont12	5460	13	7	3	0	3	0	2.4	1.3	0.5	0.0	0.5	0.0
Total		63389	208	78	51	9	59	11	3.3	1.2	0.8	0.1	0.9	0.2

Intervention group n= 135 lower limb injuries Control group n=208 lower limb injuries
Injury incidences is expressed per 1000 hours of exposure

Further analysis was conducted to assess for the difference in the incidence of lower limb injuries in both study groups. Data on team injury incidence for lower limb, thigh and groin, knee and ankle injuries were normally distributed; therefore, a t-test was used to compare the incidence of rates. A Mann-

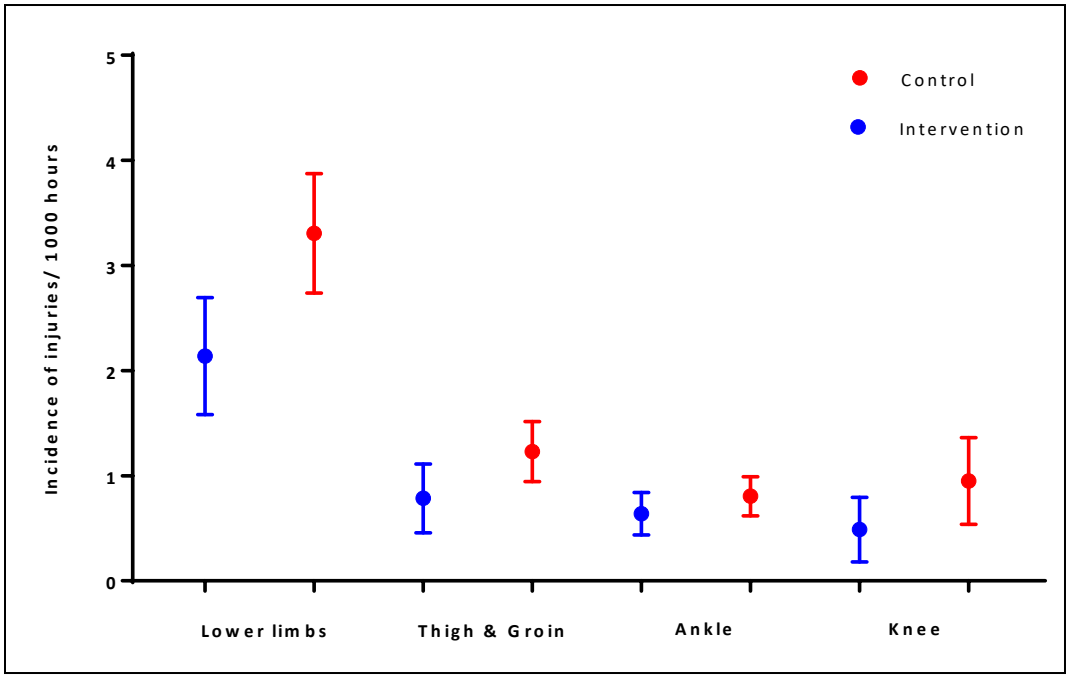
Whitney U test was used to analyse the difference between the incidence of Achilles and lower leg injuries and foot injuries as they were not normally distributed.

The incidence rates of lower limb, thigh and groin, knee and ankle injuries were all significantly lower in the intervention group (Table 6-16). Figure 6-5 provides the visual representation of the incidence of lower limb injuries.

Table 6-16: Comparison of the weighted lower limb mean injury incidences of teams in the intervention and control groups.

Exposure	Mean Intervention	Mean Control	t-value	DF	P 2-sided	SD Intervention	SD Control	F-ratio Variances	p Variances
Lower limbs	2.1	3.3	-5.081	22	***<0.001***	0.557	0.569	0.232	0.635
Thigh & groin	0.8	1.2	-3.559	22	***0.002***	0.327	0.284	0.674	0.420
Knee	0.6	0.8	-2.085	22	***0.049***	0.203	0.187	0.553	0.465
Ankle	0.5	1.0	-3.115	22	**0.005**	0.307	0.413	1.781	0.196
	Mean Rank Intervention	Mean Rank Control	Z	U	P-value 2-sided	Sum of Ranks Intervention	Sum of Ranks Control		
Achilles & lower leg	12.83	12.17	-0.257	68.0	0.767	154	146		
Foot	10.29	14.71	-1.708	45.5	0.088	123.5	176.5		

DF: Degrees of freedom *SD: Standard deviation*
Intervention group n= 135 lower limb injuries *Control group n=208 lower limb injuries*



Intervention group: n=135 lower limb injuries Control group: n=208 lower limb injuries
The middle valuerepresents the adjusted team mean injury incidences per 1000 hours of exposures while the whiskers represent the standard deviation.

Figure 6-5: Incidences of all and specific lower limb injuries.

A cluster-adjusted odds ratio indicated a significant association between subgroups and group membership in those withlower limb injuries (Cluster adjusted OR: 1.40, 95% Confidence limits: 1.02-1.93) and ankle injuries (Cluster adjusted OR: 1.92, 95% Confidence limits: 1.18-3.13) (Table 6-17).

Table 6-17: Association between study group and lower limb three most common injuries.

STUDY GROUP	Lower Limb Injury		Thigh Injury		Knee Injury		Ankle Injury		
	No	Yes	No	Yes	No	Yes	No	Yes	TOTAL
Intervention	196	116	264	20	274	38	285	27	312
Row %	62.8	37.2	93.0	7.0	87.8	12.2	91.4	8.6	100
SE %	2.521	2.521	1.668	1.668	1.748	1.748	1.43	1.43	
LCL %	57.6	32.0	89.5	3.6	84.2	8.6	88.4	5.7	
UCL %	68.0	42.4	96.4	10.5	91.4	15.8	94.3	11.6	
Design Effect	0.846	0.846	1.202	1.202	0.889	0.889	0.804	0.804	
Control	174	144	285	33	275	43	269	49	318
Row %	54.7	45.3	89.6	10.4	86.5	13.5	84.6	15.4	100
SE %	2.7	2.7	1.3	1.3	1.6	1.6	2.0	2.0	
LCL %	49.1	39.6	86.9	7.7	83.3	10.3	80.5	11.3	
UCL %	60.4	50.9	92.3	13.1	89.7	16.7	88.7	19.5	
Design Effect	0.959	0.959	0.571	0.571	0.651	0.651	0.944	0.944	
TOTAL	370	260	549	53	549	81	554	76	630
Row %	58.7	41.3	91.2	8.8	87.1	12.9	87.9	12.1	100
SE %	2.070	2.070	1.119	1.119	1.184	1.184	1.400	1.400	
LCL %	54.4	37.0	88.9	6.5	84.7	10.4	85.0	9.2	
UCL %	63.0	45.6	93.5	11.1	89.6	15.3	90.8	15.0	
Design Effect	1.112	1.112	0.937	0.937	0.787	0.787	1.162	1.162	
Odds Ratio (OR)	***1.40***		1.69		1.13		***1.92***		
Standard Error (SE)	***0.213***		0.503		0.234		***0.478***		
95% Conf. Limits	***(1.02-1.93)***		(0.90-3.17)		(0.73-1.74)		***(1.18-3.13)***		

SE: Standard error, LCL: Lower confidence limits, UCL: Upper confidence limits
Conf. Limits: Confidence Limits

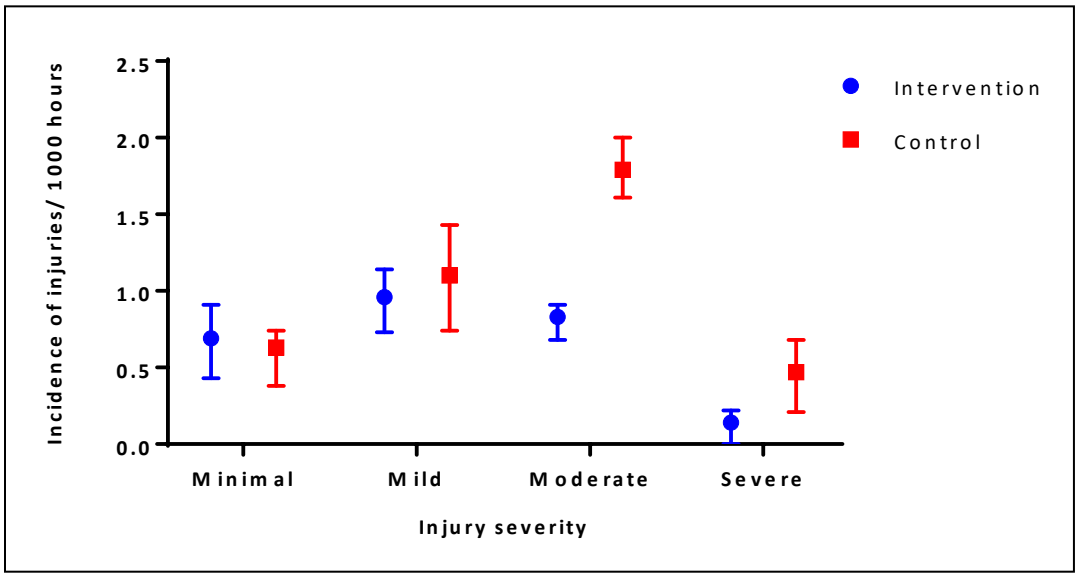
6.4.5.5 Effect of the intervention on the severity of injuries

Players in the intervention group lost a mean of 9 days (SD=12; range 1-84) due to injuries compared to a mean of 15 days (SD=19; range 1-153 days) in the control group. Therefore, there was a 40% reduction of the days lost in the intervention compared to the control group. This difference was found to be

significant (p=0.001) (Table 6-18). The incidences of the classification of injuries weighted for the intervention and control group are displayed in Figure 6-6.

Table 6-18: Cluster-adjusted comparison of lay off time due to injury between the intervention and control group.

Research Group	Count	Mean	Robust Std. Error	95% Confidence Limits		Minimum	Maximum	t-value	P-value
				Lower	Upper				
Intervention	168	8.905	0.878	7.088	10.722	1	84		
Control	252	14.687	1.298	12.002	17.371	1	153	3.69	0.001
TOTAL	420	12.374	1.034	10.236	14.512	1	153		
Difference		-5.782	1.567	-9.023	-2.54				



Intervention group: n=168 injuries Control group: n=252 injuries
Data are presented as study group weighted injury incidence per 1000 hours of exposure; error bars represent 25th and 75th percentiles.

Figure 6-6: Effect of the injury prevention programme on the severity of injuries.

Adjusting for clusters, injury severity was found to be associated with group membership as those in the intervention group were more likely to sustain minimal injuries. There was a statistically significant increase in the odds of sustaining a moderate to severe injury in the control group (OR: 2.3, 95% Confidence limits: 1.56-3.40) (Table 6-19). There was a 20% reduction in the risk of sustaining a moderate/severe injury (95% CI: 1.56-3.40) in the intervention group.

Table 6-19: Association between study group and severity of injuries.

RESEARCHGROUP	Severity dichotomised		
	Minimal/ Mild	Moderate/Severe	TOTAL
Intervention	107	61	168
Row %	63.69	36.31	100
SE %	3.574	3.574	
LCL %	56.297	28.916	
UCL %	71.084	43.703	
Design Effect	0.922	0.922	
Control	109	143	252
Row %	43.254	56.746	100
SE %	2.656	2.656	
LCL %	37.76	51.252	
UCL %	48.748	62.24	
Design Effect	0.721	0.721	
TOTAL	216	204	420
Row %	51.429	48.571	100
Col %	100	100	100
SE %	2.904	2.904	
LCL %	45.42	42.563	
UCL %	57.437	54.58	
Design Effect	1.415	1.415	
Odds Ratio (OR)	***2.3***		
Standard Error (SE)	***0.479***		
95% Conf. Limits	***(1.56-3.40)***		
Risk difference	20.40%		

Intervention group: n=168 injuries *Control group: n=252 injuries*

6.4.6 Compliance with the injury prevention programme and injuries

6.4.6.1 Compliance with the injury prevention programme

The 12 teams in the intervention group performed the injury prevention programme in 1196 out of a total of 1563 training sessions and matches during the full season (mean per team=99.7; SD=18.4, range 78-137). The programme was performed 953 times during training sessions (mean per team=79.4; SD=17.0; range: 58-113) and 243 during matches (mean per team= 20.3; SD=18.0; range 78-137). The teams completed the injury prevention programme in approximately 75% of combined training sessions and matches. The programme was followed in 91% of the match sessions. The team with the lowest proportion performed the injury prevention programme at a rate of 60%, while the team with the highest proportion performed the injury prevention programme for 97% of all training sessions and matches. The teams carried out the injury prevention programme on an average of 3.6 times per week.

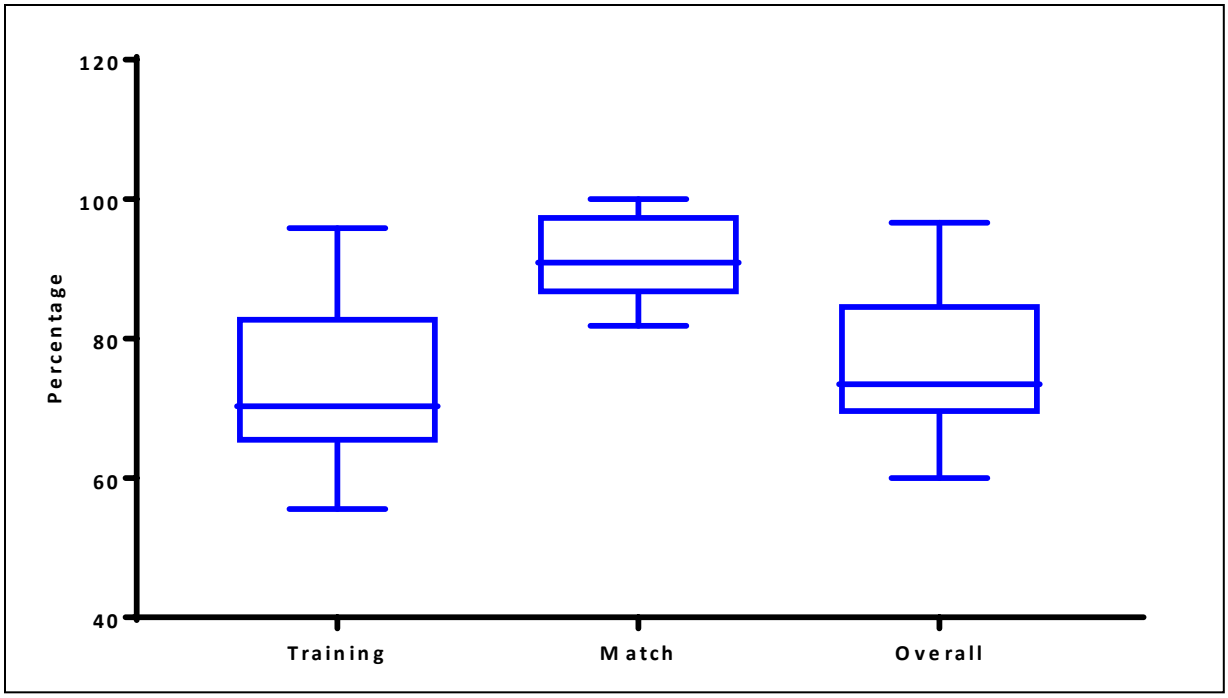
The team with the lowest proportion performed the injury prevention programme 2.8 times per week while the highest proportion was 4.9 times per week (Table 6-20). No team in the control group performed the 11+ programme throughout the season.

Table 6-20: Implementation of the FIFA 11+ warm up programme in training and matches throughout the season.

Teams	Total training sessions per season	Total matches per season	Total	FIFA 11+ in training sessions	FIFA 11+ in matches	Total	Average FIFA 11+ performance per week
	N	N	N	N (%)	N (%)	N (%)	
Int1	99	22	121	58 (59)	21 (95)	79 (65)	2.8
Int2	108	22	130	60 (56)	18 (82)	78 (60)	2.8
Int3	112	22	134	73 (65)	19 (86)	92 (69)	3.3
Int4	106	22	128	72 (68)	18 (82)	90 (70)	3.2
Int5	111	22	133	78 (70)	19 (86)	97 (73)	3.5
Int6	114	22	136	105 (92)	22 (100)	127 (93)	4.5
Int7	97	22	119	63 (65)	20 (91)	83 (70)	3.0
Int8	112	22	134	83 (74)	19 (86)	102 (76)	3.6
Int9	116	22	138	82 (71)	21 (95)	103 (75)	3.7
Int10	96	22	118	92 (96)	22 (100)	114 (97)	4.1
Int11	106	22	128	74 (70)	20 (91)	94 (73)	3.4
Int12	120	24	144	113 (94)	24 (100)	137 (95)	4.9
Mean	108	22	130	79 (73)	20 (91)	100 (76)	4
SD	8	1	8	17 (14)	2 (7)	18 (12)	1

SD: standard deviation Intervention group: n=12 teams,
Values are presented as numbers and where applicable percentages. Average FIFA 11+ performances per week were obtained out of 28 weeks of the season.

In the intervention group, five teams performed the injury prevention programme for more than 75% of training sessions and matches. These teams were classified as highly compliant to the injury prevention programme. The remaining seven teams performed the injury prevention programme for less than 75% and were classified as medium compliant teams. No teams were classified as low compliant. Figure 6-7 shows that teams implemented on average the FIFA 11+ more in matches (mean=91, SD=6) than in trainings (mean=73, SD=12).



Intervention group: n=12 teams
The middle line represents the mean, the bottom and the top of the box represent the 75% confidence intervals while the whiskers represent the minimum and the maximum.

Figure 6-7: Proportion of the compliance with the programme for training, matches and overall.

6.4.6.2 Coach-related factors and compliance

Further analysis of the demographic characteristics of the coaches and their perception towards injuries as well as the compliance percentage in the intervention group was conducted. There was a strong negative correlation between age and compliance (rho (12) =-0.64, p<0.025). This indicated that compliance decreased with an increase in coaches' age. No significant relationships were observed between the other coach-related factors and compliance to the injury prevention programme (Table 6-21).

Table 6-21: Relationships between coach-related factors and compliance to the injury prevention programme.

	Compliance	
Demographic characteristics	Statistics	p-value
Age	r = -0.641	***0.025***
Coaching experience	r = -0.307	0.331
Second division coaching experience	r = -0.317	0.316
Current club coaching experience	r = 0.160	0.618
Education level	Kruskal-Wallis test	0.140
Coaching licence level	Mann-Whitney U Test	0.933

Intervention group: n=12 coaches

6.4.6.3 Compliance and injuries

Teams in the intervention group sustained 168 injuries overall, comprising of 64 training and 104 match injuries. The highly compliant teams sustained 64 overall injuries in total, comprised of 39 match and 25 training injuries. Therefore, the incidence of injuries in the highly compliant teams was 2.3 (95% CI: 1.8-2.9) injuries per 1000 hours of soccer exposure with 21.3 (95% CI: 15.6-29.0) and 1.0 (95% CI: 0.7-1.4) incidences of match and training injuries respectively. The teams in the medium compliant teams sustained 104 injuries in total, comprising of 65 match and 39 training injuries. Medium compliant teams had an incidence of 2.8 (95% CI: 2.3-3.4) overall injuries with 26.4 (95% CI: 20.8-33.6) match and 1.1 (95% CI: 0.8-1.5) training injuries. There was no statistically significant difference in the incidence of all, training, match, lower limb or any other subtype of injuries as evidenced by the overlap in CIs of incidence and the inclusion of 1 in the CIs of the rate ratios (Table 6-22).

Table 6-22: Injuries according to the compliance level.

		High compliant (HC)		Medium compliant (MC)		Rate Ratios (95% CI)
		Number	**Incidence (95% CI)**	**Number**	**Incidence (95% CI)**	**HC vs MC**
All injuries		64	2.3 (1.8-2.9)	104	2.8 (2.3-3.4)	0.8 (0.6-1.1)
	Training	39	1.0 (0.7-1.4)	65	1.1 (0.8-1.5)	0.8 (0.5-1.2)
	Match	25	21.3 (15.6-29.0)	39	26.4 (20.8-33.6)	0.9 (0.5-1.4)
Lower limb		50	1.8 (1.4-2.4)	85	2.3 (1.8-2.8)	0.8 (0.6-1.1)
	knee	17	0.6 (0.4-1.0)	23	0.6 (0.4-0.9)	1.0 (0.5-1.9)
	Ankle	8	0.3 (0.1-0.6)	23	0.6 (0.4-0.9)	0.5 (0.2-1.0)
	Thigh & groin	19	0.7 (0.4-1.1)	30	0.9 (0.6-1.1)	0.9 (0.5-1.5)
	Sprain	24	0.9 (0.6-1.3)	44	1.2 (0.9-1.6)	0.7 (0.4-1.2)
	Strain	19	0.7 (0.4-1.1)	23	0.6 (0.4-0.9)	1.1 (0.6-2.0)
Severity						
	Minimal	14	0.5 (0.3-0.8)	30	0.8 (0.6-1.1)	0.6 (0.3-1.2)
	Mild	26	0.9 (0.6-1.4)	37	1.0 (0.7-1.4)	0.9 (0.6-1.6)
	Moderate	19	0.7 (0.4-1.1)	33	0.9 (0.6-1.2)	0.8 (0.4-1.4)
	Severe	5	0.2 (0.1-0.4)	4	0.1 (0.0-0.3)	1.7 (0.5-6.3)

N=168 injuries High compliant: n=5 teams Medium compliant: n=7 teams
Data are presented as number injuries with respective incidences per 1000 hours of exposure and 95% Confidence intervals. The rate Ratios and 95% confidence intervals between the high compliant and medium compliant groups are presented.

Table 6-23 indicates that there were no differences between highly compliant and medium compliant groups in injured players for playing situation, injury severity and involved body parts, with the confidence limits of the cluster adjusted OR including the value 1.

Table 6-23: Associations between compliance group and playing situation, injury severity and area of injury.

COMPLIANCE	Playing situation		Severity		Body parts		
	Training	Match	Minimal/Mild	Moderate/Severe	Lower Limb	Other	TOTAL
High Compliant	25	39	40	24	50	14	64
Row %	39.063	60.938	62.5	37.5	78.125	21.875	100
SE %	4.44	4.44	7.201	7.201	4.427	4.427	
LCL %	29.29	51.165	46.651	21.651	68.382	12.132	
UCL %	48.835	70.71	78.349	53.349	87.868	31.618	
Design Effect	0.522	0.522	1.394	1.394	0.722	0.722	
Medium Compliant	39	65	67	37	85	19	104
Row %	37.5	62.5	64.423	35.577	81.731	18.269	100
SE %	2.906	2.906	3.836	3.836	3.174	3.174	
LCL %	31.103	56.103	55.979	27.133	74.746	11.284	
UCL %	43.897	68.897	72.867	44.021	88.716	25.254	
Design Effect	0.371	0.371	0.661	0.661	0.695	0.695	
TOTAL	64	104	107	61	135	33	168
Row %	38.095	61.905	63.69	36.31	80.357	19.643	100
SE %	2.484	2.484	3.654	3.654	2.634	2.634	
LCL %	32.627	56.437	55.647	28.266	74.56	13.845	
UCL %	43.563	67.373	71.734	44.353	86.155	25.44	
Design Effect	0.437	0.437	0.964	0.964	0.734	0.734	
Odds Ratio (OR)	1.068		0.92		0.798		
Standard Error (SE)	0.236		0.328		0.282		
95% Conf. Limits	(0.65-1.75)		(0.43, 1.99)		(0.38, 1.67)		

SE: Standard error, LCL: Lower confidence limits, UCL: Upper confidence limits
Conf. Limits: Confidence Limits
N=168 injuries

6.4.7 Summary of findings

All the teams eligible for enrolment participated in the study. A total of 24 teams comprising of 630 players took part in the study over the season, equally distributed between the intervention and control teams. Other than increased levels of coaching experience, there were no differences between the demographic and licence level of the coaches. At the commencement of the study, very few coaches were in the preparation or higher stages of behaviour change regarding coaching practices. Within six months of receiving the training, several of the coaches in both the intervention and control groups had moved to the preparation phase and beyond. The only difference between the two groups was that each of the coaches in the intervention group were in the implementation of injury prevention phase at six months.

Injuries were sustained by a total of 52% of all players, 63% in the control group and 40% in the intervention group. A one-way ANOVA indicated a significant difference in the mean overall exposure hours between the 24 teams and training exposure hours with the intervention group players having greater exposure. There was no difference in match exposure hours. To allow for the cluster sampling design, the incidence rates were compared at the team level rather than at the group level, weighted for the number of players in each team. The overall, training and match incidence rates were all significantly lower in the intervention group ($p<0.001$). The odds and risk ratios for injuries were significantly higher in the control group for overall injuries but the CIs included one for the training and match injuries. The overall risk difference between the two groups was 10.65%, which was significantly higher in the control group.

Team weighted incidence of lower limb injuries was significantly lower in the intervention group ($p<0.001$) as well as in thigh and groin ($p=0.002$), knee ($p=0.049$) and ankle ($p=0.005$) injury incidence. Lower limb and ankle injuries were associated with group membership, weighted according to team membership. The intervention was significantly associated with the number of days lost due to injury (six days). There was a 20% reduction in the risk of sustaining moderate and severe injuries in the intervention group. The teams carried out the injury prevention programme an average 3.6 times per week and at 77% of all training sessions and matches. The compliance level decreased with an increase in age. Compliance levels did not have any impact on the incidence of any injury subtype.

6.5 Discussion

The aim and objectives of the present study were achieved in that the introduction of the FIFA 11+ programme was associated with a decrease in the incidence of injuries. This was evidenced by a significantly lower overall, training and match incidence rates in the intervention group, using the teams as the unit of analysis. In addition, the severity of injury was less in the intervention group and fewer days were lost due to injury. The coaches in the intervention group all moved to the stage of implementation in the injury prevention programme. The programme was implemented in at least three quarters of all sessions, rising to 91% of pre-match sessions. These findings required support in the form of empirical evidence to establish the impact of the programme, as to date and to the best of our knowledge, only four other studies have examined the effect of the FIFA 11+ warm up programme on the incidence of injuries[439;442;445;446].

The recruitment of all eligible coaches and players in the second division and the follow-up over a full season implies that the results are generalisable to players at a similar level of soccer participation. In addition, the satisfactory levels of coach and player compliance achieved in the present study resulted in the programme being given a fair trial. As there were no significant differences in the demographic variables of the players and few differences between the coaches of the two groups (Section 5.4.2), it is likely that the study had internal validity.

6.5.1 Impact of training on the coaches

Several studies have indicated that coaches play a pivotal role in injury prevention and several exercise interventions have been directed towards the coaching staff[443;450;452;489]. A study conducted among coaching and medical staff in soccer indicated that participants agreed that the coach holds a crucial role in injury prevention [490;491]. Similarly, the role of the coaches was crucial in the present study.

The cohort of second division coaches were primarily comprised of young coaches who had completed their playing careers and were currently launching their coaching careers. This was also reflected by the few years of overall coaching experience, coaching in the second division and coaching the current team. Although there was a significant difference in coaching experience as the coaches in the control group had more years of experience, it was unclear whether this introduced bias into the study. It may be that the teams with more experienced coaches were less likely to sustain any injury or it may be that the more experienced coaches are more set in their ways and less likely to change their practice styles. Nonetheless, no differences were detected between the stages of current behaviour between the two groups. As the difference in experience did not affect the baseline behaviour, it is thus unlikely to have had an impact on the overall results.

Norcross et al[485] recognised that the qualification level of coaches is important in the implementation of injury prevention programmes. In their study, 20 out of 24 coaches had completed at least secondary level education while six of them completed a tertiary level education[485]. In the present study, although the majority of coaches had some level academic qualification, only ten coaches held a recognised coaching license, as it is not compulsory to hold a coaching license at second division level in Rwanda. White et al[492] reported that education levels of coaches also plays an important role in injury prevention, as it may increase the motivation to adopt an injury prevention programme[492].

The present study did not find any significant differences in the education and license levels among coaches in the intervention and control groups. Therefore, there may not have been any differences in the motivation of coaches towards injury prevention in either group.

However, there was clearly a need for further training, which was demonstrated by the satisfactory recruitment and full attendance at both the control and experimental training groups. Both the FIFA 11+ programme and the first aid training resulted in a shift towards the direction of safer play, evident in the almost universal move towards the contemplation stage immediately following the training session. At baseline level, the coaches were not actively engaged in any form of injury prevention practice and may not have been aware of their contribution to the safety of the players or their critical position in preventive effort organisation, as reported by Sharkey and Gaskill[484]. It was thus encouraging that, in the six months following the training session, participants in both groups had moved into the preparation and action phases, particularly relating to checking protective equipment and the safety of playing fields and facilities. The training session appeared to have increased the coaches awareness of their role in injury prevention by identifying risk situations and considering prevention measures as suggested by Weaver et al[493]. The specific impact of the FIFA 11+ programme training was evident in that every coach in the intervention group had progressed to the maintenance stage of the injury prevention programme. Therefore, there is need for sports coaches in Rwanda to undergo similar training.

6.5.2 Intervention

There may be several additional reasons why the training programme resulted in high compliance levels (Section 5.5.4) and ultimately a reduction in injuries. For knowledge transfer to take place, there is a need of a beneficial relationship between the trainer and the coaches[494]. In this case, one of the trainers was a qualified physiotherapist who had several years of experience within the Rwandan soccer fraternity and was familiar with the context of the training and known to several of the coaches. It is thus likely that this would have resulted in a good rapport between this trainer and coaches.

The method of training varies across published studies and no specific model was followed in this study. Error management and a realistic training environment are the elements of training design that have an impact on the transfer of training[495].

The current training took place over three days, in contrast to many previous studies where the duration of training ranged between 1.5 hours[496] and 8 hours[497;498] encompassing theory and practice[497;498]. The longer training programme used in the present study allowed for both theoretical and practical training within a real-world context, and enabled coaches to assimilate and master the correct instruction of exercises. Emphasis was placed on the appropriateness of the instructions to provide corrections for body alignment and the correct execution of the movements. In addition, follow-up visits were made to the teams and contact was maintained with coaches throughout the season to provide motivation, additional training where necessary, and to reduce errors.

The motivation of the coaches to improve their practice is an important element of successful training[499]. The use of accredited FIFA training material and careful instruction regarding the correct application of the exercises may have provided the coaches with confidence in the potential of the programme to reduce injuries. A number of studies provided instructional videos to coaches, together with training manuals, posters[450;451;452] or a book describing the exercises[497]. Similarly, coaches that participated in the present study were provided with DVDs which included descriptions of the exercises, a complete programme of instructions, a booklet and the FIFA link for references. This may have contributed to the satisfactory levels of compliance observed in this study. The high compliance rate, particularly in match preparation, also points to the effectiveness of the training and the desire of the coaches to improve their practice. It may also be that, within a low- to middle-income country setting, there are fewer opportunities for further training and thus any opportunities to attend training sessions and to implement skills acquired during training are fully utilised.

Only one study reported on the side effects of the intervention, as players reported muscle soreness and one hamstring strain during the 11+ warm up programme[445]. The results of this study indicated that no player sustained any injuries while performing the 11+ programme. Therefore, this indicates that there were no harmful effects resulting from the intervention.

6.5.3 Impact of the FIFA 11+ programme on injuries

The overall, training and match incidence rates were all significantly lower in the intervention group, with an 11% reduction in the overall number of injured players and an average reduction of time off play by six days, compared to the control group.

At an individual level of analysis, the intervention significantly decreased the risk of injuries in the intervention group by 55%; and the odds of sustaining injury in the control group were comparatively increased by 36% and 41% for training and matches respectively. Similar positive effects of the intervention have been reported in three of the four RCTs on the FIFA 11+ programme conducted to date[439;442;445]. However, a further two studies reported a greater reduction in overall injuries. Silvers-Granelli et al[445] reported a 46% reduction of time loss injuries in male youth players. The only other study conducted in African soccer players reported a 41% reduction in the occurrence of overall injuries[439]. This reinforces the results from previous studies that demonstrated the efficacy of the FIFA 11+ warm up programme in preventing injuries in general (Table 6-24).

In the present study, the warm-up intervention programme significantly reduced the incidence of match injuries. Similarly, reduced match injuries were reported among Nigerian soccer players[439] and collegiate first division soccer players in the USA[445]. Any reduction in match injuries would be considered beneficial, as match injury incidences are consistently higher than those sustained during training. This finding is supported by the study conducted among first division players (as discussed in Chapter Three), as well as in several other soccer studies[25;26;27;28;116;121].

The present study found that the intervention reduced contact injuries. The reduction of contact injuries may have resulted from the neuromuscular effects of the FIFA 11+ programme. The completion of the FIFA 11+ programme twice per week improved the physical fitness of young players participating in indoor soccer[500], whereas performing the programme three times per week improved neuromuscular control in amateur soccer players in Italy[501]. Improvement in neuromuscular control and fitness may have prepared players to withstand a number of contacts that would otherwise have resulted in injuries. The results of this study are in contrast with the studies conducted by Owoeye et al[439] and Hammes et al[446], which did not find any effects of the FIFA 11+ programme on contact injuries. However, these studies[439;446] reported poor compliance rates and it is possible that the neuromuscular benefits of the programme may not have been achieved. The same studies[439;446] did not find significant reductions in training injury occurrences[439;446]. Underperformance on the FIFA 11+ programme may have played a role in lack of the effectiveness of the programme in reducing training injuries. Possibly, greater compliance levels should be obtained to achieve the desired effect of the FIFA 11+ programme on training injuries. Further studies would be important to investigate the level of compliance required to prevent training injuries.

Significantly lower incidences were observed in the intervention group for moderate and severe injuries, which is in accordance with the studies conducted by Silvers-Granelli et al[445] and Hammes et al[446]. Reducing severe injuries had a significant effect of the decrease of the time loss due to injuries. The results of the study indicated that the intervention might have protected players from suffering severe injuries, and that injured players in the intervention group returned to play more quickly than players in the control group. It appears the FIFA 11+ programme may not only have reduced the severity of injuries but have contributed to the recovery of the players; although the effect on recovery has not been systematically investigated and should be studied further.

A similar positive impact of the FIFA11+ programme on overall or training incidence was reported in two of the three studies that tested the intervention using RCTs (Table 6-24). The impact in terms of absolute reduction varied from -11% (current study) to -49%[445].These results are not easy to compare as the incidence of injury was heterogeneous (0.8-15.4 per 1000 hours of play)[439;445;446].

Table 6-24: Comparison of current study results and the three RCTs conducted in male soccer players.

Study	**Current**	**Silvers-Granelli et al[445]**	**Owoeye et al[439]**	**Hammes et al[446]**
Country	Rwanda	US[#]	Nigeria	Germany
Population	2nd division, Male (17-27 years)	1st and 2nd division, Male (18-25 years)	Youth Junior league, male (14-19 years)	Veterans, Male (> 31 years)
Randomised	IG: 12 teams, 312 players CG: 12 teams, 318 players	IG: 31 teams, 775 players CG: 34 teams, 850 players	IG: 10 teams, 212 players CG: 10 teams, 204 players	IG: 10 teams, 158 players CG: 10 teams, 125 players
% of injured players	-11%	-Division I: -29% -Division II: -49%	-29%	Not reported
Overall incidence of injury	IG: 2.6* CG: 4.0	IG: 8.9 CG: 15.4	IG: 0.8* CG: 1.5	IG: 12.2 CG: 12.6
Training incidence	IG: 1.1* CG: 1.5	IG: -Division I: 5.1* -Division II: 2.4* CG: -Division I: 10.1 -Division II: 7.7	IG: 0.3 CG: 0.4	IG: 5.5 CG: 8.1
Match incidence	IG: 24.4* CG: 38.7	IG: -Division I: 18.8 -Division II: Not found CG: -Division I: 29.4 -Division II: Not found	IG: 7.5* CG: 20.3	IG: 28.3 CG: 20.5
Contact incidence	IG: 1.9* CG: 2.7	Not reported	IG: 0.6 CG: 1.1	IG: 4.1 CG: 4.8

Study	Current	Silvers-Granelli et al[445]	Owoeye et al[439]	Hammes et al[446]
Lower limb incidence	IG: 2.1* CG: 3.3	IG: 6.2* CG: 11.2	IG: 0.6* CG: 1.2	IG: 10.3 CG:10.2
Non-contact incidence	IG: 0.6 CG: 1.3	Not reported	IG: 0.2 CG: 0.3	IG: 8.2 CG: 7.8
Recurrent injury incidence	IG: 0.02* CG: 0.6	Not reported	Not reported	IG: 4.6 CG: 3.1
Difference in days off play	IG: 168 days* CG: 252days	IG: 2944 days* CG: 8790 days	Not reported	IG: median 14 days* CG: median 27 days

Negative values indicate a reduction in the experimental group. IG=Intervention Group, CG=Control Group
Incidence of injuries are presented per 1000 hours of exposure
**significantly different.*
#: US based study presented the incidence of injuries/1000Athletes Exposures (AEs)

The intervention significantly reduced the incidence of lower limb, thigh and groin, knee and ankle injuries. These results are comparable with the studies conducted by Owoeye et al[439] and Silvers-Granelli et al[445], which both reported a significant reduction of lower extremity injuries in the intervention group compared to the control group. The results are in line with the aspiration of the F-MARC that designed a programme targeting the reduction of lower limb injuries by including exercises designed to improve neuromuscular control with good posture and correct alignment of lower limb joints[442]. An experimental study conducted among 20 young athletes found that performing of 9-weeks FIFA 11+ programme over a nine-week period resulted in increased general lower limb strength as measured by countermovement and squat jumps[507]. This increased strength brought on by the programme may play a role in preventing lower limb injuries. The programme may also benefit first division soccer players by improving lower limb balance and coordination, both of which were identified as predictors of injuries[175;183;186] (as discussed in Section 4.4.6).

The present study found a significant reduction in the incidence of thigh and groin injuries. Likewise, Silvers-Granelli et al[445] found a reduced incidence rate of hamstring, groin and hip injuries. There are specific exercises targeting an increase in muscle strength. Analysing body muscle activation when performing the FIFA 11+ exercises, Nakase et al[502] found an increased core muscle activation, specifically the rectus abdominis and the gluteus medius and minimus. Additionally, the rectus abdominis and hip adductor muscles were more active when performing part two of the programme[502]. These exercises would therefore strengthen the muscles around the hip, contributing to the prevention of hip and groin injuries[503]. The programme incorporated the Nordic hamstring strengthening exercises that was found to be effective in preventing hamstring strains[54;456;457]. As mentioned above, the performance of the FIFA 11+ programme for 24 sessions reportedly increased muscle strength[472]. The study found an increased

peak torque of concentric and eccentric hamstring strength[472]. Therefore, performing the Nordic hamstring strength exercises during warm up may play a role in preventing muscle injuries specifically in the hamstring[54;184;456;457].

The incidence of knee injuries was significantly reduced in the present study, consistent with findings from two previous studies[442;445]. Improvement in neuromuscular control and the correct alignment of the hip, knee and ankle joints[501] may play an important role in knee injury prevention. In addition, a further study found an improvement in the isometric strength and the rate of force development of the quadriceps and hamstring, although these results were not statistically significant[504].The reduction of the incidence and risk of ankle injuries found in the present study may be explained by the improvement in dynamic balance. Except for a single study[445], no significant reduction of ankle injuries were reported to be associated with the warm-up programme.

The results of the present study complement the existing body of knowledge by providing evidence of the positive effects of the FIFA 11+ prevention programme. The study further updated the literature that the FIFA 11+ programme reduced recurrent and contact injuries; which was not found in any of the previous studies. The mechanisms are likely to include the enhancement of physiological performances important for soccer engagement[501;503] and the increase in dynamic balance and suitable soccer skill performance leading to the physiological preparedness of the players that subsequently reduce the risk of injuries[505]. It is therefore important to investigate the possibility of extending the use of the preventive programmes to the wider soccer community in Rwanda, specifically in first division teams. Players in the first division may benefit from the programme as they suffered from an increased rate of ankle injuries, which were also recurrent. Match and contact injuries may be reduced with the improvement of dynamic balance and coordination promoted by the implementation of the FIFA 11+ programme. The exercises incorporated in the programme targeting lower limb strength and balance included one leg stance and squat as well as jumping exercises. First division players may also benefit from the dynamic stretch component of the programme as poor flexibility was found to be related to the increased risk of injuries.

6.5.4 Compliance with the programme

Soligard et al[479] indicated that compliance with the intervention programme is a measure of the uptake of the programme by the coaches. Compliance data were obtained by the reports provided by the coaches as to whether the programme was performed by each team.

The average team compliance level in the present study was 77% for all training sessions and matches. This percentage compares favourably with results reported in the published literature, in which session compliance ranged between 30%[445] to 77% among female youth teams[479]. The uptake was therefore satisfactory and as the programme was administered an average of 3.6 times per week, with no team participating in less than 2.8 sessions a week. Therefore, the recommended implementation rate of twice per week[506] was not only met but exceeded. This indicates that teams were highly compliant with the injury prevention programme. The high compliance rate may be partially attributed to the motivation levels of the coaches. Moreover, the training stimuli comprised of various didactic materials, and the extended practical sessions and regular team visits may have contributed to the conformity to the programme. Coaches may have held beliefs that performing the programme as many times as possible would provide a greater increase in neuromuscular strength, which is an important consideration for injury prevention. However, further investigations, and perhaps qualitative studies are needed to obtain an in-depth understanding of coaches' motivations for compliance with the injury prevention programme.

Unexpectedly, the present study found no differences in either the overall injuries or any other subtype of injuries between the various compliance levels. It was also noted that the exercises were performed in 90% of match sessions. This may indicate that the frequency of programme implementation may not be as important as the regularity of performing the exercises. Similarly, the results of the study conducted by Soligard et al[479] found no differences in injury incidence between participating teams that had high, intermediate and low compliance to the programme. In contrast, Silvers-Granelli et al[445] reported that as compliance levels increased, the incidence of injuries decreased. However, team compliance in this study was low (30%) and there may have been greater variance in the frequency of sessions[445]. Further, it may be that the rate of occurrence is important, but only below a certain critical threshold which was exceeded by all the coaches in this study. Additional research is required to determine the critical threshold, which may guide frequency and duration of the warm-up sessions.

The uptake of the players is also measured by individual player performance of the programme. Owoeye[439] reported that player compliance to the programme was on average 74%, which was higher compared to the proportion reported by Soligard et al[479] of 59%. Unfortunately, due to coaches' time constraints, player compliance with the programme was not adequately reported by the coaches, despite many attempts to encourage them to do so.

Though the majority could understand the rationale and the benefits of the programme, no other incentives were provided to the coaches to ensure appropriate recording. In this context, more support directed toward coaches is needed for appropriate recording. The task of recording may also be given to other members of the coaching staff where possible.

6.5.5 Strengths and limitations of the study

The present study was conducted for a single season which took place between February and August. On average, teams participated in 22 matches and 108 training sessions. This seven-month period may be considered brief while targeting the most beneficial outcomes of the intervention and obtaining the desired neuromuscular effect. However, the duration of this study may be sufficient to determine the effect of the intervention. Studies that were conducted over short periods reported a significant reduction in the occurrence of injuries[439;445].

Additionally, the CONSORT (Consolidated Standards of Reporting Trials) extended to the cluster randomised trials[507] checklist was used to assess the methodological quality of the study (Table 6-25). The strength of the present study is that each of the criteria listed in the checklist were reported upon.

Table 6-25: Strength and limitations analysis of the study using the CONSORT checklist.

Section/Topic	***Item No***	***Checklist item***	**Reported on page number**
Title and abstract			
	1a	*Identification as a cluster randomised trial in the title*	151
	1b	*Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts45 65)*	v
Introduction			
Background and objectives	*2a*	*Rationale for using a cluster design*	151
	2b	*Whether objectives pertain to the cluster level, the individual participant level, or both*	7
Methods			
Trial design	*3a*	*Definition of cluster and description of how the design features apply to the clusters*	153
	3b	*Important changes to methods after trial commencement (such as eligibility criteria), with reasons*	No changes after commencement
Participants	*4a*	*Eligibility criteria for clusters*	153
	4b	*Settings and locations where the data were collected*	151
Interventions	*5*	*Whether interventions pertain to the cluster level, the individual participant level, or both*	155
Outcomes	*6a*	*Whether outcome measures pertain to the cluster level, the individual participant level, or both*	157

Section/Topic	*Item No*	*Checklist item*	**Reported on page number**
	6b	*Any changes to trial outcomes after the trial commenced, with reasons*	No changes after commencement
Sample size	*7a*	*Method of calculation, number of clusters(s) (and whether equal or unequal cluster sizes are assumed), cluster size, a coefficient of intracluster correlation (ICC or k), and an indication of its uncertainty*	153
	7b	*When applicable, explanation of any interim analyses and stopping guidelines*	Not applicable
Randomisation:			
Sequence generation	*8a*	*Method used to generate the random allocation sequence*	155
	8b	*Details of stratification or matching if used*	Not applicable N/A
Allocation concealment mechanism	*9*	*Specification that allocation was based on clusters rather than individuals and whether allocation concealment (if any) was at the cluster level, the individual participant level, or both*	159
Implementation	*10a*	*Who generated the random allocation sequence, who enrolled clusters, and who assigned clusters to interventions*	159
	10b	*Mechanism by which individual participants were included in clusters for the purposes of the trial (such as complete enumeration, random sampling)*	159
	10c	*From whom consent was sought (representatives of the cluster, or individual cluster members, or both) and whether consent was sought before or after randomisation*	162
Blinding	*11a*	*If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how*	155
	11b	*If relevant, description of the similarity of interventions*	Not applicable
Statistical methods	*12a*	*How clustering was taken into account outcomes*	161
	12b	*Methods for additional analyses, such as subgroup analyses and adjusted analyses*	161
Results			
Participant flow (a diagram is strongly recommended)	*13a*	*For each group, the numbers of clusters that were randomly assigned, received intended treatment, and were analysed for the primary outcome*	164
	13b	*For each group, losses and exclusions for both clusters and individual cluster members*	164
Recruitment	*14a*	*Dates defining the periods of recruitment and follow-up*	164
	14b	*Why the trial ended or was stopped*	Not applicable
Baseline data	*15*	*Baseline characteristics for the individual and cluster levels as applicable for each group*	165
Numbers analysed	*16*	*For each group, number of clusters included in each analysis*	165, 167
Outcomes and estimation	*17a*	*Results at the individual or cluster level as applicable and a coefficient of intracluster correlation (ICC or k) for each primary outcome*	170
	17b	*For binary outcomes, presentation of both absolute and relative effect sizes is recommended*	170
Ancillary analyses	*18*	*Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre- specified from*	178, 182

Section/Topic	*Item No*	*Checklist item*	**Reported on page number**
Harms	*19*	*All important harms or unintended effects in each group (for specific guidance see CONSORT for harms42)*	191
Discussion			
Limitations	*20*	*Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses*	198
Generalisability	*21*	*Generalisability to clusters and/or individual participants (as relevant)*	201
Interpretation	*22*	*Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence*	201
Other information			
Registration	*23*	*Registration number and name of trial registry*	162
Protocol	*24*	*Where the full trial protocol can be accessed, if available*	Not applicable
Funding	*25*	*Sources of funding and other support (such as supply of drugs), role of funders*	Not applicable

The text is in italics as the table was directly copied from the published paper on page 14[507]*. The checklist is open access and no permission was required.*

There were certain weaknesses that need to be noted and addressed in future studies if possible. The nature of the study required close monitoring and supervision of the coaches for compliance. In the present study, the researcher supervised the coaches; therefore, it was not possible to blind the researcher to the group allocations. Similarly, it was not possible to blind the coaches to the players' group allocation. However, the medical personnel and research assistants were blinded as to which team was allocated to the intervention or control groups. The single blinding was maintained as none of the research assistants and medical personnel had any information about the nature, type and organisation of the internvetion, from training to follow-up.

Further, the diagnosis of each injury may not have been accurate in all cases, as the study relied on the reports from the medical personnel of the teams using subjective and physical examination due to limited funding and the unavailability of resources.

In Rwanda, systematic recording of injuries and exposure is currently not standardised, therefore recording this type of data was also new to both the coaches and medical personnel. This process placed an additional load to their usual work activities. As a result, coaches were not willing to provide player compliance information as this was too time consuming.

The work of the research assistants would be acknowledged who ensured that there was no missing or unclear data obtained. Additionally, the medical personnel and coaches were instructed to record data as soon as possible to avoid inaccuracies associated with recording information retrospectively.
It would also be interesting to explore barriers and facilitators to the use of standardised injury reporting methods within this context; and to identify how acceptability of injury reporting methods and training loads could be improved.

6.6 Conclusion and Recommendations

The results of the present study, which concur with the majority of studies that have examined the impact of the FIFA 11+ programme, indicate that the programme is worth pursuing, particularly within the second division and possibly at less experienced club level. Silvers-Granelli et al[445] reported that the impact of the intervention was greater in second division players and thus, it may not be as effective at a higher levels of competition. Additional research is required to provide empirical evidence supporting the roll out of the programme at every level of play. The FIFA 11+ programme significantly reduced lower limb injury incidence and, more specifically, the risk of ankle injuries in second division players. Therefore, the use of the programme would be advocated to reduce the likelihood of lower limb injuries as it has been reported that the lower limbs are most affected by participating in soccer.

The improvement in coaching behaviours witnessed in the coaches in both the intervention and control groups indicate that Rwandan coaches are open to change. Further training regarding safe practice and injury prevention is thus likely to be well-received and may facilitate improved practice. The scarcity of opportunities for training in low to middle-income countries may have contributed to the high level of compliance observed in this study, which may also have played a role in the observed effectiveness of the programme. However, strategies are required to facilitate sustained behaviour change and the overall long-term impact of training programmes. More understanding of the barriers and facilitators to the use of standardised injury and load reporting methods within this context would be important.

The programme may also benefit first division soccer players by improving lower limb balance and coordination, both of which were identified as predictors of injuries. The injury prevention strategies found effective in soccer would also be investigated in other sporting codes that involve activities somehow similar to soccer. Further recommendations for practice, policy and research are presented in Chapter Seven.

CHAPTER 7. GENERAL CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

The prospective cohort study conducted over two consecutive seasons within the first division teams (Chapter Three) resulted in a credible estimation of the incidence, nature and occurrence of soccer injuries in first division players in Rwanda. Although the results indicate similarities with published research, the most striking finding was the lower incidence of injuries, which was unexpected. Although the incidence is possibly on the lower end of the range of reported injury incidences, there were still a large number of players who sustained injuries, some of which were classified as severe. As in many low-income countries, players are unlikely to have alternative employment options apart from soccer, therefore it is essential that injury ratesare minimised as far as possible.

Matches accounted for the majority of injuries and concentrated match schedules seemed to have made the players increasingly vulnerable to sustaining injuries. The inclusion of additional teams and matches shouldbe carefully considered by the administration as it may result in a further increase in injury incidence. Furthermore, many injuries were sustained as a result foul play and ill-disciplined behaviour, which should be addressed and enforced by skilled refereeing of matches. The recurrence rate was relatively low which may indicate the appropriate management of injuries. However, the management of concussion injuries was poor and may have put players at risk for more severe brain injuries. In addition, poor flexibility, balance and coordination were associated with injury and, as these are modifiable to a certain extent, training sessions should include stretching as well as coordination training.

The RCT conducted among second division teams (Chapter Six) is the fourth RCT examining the effect of the FIFA 11+ injury prevention programme among male soccer playersand the second conducted in an African population. The teams allocated to the intervention group completed the injury prevention programme during an average of 77% of all training sessions and matches. These teams carried out the injury prevention programme an average of 3.6 times per week which indicated an acceptable level of compliance with the programme.The intention-to-treat results indicated that the FIFA 11+ programme significantly decreased the incidence of overall, training and match injuries among second division soccer players. There is therefore a need to incorporate the FIFA 11+ programme in the wider soccer community to reduce the burden of injuries. The intervention significantly reduced the incidence of lower limb injuries.

The positive effects of the programme on contact and non-recurrent injuries as well as on severe injuries had implications for reducing serious soccer injuries.There is therefore a need to incorporate the FIFA 11+ programme in Rwanda to minimise the inherent risks associated with soccer participation.

Both the FIFA 11+ programme and the first aid training have increased coaches awareness of their role in injury prevention by identifying risk situations and considering prevention, particularly by checking protective equipment and the safety of playing fields and facilities. Coaches are the key elements in the implementation of injury prevention. Therefore understanding the impact of the design, delivery and coaches' factors would enhance the ultimate real-world impact of coach-led injury prevention context. In Rwanda, a more comprehensive injury prevention should be tailored towards players' physical fitness, playing behaviour, coaching practice as well as medical interventions for utmost safety of soccer players.

7.2 Recommendations

7.2.1 Recommendations for practice

Key recommendations for practice are as follows:

- The results obtained in the present studies should be disseminated among all soccer stakeholders in Rwanda. The preventive measures suggested to minimise the incidence of injuries should be implemented by the players as well as administrative, coaching, and medical personnel.

- Players should be aware of the effects of various types of injuries as well as the risk-taking behaviour that cause injuries, such as irregular tackles and elbows to head. Players should be taught to refrain from vigorous contact that constitute injury risk, with an emphasis on fair play.

- Coaches should be knowledgeable regarding the principles of correct training and should plan training appropriately by balancing the load. Coaches should also rotate players during matches to reduce the risk of injuries seen as a result of high match load accumulation. Flexibility, balance and coordination exercises should be included in both training and warm-up programmes.

- Medical staff should comprehend their scope of practice and should strive to increase their knowledge regarding the prevention, treatment and rehabilitation of injuries. Medical staff should also stay abreast of the current practice regarding injury management and return to play risk assessment especially regarding concussion injuries.

- Team administrators should provide funding for the full time retention of medical personnel and the acquisition of the necessary equipment to prevent and manage injuries.

- Finally, collaboration among stakeholders is paramount to reach to the desired levels of injury prevention.

7.2.2 Recommendations for policy

Important recommendations for policy include:

- Sport safety policies should be developed and disseminated to protect the players. Measures should be taken to reinforce the implementation of these policies and the rules of the game. Severe sanctions on dangerous play should also be effected and enforced.

- The injury incidences that were observed and the reduction of injury risk shown by the implementation of the FIFA 11+ programme should be used to advocate for improved resourcing across all levels of soccer.

- Medical personnel should be more involved in the prevention of injuries – where FIFA 11+ programme interventions can be applied at population levels and found to be more cost effective while promoting longevity in sports participation.

- FERWAFA should assist teams at all levels by providing the necessary support to implement the programme and minimise the risk of injuries in soccer.

7.2.3 Recommendations for future studies

Further research is needed on the various aspects highlighted above to decrease the occurrence injuries and the negative impact of injuries among soccer players, particularly in low-income settings.

Based on the first and second steps of the Van Mechelen et al's[59] model and the TRIPP framefork[47] for injury prevention aiming at identifying injury risk factors, the present study highlighted that soccer players in Rwanda frequently sustained moderate to severe injuries; and that an increased risk of overall and lower limb injuries were identified. More investigations are needed though prospective surveillance follow up of players to establish intrinsic and extrinsic risk factors; as well as the mechanisms for overall or specific injuries, like the groin, thigh, knee and ankle, to further inform preventive measures.

The third and fourth steps of the Van Mechelen et al's[59] model and the TRIPP framefork[47] for injury prevention aim at developing and introducing preventive measures and scientifically assess their effectiveness mostly targeting players at risk. Implementation of individualised and tailored interventions for at-risk players is appropriate for highly-resourced teams. Although it is likely that individualised injury prevention programmes are more focussed and more beneficial to individual players, the implementation of a more general programme like the FIFA 11+ is more appropriate in teams with minimal resources. Future research should also be conducted to assess the effectiveness of injury prevention programmes that are specifically directed at the most frequent or severe injuries in soccer

Finally, the fifth and sixth stages of the TRIPP[47] framework highlight the necessity of understanding the implementation context once the prevention intervention has been found to be effective. In the present study, teams were visited regularly to monitor the implementation of the introduced intervention. Interaction with coaches, players and medical personnel would enlighten what works in the "*real world*" with commitment, involvement of all the stakeholders. Furthermore, the researcher was contactable telephonically at any time, which also played a role in the successful implementation of the injury prevention programme in this thesis. It is also important to explore barriers and facilitators to the use of standardised injury reporting methods within this context; and to identify how acceptability of injury reporting methods and training loads could be improved. Although not all the participants in this study had up-to-date technology or devices, further research could use available communication tools to improve involvement, implementation and compliance to the prevention programme.

REFERENCES

1. Costa IT, Silva JM, Greco PJ, Mesquita I. Tactical Principles of Soccer Game: concepts and application. *Motriz-Revista Educ Fis*. 2009;15(3):657-668. doi:dx.doi.org/10.5016/2488.
2. Fuller CW, Junge A, Dvorak J. Risk management: FIFA's approach for protecting the health of football players. *Br J Sports Med*. 2012;46(1):11-17. doi:10.1136/bjsports-2011-090634.
3. Covassin T, Cheng G, Nayar S, Heiden E. Epidemiology of Overuse and Acute Injuries Among Competitive Collegiate Athletes. *J Athl Train*. 2012;47(2):198-204.
4. Fuller CW, Ekstrand J, Junge a, et al. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Br J Sports Med*. 2006;40(3):193-201. doi:10.1136/bjsm.2005.025270.
5. Johnson U, Ekengren J, Andersen M. Injury Prevention in Sweden: Helping Soccer Players at Risk. *J Sport Exerc Psychol*. 2005;27(1989):32-38. doi:4643.pdf.
6. FIFA. The Big count. *FIFA Mag*. 2007;(July):11-13. http://www.fifa.com/mm/document/fifafacts/bcoffsurv/bigcount.statspackage_7024.pdf.
7. Hawkins RD, Fuller CW. A prospective epidemiological study of injuries in four English professional football clubs. *Br J Sports Med*. 1999;33:196-203. doi:doi:10.1136/bjsm.33.3.196.
8. Rosario C. Preparing a Young Player for a Try Out to a Professional Club. *Elit Soccer Dev*. Building t:1-6. www.elitesoccerdevelopment.com%0D.
9. Gabbett TJ. The training — injury prevention paradox : should athletes be training smarter and harder ? *Br J Sports Med*. 2016;50:273-280. doi:10.1136/bjsports-2015-095788.
10. Volpi P, Taioli E. The health profile of professional soccer players: future opprtunities for injury prevention. *J strength Cond Res*. 2012;26(12):3473-3479.
11. Junge A, Dvorak J, Chomiak J, Peterson L, Graf-baumann T. Medical History and Physical Findings in Football Players of Different Ages and Skill Levels. *Am J Sports Med*. 2000;28(5):16-21.
12. Junge A, Dvorak J, Rosch D, Graf-baumann T, Chomiak J, Peterson L. Psychological and Sport-Specific Characteristics of Football Players. *Am J Sports Med*. 2000;28(5):22-28.
13. Rosch D, Hodgson R, Peterson L, Graf-baumann T. Assessment and Evaluation of Football Performance. *Am J Sports Med*. 2000;28(5):29-39.
14. Dvorak J, Junge A. Football Injuries and Physical Symptoms A Review of the Literature. *Am J Sports Med*. 2000;28(suppl. 1):3-9.
15. Junge A, Dvorak J. Injuries in female football players in top-level international tournaments. *Br J Sports Med*. 2007;10(41):3-8. doi:10.1136/bjsm.2007.036020.
16. Dvorak J, Junge A, Chomiak J, Graf-baumann T, Peterson L, Ro D. Risk Factor Analysis for Injuries in Football Players Possibilities For a Prevention Program. *Am J Sports Med*. 2000;28(5):69-74.
17. Junge A, Langevoort G, Pipe A, et al. Injuries in team sport tournaments during the 2004 Olympic Games. *Am J Sports Med*. 2006;34(4):565-576. doi:10.1177/0363546505281807.
18. Hägglund M, Waldén M, Ekstrand J. Previous injury as a risk factor for injury in elite football: a prospective study over two consecutive seasons. *Br J Sports Med*. 2006;40(9):767-772. doi:10.1136/bjsm.2006.026609.
19. Nilstad A, Andersen TE, Bahr R, Holme I, Steffen K. Risk factors for lower extremity injuries in elite female soccer players. *Am J Sports Med*. 2014;42(4):940-948. doi:10.1177/0363546513518741.
20. Henry T, Evans K, Snodgrass SJ, Miller A, Callister R. Risk Factors for Noncontact Ankle Injuries in Amateur Male Soccer Players: A Prospective Cohort Study. *Clin J Sport Med*. September 2015. doi:10.1097/JSM.0000000000000240.
21. Dauty M, Collon S. Incidence of injuries in french professional soccer players. *Int J Sports Med*. 2011;32(12):965-969. doi:10.1055/s-0031-1283188.
22. Hagglung M, Walden M, Ekstrand J. Injuries among male and female elite football players. *Scand*

J Med Sci Sports. 2009;19:819-827. doi:10.1111/j.1600-0838.2008.00861.x.
23. Ekstrand J, Hägglund M, Waldén M. Injury incidence and injury patterns in professional football: the UEFA injury study. *Br J Sports Med*. 2011;45(7):553-558. doi:10.1136/bjsm.2009.060582.
24. Eirale C, Farooq A, Smiley FA, Tol JL, Chalabi H. Epidemiology of football injuries in Asia : A prospective study in Qatar. *J Sci Med Sport*. 2013;16(2):113-117. doi:10.1016/j.jsams.2012.07.001.
25. Konopinski MD, Jones GJ, Johnson MI. The Effect of Hypermobility on the Incidence of Injuries in Elite-Level Professional Soccer Players. *Am J Sports Med*. 2012;40(4):763-769. doi:10.1177/0363546511430198.
26. Gallo PO, Argemi R, Batista J, Lic LG, Liotta G. The epidemiology of injuries in a professional soccer team in Argentina. *Int Sport J*. 2006;7(4):255-265.
27. Mallo J, González P, Veiga S, Navarro E. Injury incidence in a Spanish sub-elite professional football team : A prospective study during four consecutive seasons. *J Sport Sci Med*. 2011;10:731-736.
28. Reis GF, Santos TRT, Lasmar RCP. Sports injuries profile of a first division Brazilian soccer team : a descriptive cohort study. *Brazilian J Phys Ther*. 2015;19(5):390-397.
29. Sousa P, Rebelo A, Brito J. Injuries in amateur soccer players on arti fi cial turf : A one-season prospective study. *Phys Ther Sport*. 2013;14(3):146-151. doi:10.1016/j.ptsp.2012.05.003.
30. Beijsterveldt A Van, Steffen K, Stubbe JH, Frederiks JE, Port IGL Van De, Backx FJG. Soccer Injuries and Recovery in Dutch Male Amateur Soccer Players : Results of a Prospective Cohort Study. *Clin J Sport Med*. 2014;24(4):337-342.
31. Brito J, Malina RM, Seabra A, et al. Injuries in portuguese youth soccer players during training and match play. *J Athl Train*. 2012;47(2):191-197.
32. Owoeye OB a, Akinbo SR a, Olawale O a, Tella B a. Injury prevention in football : Knowledge and behaviour of players and availability of medical care in a Nigerian youth football league. *South African J Sport Med*. 2013;25(3):77-80. doi:10.7196/SAJSM.471.
33. Akodu A, Owoeye O, Ajenifuja M, Akinbo S, Olatona F, Ogukunle O. Incidence and characteristics of injuries during the 2011 West Africa Football Union (WAFU) Nations' Cup. *Afr J Med Med Sci*. 2012;41(4):423-428.
34. Azubuike SO, Okojie OH. An epidemiological study of football (soccer) injuries in Benin City, Nigeria. *Br J Sports Med*. 2009;43(5):382-386. doi:10.1136/bjsm.2008.051565.
35. Ani UK, Ibikunle PO, Akosile CO, Useh U. The UEFA model in identification of types , severity and mechanism of injuries among professional footballers in the Nigerian Premier League. *South African J Sport Med*. 2015;27(1):12-15. doi:10.7196/SAJSM.514.
36. Calligeris T, Burgess T, Lambert M. The incidence of injuries and exposure time of professional football club players in the Premier Soccer League during football season. *South African J Sport Med*. 2015;27(1):27-30. doi:10.7196/SAJSM.610.
37. Frantz JM, Amosun S., Weitz W. Injuries among adolescent soccer players during an interprovincial tournament in South Africa. *South African J Sport Med*. 1999;6(2):13-15.
38. Twizere J. Epidemiology of Soccer injuries in Rwanda: A need for Physiotherapy intervention. *Cape Town, Univ West Cape*. 2004:154.
39. Nshimiyimana JB, Frantz JM. Epidemiology of soccer-related injuries among male high school players in Kigali , Rwanda. *African J Phys Heal Educ Recreat Danc*. 2012;18(3):597-603.
40. Niyonsenga JD, Phillips JS. Factors associated with injuries among first-division Rwandan female soccer players. *Afr Health Sci*. 2013;13(4):1021-1026. doi:10.4314/ahs.v13i4.23.
41. Ristolainen L, Heinonen A, Turunen H, et al. Type of sport is related to injury profile: A study on cross country skiers, swimmers, long-distance runners and soccer players. A retrospective 12-month study. *Scand J Med Sci Sport*. 2010;20(3):384-393. doi:10.1111/j.1600-0838.2009.00955.x.

42. Darrow CJ, Collins CL, Yard EE, Comstock RD. Epidemiology of severe injuries among United States high school athletes: 2005-2007. *Am J Sports Med*. 2009;37(9):1798-1805. doi:10.1177/0363546509333015.
43. Parkkari J, Kujala UM, Kannus P. Is it possible to prevent sports injuries? Review of controlled clinical trials and recommendations for future work. *Sport Med*. 2001;31(14):985-995. doi:311403 [pii].
44. Arnason A, Sigurdsson SB, Gudmundsson A, Holme I, Engebretsen L, Bahr R. Physical Fitness, Injuries, and Team Performance in Soccer. *Med Sci Sports Exerc*. 2004;36(2):278-285. doi:10.1249/01.MSS.0000113478.92945.CA.
45. Eirale C, Tol JL, Farooq A, Smiley F, Chalabi H. Low injury rate strongly correlates with team success in Qatari professional football. *Br J Sports Med*. 2013;47:807-808. doi:10.1136/bjsports-2012-091040.
46. van Mechelen W, Hlobil H, Kemper HC. Incidence, severity, aetiology and prevention of sports injuries. A review of concepts. *Sports Med*. 1992;14(2):82-99. doi:10.2165/00007256-199214020-00002.
47. Finch C. A new framework for research leading to sports injury prevention. *J Sci Med Sport*. 2006;9(1-2):3-9. doi:10.1016/j.jsams.2006.02.009.
48. Klügl M, Shrier I, McBain K, et al. The prevention of sport injury: an analysis of 12,000 published manuscripts. *Clin J Sport Med*. 2010;20(6):407-412. doi:10.1097/JSM.0b013e3181f4a99c.
49. Engebretsen L, Bahr R. An ounce of prevention? *Br J Sports Med*. 2005;39(6):312-313. doi:10.1136/bjsm.2005.018333.
50. Tropp H, Askling CM, Gillquist J. Prevention of ankle sprains. *Am J Sports Med*. 1985;13(4):259-262. doi:10.1177/036354658501300408.
51. Surve I, Schwellnus M, Noakes T, Lombard C. A Fivefold Reduction in the Incidence of Recurrent Ankle Sprains in Soccer Players Using the Sport-Stirrup Orthosis. *Am J Sports Med*. 1994;22(5):601-606. doi:10.1177/036354659402200506.
52. Sharpe SR, Knapik J, Jones B. Ankle Braces Effectively Reduce Recurrence of Ankle Sprains in Female Soccer Players. *J Athl Train*. 1997;32(1):21-24.
53. Soderman K, Werner S, Pietilä T, Engström B, Alfredson H. Balance board training : prevention of traumatic injuries of the lower extremities in female soccer players ? A prospective randomized intervention study. *Knee Surgery, Sport Traumatol Arthrosc*. 2000;8:356-363. doi:10.1007/s001670000147.
54. Arnason a., Andersen TE, Holme I, Engebretsen L, Bahr R. Prevention of hamstring strains in elite soccer: An intervention study. *Scand J Med Sci Sport*. 2008;18(1):40-48. doi:10.1111/j.1600-0838.2006.00634.x.
55. Van Beijsterveldt AMC, Van De Port IGL, Krist MR, et al. Effectiveness of an injury prevention programme for adult male amateur soccer players: A cluster-randomised controlled trial. *Br J Sports Med*. 2012;45(5):6-13. doi:10.1136/bjsports-2012-091277.
56. Croisier J, Ganteaume S, Binet J, Genty M, Ferret J. Strength Imbalances and Prevention of Hamstring Injury in Professional Soccer Players A Prospective Study. *Am J Sports Med*. 2008;36(8):1469-1475. doi:10.1177/0363546508316764.
57. Mohammadi F. Comparison of 3 preventive methods to reduce the recurrence of ankle inversion sprains in male soccer players. *Am J Sports Med*. 2007;35(6):922-926. doi:10.1177/0363546507299259.
58. Emery CA, Meeuwisse WH. The effectiveness of a neuromuscular prevention strategy to reduce injuries in youth soccer : a cluster-randomised controlled trial. *Br J Sports Med*. 2010;44:555-562. doi:10.1136/bjsm.2010.074377.
59. van Mechelen W, Hlobil H, Kemper HCG. Incidence , Severity , Aetiology and Prevention of Sports

Injuries : A Review of Concepts. *Sport Med*. 1992;14(2):82-99. doi:10.2165/00007256-199214020-00002.
60. Twagiramungu F. *Environmental Profile of Republic of Rwanda*.; 2006.
61. NISR NI of S of R. the Third Integrated Household Living Conditions Survey (Eicv3). 2011.
62. Nkuutu H. No more excuses for Gen. Kazura. *The new times*. http://allafrica.com/stories/201001040575.html. Published August 13, 2010.
63. Ferwafa. Competition regulation of Ferwafa. 2015:1-48. http://www.ferwafa.rw/IMG/pdf/ferwafa_competition_regulations.pdf.
64. Junge A, Dvorak J. Soccer injuries: A review on incidence and prevention. *Sport Med*. 2004;34(13):929-938. doi:10.2165/00007256-200434130-00004.
65. Verhagen E a LM, van Stralen MM, van Mechelen W. Behaviour, the key factor for sports injury prevention. *Sports Med*. 2010;40(11):899-906. doi:10.2165/11536890-000000000-00000.
66. Krustrup P, Nielsen JJ, Krustrup BR, et al. Recreational soccer is an effective health-promoting activity for untrained men. *Br J Sports Med*. 2009;43(11):825-831. doi:10.1136/bjsm.2008.053124.
67. Nybo L, Sundstrup E, Jakobsen MD, et al. High-intensity training versus traditional exercise interventions for promoting health. *Med Sci Sports Exerc*. 2010;42(10):1951-1958. doi:10.1249/MSS.0b013e3181d99203.
68. Hollekim-Strand SM, Bjørgaas MR, Albrektsen G, Tjønna AE, Wisløff U, Ingul CB. High-intensity interval exercise effectively improves cardiac function in patients with type 2 diabetes mellitus and diastolic dysfunction: A randomized controlled trial. *J Am Coll Cardiol*. 2014;64(16):1758-1760. doi:10.1016/j.jacc.2014.07.971.
69. Pedersen BK, Saltin B. Evidence for prescribing exercise as therapy in chronic disease. *Scand J Med Sci Sports*. 2006;16 Suppl 1:3-63. doi:10.1111/j.1600-0838.2006.00520.x.
70. Krustrup P, Randers MB, Andersen LJ, Jackman SR, Bangsbo J, Hansen PR. Soccer improves fitness and attenuates cardiovascular risk factors in hypertensive men. *Med Sci Sports Exerc*. 2013;45(3):553-560. doi:10.1249/MSS.0b013e3182777051.
71. Hayashino Y, Jackson JL, Fukumori N, Nakamura F, Fukuhara S. Effects of supervised exercise on lipid profiles and blood pressure control in people with type 2 diabetes mellitus: A meta-analysis of randomized controlled trials. *Diabetes Res Clin Pract*. 2012;98(3):349-360. doi:10.1016/j.diabres.2012.10.004.
72. Randers MB, Petersen J, Andersen LJ, et al. Short-term street soccer improves fitness and cardiovascular health status of homeless men. *Eur J Appl Physiol*. 2012;112(6):2097-2106. doi:10.1007/s00421-011-2171-1.
73. Randers M, Nielsen J, Krustrup B, et al. Positive performance and health effects of a football training program over 12 weeks can be maintained over a 1-year period with reduced training frequency. *Scand J Med Sci Sport*. 2010;20(SUPPL. 3):80-89. doi:10.1111/j.1600-0838.2010.01091.x.
74. Helge EW, Andersen TR, Schmidt JF, et al. Recreational football improves bone mineral density and bone turnover marker profile in elderly men. *Scand J Med Sci Sports*. 2014;24 Suppl 1:98-104. doi:10.1111/sms.12239.
75. Krustrup P, Christensen JF, Randers MB, et al. Muscle adaptations and performance enhancements of soccer training for untrained men. *Eur J Appl Physiol*. 2010;108(6):1247-1258. doi:10.1007/s00421-009-1319-8.
76. Faude O, Kerper O, Multhaupt M, et al. Football to tackle overweight in children. *Scand J Med Sci Sports*. 2010;20:103-110. doi:10.1111/j.1600-0838.2009.01087.x.
77. Bangsbo J, Hansen PR, Dvorak J, Krustrup P. Recreational football for disease prevention and treatment in untrained men: a narrative review examining cardiovascular health, lipid profi le,

body composition, muscle strength and functional capacity. *Br J Sports Med*. 2015;49:568-576.
78. Ottesen L, Jeppesen RS, Krustrup BR. The development of social capital through football and running: studying an intervention program for inactive women. *Scand J Med Sci Sports*. 2010;20:118-131. doi:10.1111/j.1600-0838.2010.01123.x.
79. Nielsen G, Wikman JM, Jensen CJ, Schmidt JF, Gliemann L, Andersen TR. Health promotion: The impact of beliefs of health benefits, social relations and enjoyment on exercise continuation. *Scand J Med Sci Sport*. 2014;24(SUPPL.1):66-75. doi:10.1111/sms.12275.
80. Fuller CW, Ekstrand J, Junge a., et al. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Scand J Med Sci Sport*. 2006;16(2):83-92. doi:10.1111/j.1600-0838.2006.00528.x.
81. Brooks JHM, Fuller CW. The Influence of Methodological Issues on the Results and Conclusions from Epidemiological Studies of Sports Injuries. *Sport Med*. 2006;36(6):459-472. doi:10.2165/00007256-200636060-00001.
82. Carling C, Mccall A, Gall F Le, Dupont G. The impact of short periods of match congestion on injury risk and patterns in an elite football club. *Br J Sports Med*. 2015;0:1-6. doi:10.1136/bjsports-2015-095501.
83. Dellal A, Wong DP, Moalla W. Physical and technical activity of soccer players in the French First League – with special reference to their playing position. *Int Sport J*. 2010;11(2):278-290.
84. Gall F Le, Carling C, Reilly T, Vandewalle H, Church J, Rochcongar P. Incidence of Injuries in Elite French Youth Soccer Players A 10-Season Study. 2006;34(6):26-30. doi:10.1177/0363546505283271.
85. Le Gall F, Carling C, Reilly T. Injuries in young elite female soccer players: an 8-season prospective study. *Am J Sports Med*. 2008;36:276-284. doi:10.1177/0363546507307866.
86. Cloke DJ, Spencer S, Hodson A, Deehan D. The epidemiology of ankle injuries occurring in English Football Association academies. *Br J Sports Med*. 2008;43:1119-1126. doi:10.1136/bjsm.2008.052050.
87. Cloke DJ, Ansell P, Avery P, Deehan D. Ankle injuries in football academies : a three-centre prospective study. *Br J Sports Med*. 2011;45:702-708. doi:10.1136/bjsm.2009.067900.
88. Collinge R, Simmonds J V. Hypermobility , injury rate and rehabilitation in a professional football squad – A preliminary study. *Phys Ther Sport*. 2009;10(3):91-96. doi:10.1016/j.ptsp.2009.03.001.
89. Aus der Funten K, Faude O, Lensch J, Meyer T. Injury Characteristics in the German Professional Male Soccer Leagues After a Shortened Winter Break. *J Athl Train*. 2014;49(6):786-793. doi:10.4085/1062-6050-49.3.51.
90. Krutsch W, Zeman F, Zellner J, Pfeifer C, Nerlich M, Angele P. Increase in ACL and PCL injuries after implementation of a new professional football league. *Knee Surgery, Sport Traumatol Arthrosc*. 2014;Epub ahead. doi:10.1007/s00167-014-3357-y.
91. Bjørneboe J, Bahr R, Andersen TE. Gradual increase in the risk of match injury in Norwegian male professional football : A 6-year prospective study. *Scand J Med Sci Sports*. 2014;24:189-196. doi:10.1111/j.1600-0838.2012.01476.x.
92. Kristenson K, Bjørneboe J, Waldén M, Andersen TE, Ekstrand J, Hägglund M. Injuries in male professional football : A prospective comparison between individual and team-based exposure registration. *Scand J Med Sci Sports*. 2015:1-8. doi:10.1111/sms.12551.
93. Hägglund M, Waldén M, Ekstrand J. Injuries among male and female elite football players. *Scand J Med Sci Sport*. 2009;19:819-827. doi:10.1111/j.1600-0838.2008.00861.x.
94. Timpka T, Risto O, Bjormsjo M. Boys soccer league injuries : a community-based study of time-loss from sports participation and long-term sequelae. *Eur J Public Health*. 2007;18(1):19-24. doi:10.1093/eurpub/ckm050.
95. Kristenson K, Bjørneboe J, Waldén M, Andersen TE, Ekstrand J, Hägglund M. The Nordic Football

Injury Audit: higher injury rates for professional football clubs with third-generation artificial turf at their home venue. *Br J Sports Med*. 2013;47(12):775-781. doi:10.1136/bjsports-2013-092266.
96. Rössler R, Junge A, Chomiak J, Dvorak J, Faude O. Soccer injuries in players aged 7 to 12 years: A descriptive epidemiological study over 2 seasons. *Am J Sports Med*. 2016;44(2):309-316. doi:10.1177/0363546515614816.
97. Bengtsson H, Ekstrand J, Hägglund M. Muscle injury rates in professional football increase with fi xture congestion : an 11-year follow-up of the UEFA Champions League injury study. *Br J Sports Med*. 2013;47:743-747. doi:10.1136/bjsports-2013-092383.
98. Ekstrand J, Hägglund M, Kristenson K, Magnusson H, Waldén M. Fewer ligament injuries but no preventive effect on muscle injuries and severe injuries : an 11-year follow-up of the UEFA Champions League injury study. *Br J Sports Med*. 2013;47:732-737. doi:10.1136/bjsports-2013-092394.
99. Lundblad M, Waldén M, Magnusson H, Karlsson J, Ekstrand J. The UEFA injury study : 11-year data concerning 346 MCL injuries and time to return to play. *Br J Sports Med*. 2013;47:759-762. doi:10.1136/bjsports-2013-092305.
100. Waldén M, Hägglund M, Ekstrand J. Time-trends and circumstances surrounding ankle injuries in men ' s professional football : an 11-year follow-up of the UEFA Champions League injury study. *Br J Sports Med*. 2013;47:748-753. doi:10.1136/bjsports-2013-092223.
101. Vilamitjana J, Lentini N, Masabeu E. THE INFLUENCE OF MATCH FREQUENCY ON THE RISK OF INJURY IN PROFESSIONAL SOCCER. *Int Sport J*. 2016;14(3):139-147. doi:10.13140/2.1.2019.3921.
102. Owoeye OBA, Aiyegbusi AI, Fapojuwo OA, Badru OA, Babalola AR. Injuries in male and female semi-professional football (soccer) players in Nigeria: prospective study of a National Tournament. *BMC Res Notes*. 2017;10(1):133. doi:10.1186/s13104-017-2451-x.
103. Lislevand M, Andersen TE, Junge A, Dvorak J, Steffen K. Injury surveillance during a 2-day national female youth football tournament in Kenya. *Br J Sports Med*. 2014;48:924-928. doi:10.1136/bjsports-2013-092307.
104. Eirale C, Hamilton B, Bisciotti G, Grantham J, Chalabi H. Injury epidemiology in a national football team of the Middle East. *Scand J Med Sci Sports*. 2012;22:323-329. doi:10.1111/j.1600-0838.2010.01227.x.
105. Eirale C, Tol JL, Smiley F, Farooq A, Chalabi H. Does Ramadan Affect the Risk of Injury in Professional Football ? *Clin J Sport Med*. 2013;23(4):261-266.
106. Aoki H, O'Hata N, Kohno T, Morikawa T, Seki J. A 15-Year Prospective Epidemiological Matches in Japan. *Am J Sports Med*. 2012;40(5):106-1014. doi:10.1177/0363546512438695.
107. Almutawa M, Scott M, George KP, Drust B. The incidence and nature of injuries sustained on grass and 3rd generation arti fi cial turf : A pilot study in elite Saudi National Team footballers. *Phys Ther Sport*. 2014;15(1):47-52. doi:10.1016/j.ptsp.2013.02.004.
108. Meyers MC. Incidence , Mechanisms , and Severity of Game-Related College Football Injuries on FieldTurf Versus Natural Grass. *Am J Sports Med*. 2010;41(10):2409-2420. doi:10.1177/0363546509352464.
109. Schiff MA, Mack CD, Polissar NL, Levy MR, Dow SP, O'Kane JW. Soccer Injuries in Female Youth Players: Comparison of Injury Surveillance by Certified Athletic Trainers and Internet. *J Athl Train*. 2010;45(3):238-242. doi:10.4085/1062-6050-45.3.238.
110. Waibel NG, Roberts WO, Lunos S. The influence of game scheduling on medical encounters at the USA Cup soccer tournament. *Br J Sports Med*. 2012;46:424-429. doi:10.1136/bjsm.2010.077198.
111. Agel J, Evans TA, Dick R, Putukian M, Marshall SW. Descriptive Epidemiology of Collegiate Men ' s Soccer Injuries : National Collegiate Athletic Association Injury Surveillance System , 1988 – 1989 Through 2002 – 2003. *J Athl Train*. 2007;42(2):270-277.
112. Dick R, Putukian M, Agel J, Evans TA, Marshall SW. Descriptive Epidemiology of Collegiate

Women ’ s Soccer Injuries : National Collegiate Athletic Association Injury Surveillance System , 1988 – 1989 Through 2002 – 2003. 2007;42(2):278-285.
113. Hootman JM, Dick R, Agel J. Epidemiology of Collegiate Injuries for 15 Sports : Prevention Initiatives. *J Athl Train*. 2007;42(2):311-319.
114. Deehan DJ, Bell K, Mccaskie AW. Adolescent musculoskeletal injuries in a football academy. *J Bone Jt Surg*. 2007;89(1):5-8. doi:10.1302/0301-620X.89B1.18427.
115. Clausen MB, Zebis MK, Møller M, et al. High injury incidence in adolescent female soccer. *Am J Sports Med*. 2014;42:2487-2494. doi:10.1177/0363546514541224.
116. Owen A l, Forsyth JJ, Wong DP, Dellal A, Connelly SP, Chamari K. HEART RATE –BASED TRAINING INTENSITY AND ITS IMPACT ON INJURY INCIDENCE AMONG ELITE-LEVEL PROFESSIONAL SOCCER PLAYERS. *J strength Cond Res*. 2015;29(6):1705-1712.
117. Ekstrand J, Hägglund M, Waldén M. Epidemiology of Muscle Injuries in Professional Football (Soccer). *Am J Sports Med*. 2011;39(6):1226-1232. doi:10.1177/0363546510395879.
118. Hägglund M, Waldén M, Magnusson H, Kristenson K, Bengtsson H, Ekstrand J. Injuries affect team performance negatively in professional football : an 11-year follow-up of the UEFA Champions League injury study. *Br J Sports Med*. 2013;47:738-742. doi:10.1136/bjsports-2013-092215.
119. Salces NJ, Gómez-Carmona PM, Gracia-Marco L, Moliner-Urdiales D, Sillero-Quintana M. Epidemiology of injuries in First Division Spanish football. *J Sports Sci*. 2014;32(13):1263-1270. doi:10.1080/02640414.2014.884720.
120. Stubbe JH, Van Beijsterveldt A-MM, Van der Knaap S, et al. Injuries in Professional Male Soccer Players in the Netherlands: A Prospective Cohort Study. *J Athl Train*. 2015;50(2):211-216. doi:10.4085/1062-6050-49.3.64.
121. Dupont G, Nedelec M, McCall A, McCormack D, Berthoin S, Wisløff U. Effect of 2 Soccer Matches in a Week on Physical Performance and Injury Rate. *Am J Sports Med*. 2010;38:1752-1758. doi:10.1177/0363546510361236.
122. Beijsterveldt AMCA Van, Stubbe JH, Schmikli SL, Port IGL Van De, Backx FJG. Differences in injury risk and characteristics between Dutch amateur and professional soccer players. *J Sci Med Sport*. 2015;18(2):145-149. doi:10.1016/j.jsams.2014.02.004.
123. Merron R, Selfe J, Swire R, Rolf C. Injuries among professional soccer players of different age groups: A prospective four-year study in an English Premier League Football Club. *Int Sport J*. 2006;7(4):266-276.
124. Brito J, Rebelo A, Soares JM, Seabra A, Krustrup P, Malina RM. Injuries in Youth Soccer During the Preseason. *Clin J Sport Med*. 2011;21(3):259-260.
125. Moore O, Cloke D, Avery P, Beasley I, Deehan D. English Premiership Academy knee injuries: lessons from a 5 year study. *J Sports Sci*. 2011;29(14):1535-1544. doi:10.1080/02640414.2011.605162.
126. Cloke D, Moore O, Shab T, Rushton S, Mark DF, Deehan DJ. Thigh muscle injuries in youth soccer: Predictors of recovery. *Am J Sports Med*. 2012;40(2):433-439. doi:10.1177/0363546511428800.
127. Waldén M, Hägglund M, Orchard J, Kristenson K, Ekstrand J. Regional differences in injury incidence in European professional football. *Scand J Med Sci Sports*. 2013;23:424-430. doi:10.1111/j.1600-0838.2011.01409.x.
128. Carling C, Orhant E, LeGall F. Match Injuries in Professional Soccer : Inter-Seasonal Variation and Effects of Competition Type , Match Congestion and Positional Role. *Int J Sports Med*. 2010;31:271-276.
129. Ergün M, Denerel HN, Nnet MSB, Ertat KA. Injuries in elite youth football players : a prospective three-year study. *Acta Ortop Traumatol Turc*. 2013;47(5):339-346. doi:10.3944/AOTT.2013.3177.
130. Askling CM, Malliaropoulos N, Karlsson J. High-speed running type or stretching-type of

hamstring injuries makes a difference to treatment and prognosis. *Br J Sports Med*. 2012;46(2):86-87. doi:10.1136/bjsports-2011-090534.
131. Askling CM, Tengvar M, Saartok T, Thorstensson A. Acute first-time hamstring strains during slow-speed stretching: clinical, magnetic resonance imaging, and recovery characteristics. *Am J Sports Med*. 2007;35(10):1716-1724. doi:10.1177/0363546507303563.
132. Askling CM, Tengvar M, Saartok T, Thorstensson A. Proximal hamstring strains of stretching type in different sports: injury situations, clinical and magnetic resonance imaging characteristics, and return to sport. *Am J Sports Med*. 2008;36(9):1799-1804. doi:10.1177/0363546508315892.
133. Werner J, Hagglund M, Walden M, Ekstrand J. UEFA injury study : a prospective study of hip and groin injuries in professional football over seven consecutive seasons. *Br J Sports Med*. 2009;43:1036-1040. doi:10.1136/bjsm.2009.066944.
134. Hölmich P, Thorborg K, Dehlendorff C, Krogsgaard K, Gluud C. Incidence and clinical presentation of groin injuries in sub-elite male soccer. *Br J Sports Med*. 2014;48:1245-1250. doi:10.1136/bjsports-2013-092627.
135. Holmich P, Holmich LR, Bjerg AM. Clinical examination of athletes with groin pain: an intraobserver and interobserver reliability study. *Br J Sports Med*. 2004;38:446-452. doi:10.1136/bjsm.2003.004754.
136. O'Kane JW, Tencer A, Neradilek M, et al. Is Knee Separation During a Drop Jump Associated With Lower Extremity Injury in Adolescent Female Soccer Players? *Am J Sports Med*. 2016;44(2):318-323. doi:10.1177/0363546515613076.
137. Petersen W, Taheri P, Forkel P, Zantop T. Return to play following ACL reconstruction: a systematic review about strength deficits. *Arch Orthop Trauma Surg*. 2014;134(10):1417-1428. doi:10.1007/s00402-014-1992-x.
138. Zaffagnini S, Grassi A, Muccioli GMM, et al. Return to sport after anterior cruciate ligament reconstruction in professional soccer players. *Knee*. 2014;21(3):731-735. doi:10.1016/j.knee.2014.02.005.
139. Söderman K, Pietilä T, Alfredson H, Werner S. Anterior cruciate ligament injuries in young females playing soccer at senior levels. *Scand J Med Sci Sports*. 2002;12:65-68. doi:10.1034/j.1600-0838.2002.120201.x.
140. Alentorn-Geli E, Mendiguchía J, Samuelsson K, et al. Prevention of non-contact anterior cruciate ligament injuries in sports. Part II: Systematic review of the effectiveness of prevention programmes in male athletes. *Knee Surgery, Sport Traumatol Arthrosc*. 2014;22(1):16-25. doi:10.1007/s00167-013-2739-x.
141. Faude O, Junge a, Kindermann W, Dvorak J. Risk factors for injuries in elite female soccer players. *Br J Sports Med*. 2006;40(9):785-790. doi:10.1136/bjsm.2006.027540.
142. Gilchrist J, Mandelbaum BR, Melancon H, et al. A Randomized Controlled Trial to Prevent Noncontact Anterior Cruciate Ligament Injury in Female Collegiate Soccer Players. *Am J Sports Med*. 2008;36(8):1476-1483. doi:10.1177/0363546508318188.
143. Hägglund M, Waldén M. Risk factors for acute knee injury in female youth football. *Knee Surgery, Sport Traumatol Arthrosc*. 2016;24(3):737-746. doi:10.1007/s00167-015-3922-z.
144. Walden M, Hagglung M, Magnusson H, Ekstrand J. Anterior cruciate ligament injury in elite football : a prospective three-cohort study. *Knee Surgery, Sport Traumatol Arthrosc*. 2011;19:11-19. doi:10.1007/s00167-010-1170-9.
145. Toritsuka Y, Horibe S, Hiro-oka A, Mitsuoka T, Nakamura N. Conservative treatment for rugby football players with an acute isolated posterior cruciate ligament injury. *Knee Surgery, Sport Traumatol Arthrosc*. 2004;12(2):110-114. doi:10.1007/s00167-003-0381-8.
146. Schulz MS, Russe K, Weiler A, Eichhorn HJ, Strobel MJ. Epidemiology of posterior cruciate ligament injuries. *Arch Orthop Trauma Surg*. 2003;123(4):186-191. doi:10.1007/s00402-002-

0471-y.
147. Majewski M, Susanne H. Epidemiology of athletic knee injuries : A 10-year study. *Knee*. 2006;13:184-188. doi:10.1016/j.knee.2006.01.005.
148. Beynnon BD, Murphy DF, Alosa DM. Predictive factors for lateral ankle sprains: a literature review. *J Athl Train*. 2002;37(4):376-380. http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12937558.
149. Stasinopoulos D. Comparison of three preventive methods in order to reduce the incidence of ankle inversion sprains among female volleyball players. *Br J Sport Med*. 2004;38(July 2005):182-185. doi:10.1136/bjsm.2002.003947.
150. Hassabi M, Mortazavi SM-J, Giti M-R, Hassabi M, Mansournia M-A, Shapouran S. Injury Profile of a Professional Soccer Team in the Premier League of Iran. *Asian J Sports Med*. 2010;1(4):201-208. doi:10.5812/asjsm.34837.
151. Ekstrand J, Hagglung M, Tornqvist H, et al. Upper extremity injuries in male elite football players. *Knee Surgery, Sport Traumatol Arthrosc*. 2013;21:1626-1632. doi:10.1007/s00167-012-2164-6.
152. Fuller C, Drawer S. The application of risk management in sport. *Sport Med*. 2004;34(6):349-356. doi:10.2165/00007256-200434060-00001.
153. Meeuwisse W. Assessing causation in sports injury: a multifactorial model. *Clin J Sport Med*. 1994;4(3):166-170.
154. Bahr R, Holme I. Risk factors for sports injuries--a methodological approach. *Br J Sports Med*. 2003;37(5):384-392.
155. Bahr R, Krosshaug T. Understanding injury mechanisms: a key component of preventing injuries in sport. *Br J Sports Med*. 2005;39(6):324-329. doi:10.1136/bjsm.2005.018341.
156. Bittencourt NFN, Meeuwisse WH, Mendonça LD, Ocarino JM, Fonseca ST. Complex systems approach for sports injuries : moving from risk factor identi fi cation to injury pattern recognition — narrative review and new concept. *Br J Sports Med*. 2016;50:1309-1314. doi:10.1136/bjsports-2015-095850.
157. Arnason A, Sigurdsson S, Gudmundsson Á, Holme I, Engebretsen L, Bahr R. Risk Factors for Injuries in Football. *Am J Sports Med*. 2004;32(1):5S-16S. doi:10.1177/0363546503258912.
158. Meeuwisse W, H MD P, Tyreman H, Hagel B, Emery C, BScPT P. A Dynamic Model of Etiology in Sport Injury: The Recursive Nature of Risk and Causation. *Clin J Sport Med*. 2007;17(3):215-219. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=ovfti&NEWS=N&AN=00042752-200705000-00011.
159. Bleakley C, Tully M, Connor SO. Epidemiology of Adolescent Rugby Injuries : A Systematic Review. *J Athl Train*. 2011;46(5):555-565.
160. Kristenson K, Waldén M, Ekstrand J, Hägglund M. Lower Injury Rates for Newcomers to Professional Soccer: A prospective cohort study over 9 consecutive seasons. *Am J Sports Med*. 2013;41(6):1419-1425. doi:10.1177/0363546513485358.
161. Hawkins RD, Hulse M, Wilkinson C, Hodson A, Gibson M. The Football Association medical research programme: an audit of injuries in professional football-analysis of hamstring injuries. *Br J Sports Med*. 2001;38(4):466-471. doi:10.1136/bjsm.2003.005165.
162. Hägglund M, Waldén M, Ekstrand J. Factors for Lower Extremity Muscle Injury in Professional Soccer. *Am J Sports Med*. 2013;41(2):327-335. doi:10.1177/0363546512470634.
163. Gajhede-knudsen M, Ekstrand J, Magnusson H, Maffulli N. Recurrence of Achilles tendon injuries in elite male football players is more common after early return to play : an 11-year follow-up of the UEFA Champions League injury study. *Br J Sports Med*. 2013;47:763-768. doi:10.1136/bjsports-2013-092271.
164. Vanlommel L, Vanlommel J, Bollars P, et al. Incidence and risk factors of lower leg fractures in

Belgian soccer players. *Injury*. 2013;44(12):1847-1850. doi:10.1016/j.injury.2013.07.002.
165. Kofotolis ND. Ankle sprain injuries in soccer players aged 7-15 years during a one-year season. *Biol Exerc*. 2014;10(2):37-55. http://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,shib&db=s3h&AN=99179720&site=ehost-live&scope=site.
166. Peterson L, Junge A, Chomiak J, Graf-baumann T. Incidence of Football Injuries and Complaints in Different Age Groups and Skill-Level Groups. *Am J Sports Med*. 2000;28(5):51-57.
167. Ekstrand J, Torstveit MK. Stress fractures in elite male football players. *Scand J Med Sci Sports*. 2012;22:341-346. doi:10.1111/j.1600-0838.2010.01171.x.
168. Ekstrand J, Gillquist J. Soccer injuries and their mechanisms: a prospective study. *Med Sci Sports Exerc*. 1983;15(3):267-270. doi:10.1249/00005768-198315030-00014.
169. Chomiak J, Junge A, Peterson L, Dvorak J. Severe Injuries in Football Players Influencing Factors. *Am J Sports Med*. 2000;28(5):58-68.
170. Walden M, Hagglung M, Ekstrand J. Football injuries during European Championships 2004 – 2005. *Knee Surgery, Sport Traumatol Arthrosc*. 2007;15:1155-1162. doi:10.1007/s00167-007-0290-3.
171. Hagglund M, Walden M, Ekstrand J. UEFA injury study — an injury audit of European Championships 2006 to 2008 M Ha. *Br J Sports Med*. 2008;43:483-490. doi:10.1136/bjsm.2008.056937.
172. Froholdt A, Olsen OE, Bahr R. Low Risk of Injuries Among Children Playing Organized Soccer. *Am J Sports Med*. 2009;37(6):1155-1160. doi:10.1177/0363546508330132.
173. Kucera KL, Marshall SW, Kirkendall DT, Marchak PM, Garrett WE. Injury history as a risk factor for incident injury in youth soccer. *Br J Sports Med*. 2005;39:462-467. doi:10.1136/bjsm.2004.013672.
174. Kofotolis ND, Kellis E, Vlachopoulos SP. Ankle sprain injuries and risk factors in amateur soccer players during a 2-year period. *Am J Sports Med*. 2007;35(3):458-466. doi:10.1177/0363546506294857.
175. Trojian TH, McKeag DB. Single leg balance test to identify risk of ankle sprains. *Br J Sports Med*. 2006;40(7):610-3; discussion 613. doi:10.1136/bjsm.2005.024356.
176. Engebretsen AH, Myklebust G, Holme I, Engebretsen L, Bahr R. Intrinsic risk factors for acute ankle injuries among male soccer players: A prospective cohort study. *Scand J Med Sci Sport*. 2010;20(3):403-410. doi:10.1111/j.1600-0838.2009.00971.x.
177. Baumhauer JF, Alosa DM, Renström PAFH, Trevino S, Beynnon B. A Prospective Study of Ankle Injury Risk Factors. *Am J Sport Med* . 1995;23(5):564-570. doi:10.1177/036354659502300508.
178. Tropp H, Ekstrand J, Gillquist J. Stabilometry in functional instability of the ankle and its value in predicting injury. *Med Sci Sports Exerc*. 1984;16:64-66.
179. Witvrouw E, Danneels L, Asselman P, D'Have T, Cambier D. Muscle flexibility as a risk factor for developing muscle injuries in male professional soccer players. A prospective study. *Am J Sports Med*. 2003;31(1):41-46. doi:10.1177/03635465030310011801.
180. Gleim G, McHugh MP. Flexibility and Its Effects on Sports Injury and Performance. *Sport Med*. 1997;24(5):289-299. doi:10.2165/00007256-199724050-00001.
181. Árnason Á, Gudmundsson Á, Dahl HA, Jóhannsson E. Soccer injuries in Iceland. *Scand J Med Sci Sports*. 1996;6(1):40-45. doi:10.1111/j.1600-0838.1996.tb00069.x.
182. Ekstrand J, Gillquist J. The avoidability of soccer injuries. *Int J Sports Med*. 1983;4(2):124-128. doi:10.1055/s-2008-1026025.
183. Beynnon BD, Renström P a, Alosa DM, Baumhauer JF, Vacek PM. Ankle ligament injury risk factors: a prospective study of college athletes. *J Orthop Res*. 2001;19(2):213-220. doi:10.1016/S0736-0266(00)90004-4.

184. Askling C, Karlsson J, Thorstensson A. Hamstring injury occurrence in elite soccer players after preseason strength training with eccentric overload. *Scand J Med Sci Sports*. 2003;13:244-250.
185. Engebretsen AH, Myklebust G, Holme I, Engebretsen L, Bahr R. Intrinsic Risk Factors for Hamstring Injuries Among Male Soccer Players: A Prospective Cohort Study. *Am J Sports Med*. 2010;38(6):1147-1153. doi:10.1177/0363546509358381.
186. Tropp H, Ekstrand J, Gillquist J. Factors affecting stabilometry recordings of single limb stance. *Am J Sports Med*. 1984;12(3):185-188. doi:10.1177/036354658401200302.
187. Lavallée L, Flint F. The relationship of stress, competitive anxiety, mood state, and social support to athletic injury. *J Athl Train*. 1996;31(4):296-299.
188. Williams JM, Andersen MB. Psychosocial antecedents of sport injury: Review and critique of the stress and injury model'. *J Appl Sport Psychol*. 1998;10(1):5-25. doi:10.1080/10413209808406375.
189. Junge A. The influence of psychological factors on sports injuries. Review of the literature. *Am J Sports Med*. 2000;28(5 Suppl):S10-5. doi:10.1177/28.suppl.
190. Ivarsson A, Johnson U. Psychological factors as predictors of injuries among senior soccer players. A prospective study. *J Sport Sci Med*. 2010;9(2):347-352.
191. Steffen K, Pensgaard AM, Bahr R. Self-reported psychological characteristics as risk factors for injuries in female youth football. *Scand J Med {&} Sci Sport*. 2009;19(3):442-451. doi:10.1111/j.1600-0838.2008.00797.x.
192. Johnson U, Ivarsson A. Psychological predictors of sport injuries among junior soccer players. *Scand J Med Sci Sport*. 2011;21(1):129-136. doi:10.1111/j.1600-0838.2009.01057.x.
193. Rogers T, Landers DM. Mediating Effects of Peripheral Vision in the Life Event Stress/Athletic Injury Relationship. *J Sport Exerc Psychol*. 2005;27(1988):271-288. doi:10.1002/9781444303650.
194. Brink MS, Visscher C, Arends S, Zwerver J, Post WJ, Lemmink KA. Monitoring stress and recovery: new insights for the prevention of injuries and illnesses in elite youth soccer players. *Br J Sports Med*. 2010;44(11):809-815. doi:10.1136/bjsm.2009.069476.
195. Hägglund M, Waldén M. Risk factors for acute knee injury in female youth football. *Knee Surg Sports Traumatol Arthrosc*. 2016;24(3):737-746. doi:10.1007/s00167-015-3922-z.
196. Maffulli N, Margiotti K, Longo UG, Loppini M, Fazio VM, Denaro V. The genetics of sports injuries and athletic performance. *Muscles Ligaments Tendons J*. 2013;3(3):173-189. doi:10.11138/mltj/2013.3.3.179.
197. Pruna R, Clos E, Bahdur K, Artells R. Influence of Genetics on Sports Injuries. *J Nov Physiother*. 2017;7(4):1-5. doi:10.4172/2165-7025.1000359.
198. Pruna R, Ribas J, Montoro JB, Artells R. The impact of single nucleotide polymorphisms on patterns of non-contact musculoskeletal soft tissue injuries in a football player population according to ethnicity. *Med Clin (Barc)*. 2015;144(3):105-110. doi:10.1016/j.medcli.2013.09.026.
199. Ficek K, Stepien-Slodkowska M, Kaczmarczyk M, et al. Does the A9285G polymorphism in collagen type XII ??1 gene associate with the risk of anterior cruciate ligament ruptures? *Balk J Med Genet*. 2014;17(1):41-46. doi:10.2478/bjmg-2014-0022.
200. Ficek K, Cieszczyk P, Kaczmarczyk M, et al. Gene variants within the COL1A1 gene are associated with reduced anterior cruciate ligament injury in professional soccer players. *J Sci Med Sport*. 2013;16(5):396-400. doi:10.1016/j.jsams.2012.10.004.
201. Pruna R, Artells R, Ribas J, et al. Single nucleotide polymorphisms associated with non-contact soft tissue injuries in elite professional soccer players: Influence on degree of injury and recovery time. *BMC Musculoskelet Disord*. 2013;14(1):1. doi:10.1186/1471-2474-14-221.
202. Pruna R, Artells R, Lundblad M, Maffulli N. Genetic biomarkers in non-contact muscle injuries in elite soccer players. *Knee Surgery, Sport Traumatol Arthrosc*. 2017;25(10):3311-3318. doi:10.1007/s00167-016-4081-6.

203. Artells R, Pruna R, Dellal A, Maffulli N. Elastin: A possible genetic biomarker for more severe ligament injuries in elite soccer. A pilot study. *Muscles Ligaments Tendons J*. 2016;6(2):188-192. doi:10.11138/mltj/2016.6.2.188.
204. Massidda M, Eynon N, Bachis V, et al. Influence of the MCT1 rs1049434 on Indirect Muscle Disorders/Injuries in Elite Football Players. *Sport Med - Open*. 2015;1(1):33. doi:10.1186/s40798-015-0033-9.
205. Merezhinskaya N, Fishbein WN, Davis JI, Foellmer JW. Mutations in MCT1 cDNA in patients with symptomatic deficiency in lactate transport. *Muscle and Nerve*. 2000;23(1):90-97. doi:10.1002/(SICI)1097-4598(200001)23:1<90::AID-MUS12>3.0.CO;2-M.
206. Massidda M, Corrias L, Bachis V, et al. Genetic Polymorphisms and Muscle Injuries among Italian Soccer Players. *Ann Sport Med Res*. 2014;1(1):1004-1009.
207. Massidda M, Corrias L, Bachis V, et al. Vitamin D receptor gene polymorphisms and musculoskeletal injuries in professional football players. *Exp Ther Med*. 2015;9(5):1974-1978. doi:10.3892/etm.2015.2364.
208. Fuller CW, Dick RW, Corlette J, Schmalz R. Comparison of the incidence, nature and cause of injuries sustained on grass and new generation artificial turf by male and female football players. Part 1: match injuries. 2007:20-27. doi:10.1136/bjsm.2007.037267.
209. Fuller CW, Dick RW, Corlette J, Schmalz R. Comparison of the incidence, nature and cause of injuries sustained on grass and new generation artificial turf by male and female football players. Part 2: training injuries. 2007:27-33. doi:10.1136/bjsm.2007.037275.
210. Ekstrand J, Hagglund M, Fuller CW. Comparison of injuries sustained on artificial turf and grass by male and female elite football players. *Scand J Med Sci Sport*. 2011;21:824-832. doi:10.1111/j.1600-0838.2010.01118.x.
211. Bjørneboe J, Bahr R, Andersen TE. Risk of injury on third-generation artifi cial turf in Norwegian professional football. *Br J Sports Med*. 2010;44:794-798. doi:10.1136/bjsm.2010.073783.
212. Soligard T, Bahr R, Andersen TE. Injury risk on artificial turf and grass in youth tournament football. *Scand J Med Sci Sports*. 2012;22:356-361. doi:10.1111/j.1600-0838.2010.01174.x.
213. Dragoo JL, Braun HJ. The effect of playing surface on injury rate: A review of the current literature. *Sport Med*. 2010;40(11):981-990. doi:10.2165/11535910-000000000-00000.
214. Aoki H, Kohno T, Fujiya H, et al. Incidence of injury among adolescent soccer players: a comparative study of artificial and natural grass turfs. *Clin J Sport Med*. 2010;20(1):1-7. doi:10.1097/JSM.0b013e3181c967cd.
215. Kristenson K, Bjørneboe J, Waldén M, Ekstrand J, Andersen TE, Hägglund M. No association between surface shifts and time-loss overuse injury risk in male professional football. *J Sci Med Sport*. 2016;19(3):218-221. doi:10.1016/j.jsams.2015.06.001.
216. Ekstrand J, Walden M, Hägglund M. Risk for injury when playing in a national football team. *Scand J Med Sci Sports*. 2004;14(1):34-38. doi:10.1111/j.1600-0838.2003.00330.x.
217. Ryynänen J, Junge A, Dvorak J, Peterson L, Karlsson J, Börjesson M. The effect of changes in the score on injury incidence during three FIFA World Cups. *Br J Sports Med*. 2013;47:960-964. doi:10.1136/bjsports-2013-092676.
218. Bengtsson H, Ekstrand J, Waldén M, Hägglund M. Match injury rates in professional soccer vary with match results, match venue, and type of competition. *Am J Sports Med*. 2013;41(7):1505-1510. doi:10.1177/0363546513486769.
219. Ekstrand J, Walden M, Hagglund M. A congested football calendar and the wellbeing of players: correlation between match exposure of European footballers before the World Cup 2002 and their injuries and performances during that World Cup. *Br J Sports Med*. 2004;38(4):493-498. doi:10.1136/bjsm.2003.009134.
220. Ryynänen J, Junge A, Dvorak J, et al. Foul play is associated with injury incidence: an

epidemiological study of three FIFA World Cups (2002-2010). *Br J Sports Med*. 2013;47(15):986-991. doi:10.1136/bjsports-2013-092676.
221. Hawkins RD, Hulse MA, Wilkinson C, et al. The association football medical research programme : an audit of injuries in professional football. *Br J Sports Med*. 2001;35:43-47. doi:10.1136/bjsm.35.1.43.
222. Mallo J, Dellal A. Injury risk in professional football players with special reference to the playing position and training periodisation. *J Sports Med Phys Fitness*. 2012;52(6):631-638.
223. Chamari K, Haddad M, Wong DP, Dellal A, Chaouachi A. Injury rates in professional soccer players during Ramadan. *J Sports Sci*. 2012;30(September):S93-S102. doi:10.1080/02640414.2012.696674.
224. Nilsson M, Hägglund M, Ekstrand J. Head and Neck Injuries in Professional Soccer. *Clin J Sport Med*. 2013;23(4):255-260.
225. Carling C, Mccall A, Gall F Le, Dupont G. The impact of in-season national team soccer play on injury and player availability in a professional club. *J Sports Sci*. 2015;33(17):1751-1757. doi:10.1080/02640414.2015.1013051.
226. Dellal A, Lago-peñas C, Rey E, Chamari K, Orhant E. The effects of a congested fixture period on physical performance , technical activity and injury rate during matches in a professional soccer team. *Br J Sports Med*. 2015;49:390-394. doi:10.1136/bjsports-2012-091290.
227. Carling C, Gall F Le, Dupond G. Are physical performance and injury risk in a professional soccer team in match play affected over a prolonged period of fixture congestion? *Int J Sports Med*. 2011;32:1-7.
228. Halson SL. Monitoring Training Load to Understand Fatigue in Athletes. *Sport Med*. 2014;44:139-147. doi:10.1007/s40279-014-0253-z.
229. Impellizzeri FM, Rampinini E, Marcora SM. Physiological assessment of aerobic training in soccer. *J Sports Sci*. 2005;23(6):583-592. doi:10.1080/02640410400021278.
230. Borresen J, Lambert MI. The Quantification of Training Load , Effect on Performance. *Sport Med*. 2009;39(9):779-795. doi:10.2165/11317780-000000000-00000.
231. Drew MK, Finch CF. The Relationship Between Training Load and Injury, Illness and Soreness: A Systematic and Literature Review. *Sport Med*. 2016;46(6):861-883. doi:10.1007/s40279-015-0459-8.
232. Meeusen R, Duclos M, Foster C, et al. Prevention, diagnosis, and treatment of the overtraining syndrome: Joint consensus statement of the european college of sport science and the American College of Sports Medicine. *Med Sci Sports Exerc*. 2013;45(1):186-205. doi:10.1249/MSS.0b013e318279a10a.
233. Smith RE, Smoll FL, Cumming SP, Grossbard JR. Measurement of multidimensional sport performance trait anxiety in children and adults: The Sport Anxiety Scale-2. *J Sport Exerc Psychol*. 2006;28(DECEMBER):479-501. doi:10.1123/jsep.28.4.479.
234. Jones CM, Griffiths PC, Mellalieu SD. *Training Load and Fatigue Marker Associations with Injury and Illness: A Systematic Review of Longitudinal Studies*. Vol 47. Springer International Publishing; 2017. doi:10.1007/s40279-016-0619-5.
235. Gabbett TJ. Incidence of injury in semi-professional rugby league players. *Br J Sports Med*. 2003;37(1):36-43. doi:10.1136/bjsm.37.1.36.
236. Aughey R. Applications of GPS technologies tofield sports. *Int J Sports Physiol Perform*. 2011;6(3):295-310. doi:https://doi.org/10.1123/ijspp.6.3.295.
237. Bahr MA, Bahr R. Jump frequency may contribute to risk of jumper's knee: a study of interindividual and sex differences in a total of 11 943 jumps video recorded during training and matches in young elite volleyball players. *Br J Sport Med*. 2014;48:1322-1326. doi:10.1136/bjsports-2014-093593.

238. Jennings D, Cormack S, Coutts AJ, Boyd L, Aughey RJ. The Validity and Reliability of GPS Units for Measuring Distance in Team Sport Specific Running Patterns. *Int J Sports Physiol Perform*. 2010;5:328-341. http://www.catapultsports.com/media/3277/jennings-et-al-2010-validity-and-reliability-of-measuring-distances-in-team-sports.pdf.
239. Eston R. Use of ratings of perceived exertion in sports. *Int J Sports Physiol Perform*. 2012;7(2):175-182. doi:10.1123/ijspp.7.2.175.
240. Beedie CJ, Terry PC, Lane AM, Terry C, Lane AM. The Profile of Mood States and athletic performance: Two meta-analyses. *J Appl Sport Psychol*. 2000;12(1):49-68. doi:10.1080/10413200008404213.
241. Silva AMB da, Enumo SRF, Araújo MF de, et al. Adaptation and validity evidences of Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) for dancers (RESTQ-Dance). *Estud Psicol*. 2016;21(3):249-260. doi:10.5935/1678-4669.20160024.
242. Ramis Y, Viladrich C, Sousa C, Jannes C. Exploring the factorial structure of the sport anxienty Scale-2: Invariance across language, gender, age and type of sport. *Psicothema*. 2015;27(2):174-181. doi:10.7334/psicothema2014.263.
243. Newton M, Duda JL, Yin Z. Examination of the psychometric properties of the perceived motivational climate in sport questionnaire-2 in a sample of female athletes. *J Sports Sci*. 2000;18(4):275-290. doi:10.1080/026404100365018.
244. Daanen HAM, Lamberts RP, Kallen VL, Jin A, Van Meeteren NLU. A systematic review on heart-rate recovery to monitor changes in training status in athletes. *Int J Sports Physiol Perform*. 2012;7(3):251-260. doi:10.1111/j.1600-0838.2009.00977.x.
245. Plews DJ, Laursen PB, Stanley J, Kilding AE, Buchheit M. Training Adaptation and Heart Rate Variability in Elite Endurance Athletes : Opening the Door to Effective Monitoring. *Sport Med*. 2013;43:773-781. doi:10.1007/s40279-013-0071-8.
246. Beneke R, Leithauser RM, Ochentel O. Blood lactate diagnostics in exercise testing and training. *Int J Sports Physiol Perform*. 2011;6(1):8-24.
247. Soligard T, Schwellnus M, Alonso J, et al. How much is too much ? (Part 1) International Olympic Committee consensus statement on load in sport and risk of injury. 2016;(Part 1):1030-1041. doi:10.1136/bjsports-2016-096581.
248. Brooks JHM, Fuller CW, Kemp SPT, Reddin DB. Epidemiology of injuries in English professional rugby union: part 1 match injuries. *Br J Sports Med*. 2005;39(10):757-766. doi:10.1136/bjsm.2005.018135.
249. Jacobsson J, Timpka T, Kowalski J, Nilsson S, Ekberg J, Dahlström Ö. Injury patterns in Swedish elite athletics: annual incidence, injury types and risk factors. *Br J Sports Med*. 2013;47:941-952. doi:10.1136/bjsports-2013-092676.
250. Greve JMD, Andere NFB, Luna NMS, et al. Risk factors for overuse injuries in runners' ankles: a literature review. *Med Express*. 2015;2(3):1-7. doi:10.5935/MedicalExpress.2015.03.01.
251. Dennis RJ, Finch CF, Farhart PJ. Is bowling workload a risk factor for injury to Australian junior cricket fast bowlers? *Br J Sports Med*. 2005;39(11):843-846. doi:10.1136/bjsm.2005.018515.
252. McNamara DJ, Gabbett TJ, Naughton G. Assessment of Workload and its Effects on Performance and Injury in Elite Cricket Fast Bowlers. *Sport Med*. 2017;47(3):503-515. doi:10.1007/s40279-016-0588-8.
253. Ristolainen L, Kettunen JA, Waller B, Heinonen A, Kujala UM. Training-related risk factors in the etiology of overuse injuries in endurance sports. *J Sports Med Phys Fitness*. 2012;147(2):135-140. doi:10.13140/RG.2.1.5129.4169.
254. Wang HK, Cochrane FN, Tsutsumi GYC, et al. A Descriptive Epidemiological Study of Shoulder Injury in Top Level English Male Volleyball Players. *Int J Sports Med*. 2001;22(2):159-163. doi:10.1055/s-2001-11346.

255. Brink MS, Visscher C, Arends S, Zwerver J, Post WJ, Lemmink KAPM. Monitoring stress and recovery: new insights for the prevention of injuries and illnesses in elite youth soccer players. *Br J Sports Med*. 2010;44:809-816. doi:10.1136/bjsm.2009.069476.
256. Gabbett TJ. Influence of injuries on team playing performance in Rugby League. *J Sci Med Sport*. 2004;7(3):340-346. doi:10.1016/S1440-2440(04)80029-X.
257. Alexandre D, da Silva CD, Hill-Haas S, et al. Heart Rate Monitoring in Soccer. *J Strength Cond Res*. 2012;26(10):2890-2906. doi:10.1519/JSC.0b013e3182429ac7.
258. Condessa LA, Cabido CET, Lima AM, et al. Analysis and comparison of intensity in specific soccer training sessions. *Motriz Rev Educ Fis*. 2015;21(1):54-60. doi:10.1590/S1980-65742015000100007.
259. Krosshaug T, Andersen TE, Olsen OE, Myklebust G, Bahr R. Research approaches to describe the mechanisms of injuries in sport: limitations and possibilities. *Br J Sports Med*. 2005;39(6):330-339. doi:10.1136/bjsm.2005.018358.
260. Lion A, Theisen D, Malisoux L, et al. Moderate to severe injuries in football : a one year prospective study of twenty four female and male amateur teams. *Bull la Société des Sci Médicales du Gd Duché Luxemb*. 2014:43-55.
261. Koch M, Zellner J, Berner A, et al. Influence of preparation and football skill level on injury incidence during an amateur football tournament. *Arch Orthop Trauma Surg*. 2015:1-8. doi:10.1007/s00402-015-2350-3.
262. Babwah TJR. Incidence of Football Injury During International Tournaments. *Res Sport Med*. 2009;17(1):61-69. doi:10.1080/15438620802689591.
263. Lee JWY, Mok KM, Chan HCK, Yung PSH, Chan KM. A prospective epidemiological study of injury incidence and injury patterns in a Hong Kong male professional football league during the competitive season. *Asia-Pacific J Sport Med Arthrosc Rehabil Technol*. 2014;1(4):119-125. doi:10.1016/j.asmart.2014.08.002.
264. McNoe BM, Chalmers DJ. Injury in community-level soccer: development of an injury surveillance system. *Am J Sports Med*. 2010;38(12):2542-2551. doi:10.1177/0363546510377415.
265. Kobayashi T, Tanaka M, Shida M. Intrinsic Risk Factors of Lateral Ankle Sprain: A Systematic Review and Meta-analysis. *Sport Heal A Multidiscip Approach*. 2015;XX(X):10-13. doi:10.1177/1941738115623775.
266. Dvorak J, Grimm K, Schmied C, Junge A. Feasibility of precompetition medical assessment at FIFA World Cups for female youth players. *Br J Sports Med*. 2011:10-12. doi:10.1136/bjsports-2011-090374.
267. Maffey L, Emery C. Physiotherapist delivered preparticipation examination: rationale and evidence. *N Am J Sports Phys Ther*. 2006;1(4):176-186.
268. Junge A, Grimm K, Feddermann N, Dvorak J. Precompetition Orthopedic Assessment of International Elite Football Players. *Clin J Sport Med*. 2009;19(4):326-328.
269. Rösch D, Hodgson R, Peterson L, et al. Assessment and Evaluation of Football Performance. *Am J Sports Med*. 2000;28(5):S29-39. doi:10.1177/28.suppl.
270. Frohm A, Heijne A, Kowalski J, Svensson P, Myklebust G. A nine-test screening battery for athletes : a reliability study. *Scand J Med Sci Sport*. 2012;22:306-315. doi:10.1111/j.1600-0838.2010.01267.x.
271. Requena B, Gonzalez-Badillo J, Saez de Villareal E, et al. Functional performance, maximal strength, and power characteristics in isometric and dynamic actions of lower extremities in soccer players. *J strength Cond Res*. 2009;23(5):1391-1401.
272. Carregaro RL, Silva LCCB, Gil Coury HJC. Comparison Between Two Clinical Tests for the Evaluation of Posterior Thigh Muscles Flexibility. *Rev bras fisioter*. 2007;11(2):13-16.
273. Jeyabalan a., Pacecca E. The development of a prospective musculoskeletal screening tool to

identify semi-professional Australian Football athletes at risk of sustaining a high prevalence injury: A pilot study. *J Sci Med Sport*. 2011;14(2011):e58. doi:10.1016/j.jsams.2011.11.119.
274. Guex K, Fourchet F, Loepelt H, Millet GP. Passive knee-extension test to measure hamstring tightness: influence of gravity correction. *J Sport Rehabil*. 2012;21(3):231-234. doi:10.1123/jsr.21.3.231.
275. van Doormaal MCM, van der Horst N, Backx FJG, Smits D-W, Huisstede BMA. No Relationship Between Hamstring Flexibility and Hamstring Injuries in Male Amateur Soccer Players: A Prospective Study. *Am J Sports Med*. 2016;45(1):363546516664162. doi:10.1177/0363546516664162.
276. Gabbe BJ, Bennell KL, Wajswelner H, Finch CF. Reliability of common lower extremity musculoskeletal screening tests. *Phys Ther Sport*. 2004;5(2):90-97. doi:10.1016/j.ptsp.2004.01.003.
277. Dennis RJ, Finch CF, Elliott BC, Farhart PJ. The reliability of musculoskeletal screening tests used in cricket. *Phys Ther Sport*. 2008;9(1):25-33. doi:10.1016/j.ptsp.2007.09.004.
278. Ellapen TJ, Narsigan S, Abrahams S, Van Heerden H. Sport Profile of the Junior Male Kwa-Zulu Natal Provincial Soccer Team , South Africa. *Athens J Sport*. 2014;(March):45-56.
279. Davis DS, Quinn RO, Whiteman CT, Williams JD, Young CR. Concurrent validity of four clinical tests used to measure hamstring flexibility. *J Strength Cond Res*. 2008;22(2):583-588. doi:10.1519/JSC.0b013e31816359f2.
280. Fousekis K, Tsepis E, Poulmedis P, Athanasopoulos S, Vagenas G. Intrinsic risk factors of non-contact quadriceps and hamstring strains in soccer: a prospective study of 100 professional players. *Br J Sports Med*. 2011;45(9):709-714. doi:10.1136/bjsm.2010.077560.
281. Bittencourt N, Ocarino J, Sorrentino F, et al. Normative data for muscle flexibility in male soccer players. *Br J Sports Med*. 2014;48(7):568-569. doi:10.1136/bjsports-2014-093494.24.
282. McIntyre MC. A comparison of the physiological profiles of elite Gaelic footballers, hurlers, and soccer players. *Br J Sports Med*. 2005;39(7):437-439. doi:10.1136/bjsm.2004.013631.
283. Baltaci G, Un N, Tunay V, Besler a, Gerçeker S. Comparison of three different sit and reach tests for measurement of hamstring flexibility in female university students. *Br J Sports Med*. 2003;37(1):59-61. doi:10.1136/bjsm.37.1.59.
284. Chillón P, Castro-Piñero J, Ruiz JR, et al. Hip flexibility is the main determinant of the back-saver sit-and-reach test in adolescents. *J Sports Sci*. 2010;28(2014):641-648. doi:10.1080/02640411003606234.
285. Ayala F, Sainz de Baranda P, De Ste Croix M, Santonja F. Absolute reliability of five clinical tests for assessing hamstring flexibility in professional futsal players. *J Sci Med Sport*. 2012;15(2):142-147. doi:10.1016/j.jsams.2011.10.002.
286. Afsharnezhad T, Nateghi N, Soufi MR. Normalizing Scores of the Modified Back-Saver Sit-And-Reach Test in Middle School Boys. *Int J Sport Sci Eng*. 2010;4(2):99-105.
287. Jackson A, Langford N. The criterion-related validity of the sit and reach test: replication and extension of previous findings. *Res Q Exerc Sport*. 1989;60(4):384-387. doi:10.1080/02701367.1989.10607468.
288. Liemohn W, Sharpe G, Wasserman J. Lumbosacral movement in the sit-and-reach and in Caillit's protective-hamstring stretch. *Spine (Phila Pa 1976)*. 1994;19(18):2127-2130.
289. López-Miñarro PA, Andújar PS de B, Rodríguez-García PL. A comparison of the sit-and-reach test and the back-saver sit-and-reach test in university students. *J Sport Sci Med*. 2009;8(1):116-122.
290. Ayala F, Sainz de Baranda P, De Ste Croix M, Santonja F. Criterion-related validity of four clinical tests used to measure hamstring flexibility in professional futsal players. *Phys Ther Sport*. 2011;12(4):175-181. doi:10.1016/j.ptsp.2011.02.005.
291. Gabbe BJ, Bennell KL, Finch CF, Wajswelner H, Orchard JW. Predictors of hamstring injury at the

elite level of Australian football. *Scand J Med Sci Sport*. 2006;16(1):7-13. doi:10.1111/j.1600-0838.2005.00441.x.
292. Mayorga-Vega D, Merino-Marban R, Viciana J. Criterion-related validity of sit-and-reach tests for estimating hamstring and lumbar extensibility: A meta-analysis. *J Sport Sci Med*. 2014;13(1):1-14.
293. Shan G, Westerhoff P. Soccer: Full-body Kinematic Characteristics of the Maximal Instep Soccer Kick by Male Soccer Players and Parameters Related to Kick Quality. *Sport Biomech*. 2005;4(1):59-72. doi:10.1080/14763140508522852.
294. Hong S, Chung C, Sakamoto K, Asai T. Analysis of the swing motion on knuckling shot in soccer. *Procedia Eng*. 2011;13:176-181. doi:10.1016/j.proeng.2011.05.069.
295. Nett B, Brosky J a, Velarde L, Pariser DP, Boyce D a. Selected Musculoskeletal and Performance Characteristics of Members of a Women's Professional Football Team: Application of a Pre-participation Examination. *N Am J Sports Phys Ther*. 2010;5(1):1-15.
296. Dennis RJ, Finch CF, McIntosh a S, Elliott BC. Use of field-based tests to identify risk factors for injury to fast bowlers in cricket. *Br J Sports Med*. 2008;42(6):477-482. doi:10.1136/bjsm.2008.046698.
297. Corkery M, Briscoe H, Ciccone N, et al. Establishing normal values for lower extremity muscle length in college-age students. *Phys Ther Sport*. 2007;8(2):66-74. doi:10.1016/j.ptsp.2006.11.004.
298. Harvey D. Assessment of the flexibility of elite athletes using the modified Thomas test. *Br J Sports Med*. 1998;32:68-70.
299. Peeler JD, Anderson JE. Reliability Limits of the Modified Thomas Test for Assessing Rectus Femoris Muscle Felxibility about the Knee Joint. *J Athl Train*. 2008;43(5):470-476.
300. Kim G, Ha S. Reliability of the modified Thomas test using a lumbo-plevic stabilization. *J Phys Ther Sci*. 2015;27:447-449.
301. Ellenbecker TS, Ellenbecker G a, Roetert EP, Silva RT, Keuter G, Sperling F. Descriptive profile of hip rotation range of motion in elite tennis players and professional baseball pitchers. *Am J Sports Med*. 2007;35(8):1371-1376. doi:10.1177/0363546507300260.
302. Ibrahim a, Murrell G a C, Knapman P. Adductor strain and hip range of movement in male professional soccer players. *J Orthop Surg (Hong Kong)*. 2007;15(1):46-49.
303. Tak I, Glasgow P, Langhout R, Weir A, Kerkhoffs G, Agricola R. Hip Range of Motion Is Lower in Professional Soccer Players With Hip and Groin Symptoms or Previous Injuries, Independent of Cam Deformities. *Am J Sports Med*. 2016;44(3):682-688. doi:10.1177/0363546515617747.
304. Nussbaumer S, Leunig M, Glatthorn JF, Stauffacher S, Gerber H, Maffiuletti NA. Validity and test-retest reliability of manual goniometers for measuring passive hip range of motion in femoroacetabular impingement patients. *BMC Musculoskelet Disord*. 2010;11:194. doi:10.1186/1471-2474-11-194.
305. Gabbett TJ, Hons B, Domrow N. Risk Factors for Injury in Subelite Rugby League Players. *Am J Sports Med*. 2005;33(3):428-434. doi:10.1177/0363546504268407.
306. Yazdifar M, Yazdifar MR, Mahmud J, Esat I, Chizari M. Evaluating the Hip Range of Motion Using the Goniometer and Video Tracking Methods. *Procedia Eng*. 2013;68:77-82. doi:10.1016/j.proeng.2013.12.150.
307. Reiman M, Manske R. *Functional Testing in Human Performance*. 1st editio. Europe: Champain: Human Kinetics; 2009.
308. Lees A, Nolan L. The biomechanics of soccer: a review. *J Sports Sci*. 1998;16(April):211-234. doi:10.1080/026404198366740.
309. Norkin CC, White DJ. *Measurement of Joint Motion A Guide to Goniometry, 4th Ed.*; 2003. doi:10.2310/6640.2004.00031.
310. Wang SS, Whitney SL, Burdett RG, Janosky JE. Lower extremity muscular flexibility in long distance runners. *J Orthop Sports Phys Ther*. 1993;17(2):102-107.

doi:10.2519/jospt.1993.17.2.102.
311. Araújo VL, Carvalhais VOC, Souza TR, Ocarino JM, Gonçalves GGP, Fonseca ST. Validity and reliability of clinical tests for assessing passive ankle stiffness. *Rev Bras Fisioter*. 2011;15(2):166-173. doi:10.1016/j.math.2010.10.009.
312. Moseley a, Adams R. Measurement of passive ankle dorsiflexion: Procedure and reliability. *Aust J Physiother*. 1991;37(3):175-181. doi:10.1016/S0004-9514(14)60540-7.
313. Martin R, McPoil T. Reliability of ankle goniometric measurements: a literature review. *J Am Podiatr Med Assoc*. 2005;95(6):564-572.
314. Bennell K, Talbot R, Wajswelner H, Techovanich W, Kelly D, Hall A. Intra-rater and inter-rater reliability of a weight-bearing lunge measure of ankle dorsiflexion. *Aust J Physiother*. 1998;44(3):175-180. doi:10.1016/S0004-9514(14)60377-9.
315. Konor MM, Morton S, Eckerson JM, Grindstaff TL. Reliability of three measures of ankle dorsiflexion range of motion. *Int J Sports Phys Ther*. 2012;7(3):279-287. http://www.ncbi.nlm.nih.gov/pubmed/22666642%5Cnhttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC3362988.
316. O'Shea S, Grafton K. The intra and inter-rater reliability of a modified weight-bearing lunge measure of ankle dorsiflexion. *Man Ther*. 2013;18(3):264-268. doi:10.1016/j.math.2012.08.007.
317. Cejudo A, Sainz de Baranda P, Ayala F, Santonja F. A simplified version of the weight-bearing ankle lunge test: Description and test-retest reliability. *Man Ther*. 2014;19(4):355-359. doi:10.1016/j.math.2014.03.008.
318. Powden CJ, Hoch JM, Hoch MC. Reliability and minimal detectable change of the weight-bearing lunge test: A systematic review. *Man Ther*. 2015;20(4):524-532. doi:10.1016/j.math.2015.01.004.
319. Schmid AB, Brunner F, Luomajoki H, et al. Reliability of clinical tests to evaluate nerve function and mechanosensitivity of the upper limb peripheral nervous system. *BMC Musculoskelet Disord*. 2009;10:11. doi:10.1186/1471-2474-10-11.
320. Miller JK. The slump test: clinical applications and interpretations. *Chiropr Tech*. 1999;11(4):157-163.
321. Maitland GD. The slump test: examination and treatment. *Aust J Physiother*. 1985;31(6):215-219. doi:10.1016/S0004-9514(14)60634-6.
322. Miller KJ. Physical assessment of lower extremity radiculopathy and sciatica. *J Chiropr Med*. 2007;6(2):75-82. doi:10.1016/j.jcme.2007.04.001.
323. Kuilart KE, Woollam M, Barling E, Lucas N. The active knee extension test and Slump test in subjects with perceived hamstring tightness. *Int J Osteopath Med*. 2005;8(3):89-97. doi:10.1016/j.ijosm.2005.07.004.
324. Walsh J, Flatley M, Johnston N, Bennett K. Slump test: sensory responses in asymptomatic subjects. *J Man Manip Ther*. 2007;15(4):231-238. doi:10.1179/106698107790819413.
325. Læssøe U, Voigt M. Modification of stretch tolerance in a stooping position. *Scand J Med Sci Sport*. 2004;14(4):239-244. doi:10.1111/j.1600-0838.2003.00332.x.
326. Johnson EK, Chiarello CM. The slump test: the effects of head and lower extremity position on knee extension. *J Orthop Sports Phys Ther*. 1997;26(6):310-317. doi:10.2519/jospt.1997.26.6.310.
327. Tucker N, Reid D, McNair P. Reliability and measurement error of active knee extension range of motion in a modified slump test position: a pilot study. *J Man Manip Ther*. 2007;15(4):85-91. doi:10.1179/jmt.2007.15.4.85E.
328. Yeung E, Jones M, Hall B. The response to the slump test in a group of female whiplash patients. *Aust J Physiother*. 1997;43(4):245-252. doi:10.1016/S0004-9514(14)60413-X.
329. Philip K, Lew P, Matyas T. The inter-therapist reliability of the slump test. *Aust J Physiother*. 1989;35(2):89-94.
330. Majlesi J, Togay H, Unalan H, Toprak S. The sensitivity and specificity of the Slump and the

Straight Leg Raising tests in patients with lumbar disc herniation. *J Clin Rheumatol*. 2008;14(2):87-91. doi:10.1097/RHU.0b013e31816b2f99.
331. Gabbe BJ, Finch CF, Bennell KL, Wajswelner H. Risk factors for hamstring injuries in community level Australian football. *Br J Sports Med*. 2005;39(June 2007):106-110. doi:10.1136/bjsm.2003.011197.
332. Kibler W Ben, Press J, Sciascia A. The Role of Core Stability in Athletic Function The Role of Core Stability in Athletic Function. *Sport Med*. 2006;36(3):189-198. doi:10.2165/00007256-200636030-00001.
333. Sharma S. Core stability–an overview. *Elixir Hum Physiol*. 2012;53:11914-11917. http://www.elixirpublishers.com/articles/1358340617_53 (2012) 11914-11917.pdf.
334. Cosio-Lima LM, Reynolds KL, Winter C, Paolone V, Jones MT. Effects of physioball and conventional floor exercises on early phase adaptations in back and abdominal core stability and balance in women. *J Strength Cond Res*. 2003;17(4):721-725. doi:10.1519/1533-4287(2003)017<0721:EOPACF>2.0.CO;2.
335. Šalaj S, Milanović D, Jukić I. The effects of proprioceptive training on jumping and agility performance. *Kinesiology*. 2007;39(2):131-141. http://hrcak.srce.hr/index.php?show=clanak&id_clanak_jezik=34524.
336. Morin JB, Edouard P, Samozino P. Technical ability of force application as a determinant factor of sprint performance. *Med Sci Sport Exerc*. 2011;43(9):1680-1688. doi:10.1249/MSS.0b013e318216ea37.
337. Kapidzic A, Huremovic T, Biberovic A. Kinematic Analysis of the Instep Kick in Youth Soccer Players. *J Hum Kinet*. 2014;42:81-90. doi:10.2478/hukin.
338. Brumitt J. The Bunkie Test: Descriptive Data for a Novel Test of Core Muscular Endurance. *Rehabil Res Pract*. 2015;2015:1-9. doi:10.1155/2015/780127.
339. Liemohn WP, Baumgartner T a, Gagnon LH. Measuring core stability. *J strength Cond Res*. 2005;19(3):583-586. doi:10.1519/1533-4287(2005)19[583:MCS]2.0.CO;2.
340. Hayashi D, Hamilton B, Guermazi A, de Villiers R, Crema MD, Roemer FW. Traumatic injuries of thigh and calf muscles in athletes: Role and clinical relevance of MR imaging and ultrasound. *Insights Imaging*. 2012;3(6):591-601. doi:10.1007/s13244-012-0190-z.
341. Sunami S, Maruyama T. Motion and EMG Analysis of Soccer-ball Heading for the Lateral Direction. *Footb Sci*. 2007;5:7-17.
342. Madeley LT, Munteanu SE, Bonanno DR. Endurance of the ankle joint plantar flexor muscles in athletes with medial tibial stress syndrome: A case-control study. *J Sci Med Sport*. 2007;10(6):356-362. doi:10.1016/j.jsams.2006.12.115.
343. Yocum A, Mccoy SW, Bjornson KF, et al. Reliability and Validity of the Standing Heel-Rise Test Reliability and Validity of the Standing Heel-Rise Test. *Phys Occup Ther Pediatr*. 2010;30(3):190-204. doi:10.3109/01942631003761380.
344. Svantesson U, Wessman C, Alricsson M. the Standing Heel-Rise Test: Reference Values and Test–Retest Reliability for Healthy Individuals From 20 To 81 Years of Age. *Phys Ther*. 2015;101:2015.
345. Hébert-Losier K, Newsham-West RJ, Schneiders AG, Sullivan SJ. Raising the standards of the calf-raise test: A systematic review. *J Sci Med Sport*. 2009;12(6):594-602. doi:10.1016/j.jsams.2008.12.628.
346. Hébert-Losier K, Schneiders AG, Newsham-West RJ, Sullivan SJ. Scientific bases and clinical utilisation of the calf-raise test. *Phys Ther Sport*. 2009;10(4):142-149. doi:10.1016/j.ptsp.2009.07.001.
347. Haber, M; Golan, E; Azoulay, L; Kahn, S R; Shrier I. Reliability of a device measuring triceps surae muscle fatigability. *Br J Sports Med*. 2004;38(2):163-167. doi:10.1136/bjsm.2002.002899.
348. Sman AD, Hiller CE, Imer A, Ocsing A, Burns J, Refshauge KM. Design and reliability of a novel heel

rise test measuring device for plantarflexion endurance. *Biomed Res Int*. 2014;2014:1-8. doi:10.1155/2014/391646.
349. Möller M, Lind K, Styf J, Karlsson J. The reliability of isokinetic testing of the ankle joint and a heel-raise test for endurance. *Knee surgery, Sport Traumatol Arthrosc*. 2005;13(1):60-71. doi:10.1007/s00167-003-0441-0.
350. Sunnerhagen KS, Hedberg M, Henning GB, Cider A, Svantesson U. Muscle performance in an urban population sample of 40- to 79-year-old men and women. *Scand J Rehabil Med*. 2000;32(4):159-167. doi:10.1080/003655000750060904.
351. Caffrey E, Docherty CL, Schrader J, Klossner J. The ability of 4 single-limb hopping tests to detect functional performance deficits in individuals with functional ankle instability. *J Orthop Sports Phys Ther*. 2009;39(11):799-806. doi:10.2519/jospt.2009.3042.
352. Augustsson J, Thomeé R, Lindén C, Folkesson M, Tranberg R, Karlsson J. Single-leg hop testing following fatiguing exercise: Reliability and biomechanical analysis. *Scand J Med Sci Sport*. 2006;16(2):111-120. doi:10.1111/j.1600-0838.2005.00446.x.
353. Gustavsson A, Neeter C, Thomeé P, et al. A test battery for evaluating hop performance in patients with an ACL injury and patients who have undergone ACL reconstruction. *Knee Surgery, Sport Traumatol Arthrosc*. 2006;14(8):778-788. doi:10.1007/s00167-006-0045-6.
354. Hamilton RT, Shultz SJ, Schmitz RJ, Perrin DH. Triple-hop distance as a valid predictor of lower limb strength and power. *J Athl Train*. 2008;43(2):144-151. doi:10.4085/1062-6050-43.2.144.
355. Taylor MJD, Cohen D, Voss C, Sandercock GRH. Vertical jumping and leg power normative data for English school children aged 10-15 years. *J Sports Sci*. 2010;28(8):867-872. doi:10.1080/02640411003770212.
356. Padua D a, Marshall SW, Boling MC, Thigpen C a, Garrett WE, Beutler AI. The Landing Error Scoring System (LESS) Is a valid and reliable clinical assessment tool of jump-landing biomechanics: The JUMP-ACL study. *Am J Sports Med*. 2009;37(10):1996-2002. doi:10.1177/0363546509343200.
357. Konz SM. Using Vertical Jump Power and Standing Long Jump Power To Determine Muscle Imbalance. In: *33rd International Conference on Biomechanics in Sports*. ; 2015:395-398.
358. Thomas C, Dos'Santos T, Comfort P, Jones P. Between-Session Reliability of Common Strength- and Power-Related Measures in Adolescent Athletes. *Sports*. 2017;5(1):15. doi:10.3390/sports5010015.
359. Myers BA, Killian C. Normative Data for Hop Tests in High School. *Int J Sport Phys Ther |*. 2014;9(5):596-603.
360. Roush J, DoVico K, Fairchild S, McGriff K, Bay R. The effect of quality of movement on the single hop test in soccer players aged 15-16 years. *Internet J Allied Heal Sci Pract*. 2010;8(2):8p. https://proxy.library.upenn.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=cin20&AN=2010667861&site=ehost-live.
361. Noyes FR, Barber SD, Mangine RE. Abnormal lower limb symmetry determined by function hop tests after anterior cruciate ligament rupture. American Journal of Sports Medicine. http://www.udel.edu/PT/manal/acl08/noyeshop.pdf. Published 1991. Accessed September 10, 2015.
362. Bolgla LA, Keskula DR. *Reliability of Lower Extremity Functional Performance Tests.* Vol 26.; 1997. doi:10.2519/jospt.1997.26.3.138.
363. Rudolph KS, Axe MJ, Snyder-Mackler L. Dynamic stability after ACL injury: who can hop? *Knee surgery, Sport Traumatol Arthrosc*. 2000;8(5):262-269. doi:10.1007/s001670000130.
364. Fitzgerald GK, Axe MJ, Snyder-Mackler L. A decision-making scheme for returning patients to high-level activity with nonoperative treatment after anterior cruciate ligament rupture. *Knee surgery, Sport Traumatol Arthrosc*. 2000;8(2):76-82. doi:10.1007/s001670050190.

365. Jerre R, Ejerhed L, Wallmon A, Kartus J, Brandsson S. Functional outcome of anterior cruciate ligament reconstruction in recreational and competitive athletes. *Scand J Med Sci Sports*. 2001;11(6):342-346. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=emed5&NEWS=N&AN=11782266.
366. Logerstedt D, Grindem H, Lynch A, Eitzen I. Single-legged Hop test as predictors of self-reported knee function after ACL reconstruction. *Am J Sports Med*. 2013;40(July 2012):2348-2356. doi:10.1177/0363546512457551.Single-legged.
367. Munro A, Herrington L. Between-session reliability of four hop tests and the agility t-test. *J strength Cond Res*. 2011;25(5):1470-1477.
368. Reid A, Birmingham TB, Stratford PW, Alcock GK, Giffin JR. Hop testing provides a reliable and valid outcome measure during rehabilitation after anterior cruciate ligament reconstruction. *Phys Ther*. 2007;87(3):337-349. doi:10.2522/ptj.20060143.
369. Brosky J, Nitz A, Malone TR, Caborn DNM, Rayens MK. Interrater reliability of selected clinical outcome measures following anterior cruciate ligament reconstruction. *Phys Ther*. 1999;29(1):39-48.
370. Butler RJ, Southers C, Gorman PP, Kiesel KB, Plisky PJ. Differences in soccer players' dynamic balance across levels of competition. *J Athl Train*. 2012;47(6):616-620. doi:10.4085/1062-6050-47.5.14.
371. Dallinga JM, Banjaminse A, Lemmink KAPM. Which Screening Tools Can Predict Injury to the Lower Extremities in Team Sports ? A Systematic Review. *Sport Med*. 2012;42(9):791-815.
372. Woods C, Hawkins R, Hulse M, Hodson A. The Football Association Medical Research Programme: an audit of injuries in professional football-Analysis of preseason injuries. *Br J Sports Med*. 2002;36:436-441. doi:10.1136/bjsm.36.6.436.
373. Heidt RS, Sweeterman LM, Carlonas RL, et al. Avoidance of Soccer Injuries with Preseason Conditioning. *Am J Sports Med*. 2000;28(5):659-662.
374. Stiffler MR, Sanfilippo JL, Brooks MA, Heiderscheit BC. Star Excursion Balance Test Performance Varies by Sport in Healthy Division I Collegiate Athletes. *J Orthop Sports Phys Ther*. 2015;45(10):772-780. doi:10.2519/jospt.2015.5777.
375. Coughlan GF, Fullam K, Delahunt E, Gissane C, Caulfield BM. A comparison between performance on selected directions of the star excursion balance test and the Y balance test. *J Athl Train*. 2012;47(4):366-371. doi:10.4085/1062-6050-47.4.03.
376. Clagg S, Paterno M V, Hewett TE, Schmitt LC. Performance on the modified star excursion balance test at the time of return to sport following anterior cruciate ligament reconstruction. *J Orthop Sports Phys Ther*. 2015;45(6):444-452. doi:10.2519/jospt.2015.5040.
377. Gribble P a., Hertel J, Plisky P. Using the star excursion balance test to assess dynamic postural-control deficits and outcomes in lower extremity injury: A literature and systematic review. *J Athl Train*. 2012;47(3):339-357. doi:10.4085/1062-6050-47.3.08.
378. Plisky PJ, Gorman PP, Butler RJ, Kiesel KB, Underwood FB, Elkins B. The reliability of an intrumented device for measuring components of the star excursion balance test. *North Am J Sport Phys Ther*. 2009;4(2):92-99.
379. Hubbard TJ, Kramer LC, Denegar CR, Hertel J. Correlations among multiple measures of functional and mechanical instability in subjects with chronic ankle instability. *J Athl Train*. 2007;42(3):361-366. doi:10.3113/FAI.2007.0343.
380. Lee DK, Kang MH, Lee TS, Oh JS. Relationships among the Y balance test, Berg Balance Scale, and lower limb strength in middle-aged and older females. *Brazilian J Phys Ther*. 2015;19(3):227-234. doi:10.1590/bjpt-rbf.2014.0096.
381. Ambegaonkar JP, Mettinger LM, Caswell S V, Burtt A, Cortes N. Relationships between core

endurance, hip strength, and balance in collegiate female athletes. *Int J Sports Phys Ther*. 2014;9(5):604-616. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4196325&tool=pmcentrez&rendertype=abstract.
382. Brumitt J, Heiderscheit BC, Manske RC, et al. Lower Extremity Functional Tests and Risk of Injury in Division Iii Collegiate Athletes. *Int J Sports Phys Ther*. 2013;8(3):216-227.
383. Davies G, Zilmer D. Functional progression of a patient through a rehabilitation program. *Orthop Phys Ther Clin North Am*. 2000;9(2):103-117.
384. Tabor M, Davies G, Kernozek T, Negrete R, Hudson V. A multicenter study of the test-retest reliability of the lower extremity test. *J Sport Rehabil*. 2002;11(3):190-201. doi:http://dx.doi.org/10.1123/jsr.11.3.190.
385. Haitz K, Shultz R, Hodgins M, Matheson GO. Test-retest and interrater reliability of the functional lower extremity evaluation. *J Orthop Sports Phys Ther*. 2014;44(12):947-954. doi:10.2519/jospt.2014.4809.
386. Cook G, Burton L, Hoogenboom B. Pre-participation screening: the use of fundamental movements as an assessment of function–part 1. *North Am J Sport Phys Ther NAJSPT*. 2006;1(2):62. doi:10.1055/s-0034-1382055.
387. Cook G, Burton L, Hoogenboom BJ, et al. Functional Movement Screen Differences Between Male and Female Secondary School Athletes. *Int J Sports Phys Ther*. 2014;9(3):62-72. doi:10.1111/j.1600-0838.2010.01267.x.
388. Kiesel K, Plisky PJ, Voight ML. Can Serious Injury in Professional Football be Predicted by a Preseason Functional Movement Screen? *N Am J Sports Phys Ther*. 2007;2(3):147-158. doi:10.1186/2052-1847-5-11.
389. Schneiders AG, Davidsson A, Hörman E, Sullivan SJ. Functional movement screen normative values in a young, active population. *Int J Sports Phys Ther*. 2011;6(2):75-82. doi:10.1519/JSC.0B013E3182606DF2.
390. Shultz R, Anderson SC, Matheson GO, Marcello B, Besier T. Test-retest and interrater reliability of the functional movement screen. *J Athl Train*. 2013;48(3):331-336. doi:10.4085/1062-6050-48.2.11.
391. Abraham A, Sannasi R, Nair R. Normative values for the functional movement screentm in adolescent school aged children. *Int J Sports Phys Ther*. 2015;10(1):29-36. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4325285&tool=pmcentrez&rendertype=abstract.
392. Samar Z, Bansal A. The Relationship between Self-Reported and on Field Lower Extremity Functional Assessment Tools Used for Assessing Functional Status in Hip Dysfunction Athletes. *Int J Sport Sci*. 2013;3(5):172-182. doi:10.5923/j.sports.20130305.05.
393. Lislevand M, Andersen TE, Junge A, Dvorak J, Steffen K. Injury surveillance during a 2-day national female youth football tournament in Kenya. 2014:924-928. doi:10.1136/bjsports-2013-092307.
394. Faul F, Erdfelder E, Buchner A, Lang A-G. Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses. *Behav Res Methods*. 2009;41(4):1149-1160. doi:10.3758/BRM.41.4.1149.
395. Hägglund M, Waldén M, Bahr R, Ekstrand J. Methods for epidemiological study of injuries to professional football players: developing the UEFA model. *Br J Sports Med*. 2005;39(6):340-346. doi:10.1136/bjsm.2005.018267.
396. Bell M, Fink K, Barker P, et al. Measuring Height/ Weight and Calculating BMI Guidelines for Schools. *Depertment Heal Soc Serv State Alaska*. 2011:1-26.
397. Parry L, Drust B. Is injury the major cause of elite soccer players being unavailable to train and play during the competitive season? *Phys Ther Sport*. 2006;7(2):58-64.

doi:10.1016/j.ptsp.2006.03.003.
398. Junge a. Football Injuries During FIFA Tournaments and the Olympic Games, 1998-2001: Development and Implementation of an Injury-Reporting System. *Am J Sports Med*. 2004;32(90010):80S-89. doi:10.1177/0363546503261245.
399. Junge A, Lamprecht M, Stamm H, et al. Countrywide campaign to prevent soccer injuries in Swiss amateur players. *Am J Sports Med*. 2011;39(1):57-63. doi:10.1177/0363546510377424.
400. World Medical Association. World Medical Association Declaration of Helsinki. Ethical principles for medical research involving human subjects. *J Am Med Assoc*. 2013;310(20):2191-2194. doi:10.1001/jama.2013.281053.
401. IBM SPSS. IBM SPSS Decision Trees 21. 2013:1-118. ftp://public.dhe.ibm.com/software/analytics/spss/documentation/statistics/24.0/en/client/Manuals/IBM_SPSS_Decision_Trees.pdf.
402. Chalmers DJ, Samaranayaka A, Mcnoe BM. Risk factors for injury in community-level football : a cohort study. *Int J Inj Contr Saf Promot*. 2013;20(1):68-78.
403. Malina RM. Growth and maturity status of youth soccer players. In: Reilly T, Williams M, eds. *Science and Soccer*. Second. London: Routledge; 2005:287-303.
404. Hölmich P, Larsen K, Krogsgaard K, Gluud C. Exercise program for prevention of groin pain in football players : a cluster-randomized trial. *Scand J Med Sci Sports*. 2010;20:814-821. doi:10.1111/j.1600-0838.2009.00998.x.
405. Hägglund M, Waldén M, Ekstrand J. Injury incidence and distribution in elite football - A prospective study of the Danish and the Swedish top divisions. *Scand J Med Sci Sport*. 2005;15(1):21-28. doi:10.1111/j.1600-0838.2004.00395.x.
406. Ekstrand J, Hägglund M, Waldén M. Injury incidence and injury patterns in professional football: the UEFA injury study. *Br J Sports Med*. 2011;45(7):553-558. doi:10.1136/bjsm.2009.060582.
407. Gabbett TJ, Domrow N. Relationships between training load , injury , and fitness in sub-elite collision sport athletes collision sport athletes. 2016;414(October). doi:10.1080/02640410701215066.
408. Hägglund M, Waldén M, Ekstrand J. Exposure and injury risk in Swedish elite football: A comparison between seasons 1982 and 2001. *Scand J Med Sci Sport*. 2003;13(6):364-370. doi:10.1046/j.1600-0838.2003.00327.x.
409. Bjørneboe J, Flørenes TW, Bahr R, Andersen TE. Injury surveillance in male professional football ; is medical staff reporting complete and accurate ? *Scand J Med Sci Sports*. 2011;21:713-720. doi:10.1111/j.1600-0838.2009.01085.x.
410. Ryynänen J, Junge A, Dvorak J, et al. Foul play is associated with injury incidence : an epidemiological study of three FIFA World Cups (2002 – 2010). *Br J Sports Med*. 2013;47:986-991. doi:10.1136/bjsports-2013-092676.
411. Nielsen AB, Yde J. Epidemiology and traumatology of injuries in soccer. *Am J Sports Med*. 1989;17(6):803-807. doi:10.1177/036354658901700614.
412. Fuller CW, Smith GL, Junge A, Dvorak J. An assessment of player error as an injury causation factor in international football. *Am J Sport Med*. 2004;32(1 Suppl):28S-35S. doi:10.1177/0363546503261247.
413. Oztekin HH, Boya H, Ozcan O, Zeren B, Pinar P. Foot and ankle injuries and time lost from play in professional soccer players. *Foot*. 2009;19(1):22-28. doi:10.1016/j.foot.2008.07.003.
414. Wong P, Hong Y. Soccer injury in the lower extremities. *Br J Sports Med*. 2005;39(8):473-482. doi:10.1136/bjsm.2004.015511.
415. Giza E, Fuller C, Junge A, Dvorak J. Mechanisms of foot and ankle injuries in soccer. *Am J Sports Med*. 2003;31(4):550-554. doi:10.1177/03635465030310041201.
416. Andersen TE. Video Analysis of the Mechanisms for Ankle Injuries in Football. *Am J Sports Med*.

2004;32(90010):69S-79. doi:10.1177/0363546503262023.
417. Henke T, Luig P. Safety in Sports. General Guidelines for the Development and Implementation of Sustainable Safety Management Schemes in High Risk Sports in the EU Countries. *Ruhr Univ Bochum Sport Med*. 2012.
418. Rintaugu EG, Mwisukha A, Onywera V. Analysis of factors that affect the standard of soccer in africa: the case of east african countries. *J Phys Educ Sport*. 2012;12(1):135-139. http://search.ebscohost.com/login.aspx?direct=true&db=sph&AN=78179569&login.asp&site=ehost-live&scope=site.
419. Andersen TE, Arnason A, Engebretsen L, Bahr R. Mechanisms of head injuries in elite football. *Br J Sports Med*. 2004;38(6):690-696. doi:10.1136/bjsm.2003.009357.
420. FIFA. Laws of the Game 2014/2015. 2014:1-141. http://www.fifa.com/mm/document/footballdevelopment/refereeing/02/36/01/11/27_06_2014_new--lawsofthegameweben_neutral.pdf.
421. Mccrory P, Meeuwisse WH, Aubry M, et al. Consensus statement on concussion in sport : the 4th International Conference on Concussion in Sport held in Zurich , November 2012. *Br J Sports Med*. 2013;47:250-258. doi:10.1136/bjsports-2013-092313.
422. McCrory P, Johnston K, Meeuwisse W, et al. Summary and agreement statement of the second international conference on concussion in sport, prague 2004. *Phys Sportsmed*. 2005;33(4):29-44. doi:10.3810/psm.2005.04.76.
423. Mohammadi F. A coach-controlled rehabilitation program reduces the risk of reinjury among amateur soccer players. *Aust J Physiother*. 2008;54(1):74. doi:10.1016/S0004-9514(08)70070-9.
424. Hägglund M, Waldén M, Ekstrand J. Injury recurrence is lower at the highest professional football level than at national and amateur levels: does sports medicine and sports physiotherapy deliver? *Br J Sports Med*. 2016;50(12):bjsports-2015-095951. doi:10.1136/bjsports-2015-095951.
425. Shrier I. Strategic Assessment of Risk and Risk Tolerance (StARRT) framework for return-to-play. *Br J Sports Med*. 2015;49:1311-1315. doi:10.1136/bjsports-2014-094569.
426. Ardern CL, Glasgow P, Schneiders A, et al. 2016 Consensus statement on return to sport from the First World Congress in Sports Physical Therapy, Bern. *Br J Sports Med*. 2016;50:853-864. doi:10.1136/bjsports-2016-096278.
427. Davis J, Bailey S. Possible mechanisms of central nervous system fatigue during exercise. *Med Sci Sport Exerc*. 1997;29(1):45-57.
428. Gleeson N, Reilly T, Mercer T, Rakowski S, Rees D. Influence of acute endurance activity on leg neuromuscular and musculoskeletal performance. *Med Sci Sport Exerc*. 1998;30(4):596-608.
429. Rahnama N. Injury risk associated with playing actions during competitive soccer. *Br J Sports Med*. 2002;36(5):354-359. doi:10.1136/bjsm.36.5.354.
430. Small K, McNaughton L, Greig M, Lovell R. The effects of multidirectional soccer-specific fatigue on markers of hamstring injury risk. *J Sci Med Sport*. 2010;13(1):120-125. doi:10.1016/j.jsams.2008.08.005.
431. Mair S, Seaber A, Glisson R, Garrett WE. The role of fatigue in susceptibility to acute muscle strain injury. *Am J Sports Med*. 1996;24(2):137-143. doi:10.1177/036354659602400203.
432. Garrett WE. Muscle strain injuries: clinical and basic aspects. *Med Sci Sport Exerc*. 1990;22(4):436-443.
433. Chan K, Mahomoodally F, Veeren R. Stretching in the prevention of hamstring strains: Attitudes, beliefs and current practices among football coaches in Mauritius. *Open J Prevetinve Med*. 2012;2(3):1-8. doi:10.4236/ojpm.2012.22021.
434. Elvin NG, Elvin AA, Arnoczky SP, Torry MR. The correlation of segment accelerations and impact forces with knee angle in jump landing. *J Appl Biomech*. 2007;23(3):203-212. doi:10.1123/jab.23.3.203.

435. Tegnanden A, Olsen OE, Moholdt TT, Engebretsen L, Bahr R. Injuries in Norwegian female elite soccer : a prospective one-season cohort study. *Knee Surgery, Sport Traumatol Arthrosc*. 2008;16:194-198. doi:10.1007/s00167-007-0403-z.
436. Woods C, Hawkins R, Hulse M, Hodson A. The Football Association Medical Research Programme: an audit of injuries in professional football: an analysis of ankle sprains. *Br J Sports Med*. 2003;37(3):233-238. doi:10.1136/bjsm.37.3.233.
437. Gatterer H, Ruedl G, Faulhaber M, Regele M, Burtscher M. Effects of the performance level and the FIFA "11" injury prevention program on the injury rate in Italian male amateur soccer players. *J Sports Med Phys Fitness*. 2012;52(1):80-84. http://search.proquest.com/docview/923600191?accountid=14500.
438. Ekstrand J, Gillquist J, Liljedahl S-O. Prevention of soccer injuries: Supervision by doctor and physiotherapist. *Am J Sports Med*. 1983;11(3):116-120. doi:10.1177/036354658301100302.
439. Owoeye OB a, Akinbo SR a, Tella B a., Olawale O a. Efficacy of the FIFA 11+ warm-up programme in male youth football: A cluster randomised controlled trial. *J Sport Sci Med*. 2014;13(2):321-328.
440. Lehnhard R, Lehnhard H, Young R, Butterfield S. Monitoring injuries on a college soccer team: the effect of strength training. *J strength Cond Res*. 1996;10(2):115-119.
441. Junge A, Rosch D, Peterson L, Graf-baumann T. Prevention of Soccer Injuries : A Prospective Intervention Study in Youth Amateur Players. *Am J Sports Med*. 2002;30(5):9-12.
442. Soligard T, Myklebust G, Steffen K, et al. Comprehensive warm-up programme to prevent injuries in young female footballers: cluster randomised controlled trial. *Br Med J*. 2008;337:a2469. doi:10.1136/bmj.a2469.
443. Steffen K, Myklebust G, Olsen OE, Holme I, Bahr R. Preventing injuries in female youth football - A cluster-randomized controlled trial. *Scand J Med Sci Sport*. 2008;18(5):605-614. doi:10.1111/j.1600-0838.2007.00703.x.
444. Steffen K, Meeuwisse WH, Romiti M, et al. Evaluation of how different implementation strategies of an injury prevention programme (FIFA 11+) impact team adherence and injury risk in Canadian female youth football players: a cluster-randomised trial. *Br J Sports Med*. 2013;47(8):480-487. doi:10.1136/bjsports-2012-091887.
445. Silvers-granelli H, Mandelbaum B, Adeniji O, et al. Efficacy of the FIFA 11+ Injury Prevention Program in the Collegiate Male Soccer Player. *Am J Sports Med*. 2015;43(11):2628-2632. doi:10.1177/0363546515602009.
446. Hammes D, Fünten K Der, Kaiser S, et al. Injury prevention in male veteran football players – a randomised controlled trial using " FIFA 11 + ." *J Sports Sci*. 2015;33(9):873-881. doi:10.1080/02640414.2014.975736.
447. Zouita S, Zouita A, Kebsi W, et al. STRENGTH T RAINING R EDUCES INJURY RATE IN ELITE YOUNG SOCCER PLAYERS DURING ONE SEASON. *J strength Cond Res*. 2016;30(5):1295-1307.
448. Mcguine TA, Keene JS. The Effect of a Balance Training Program on the Risk of Ankle Sprains in High School Athletes. *Am J Sports Med*. 2006;34(7):1103-1111. doi:10.1177/0363546505284191.
449. Caraffa a., Cerulli G, Projetti M, Aisa G, Rizzo a. Prevention of anterior cruciate ligament injuries in soccer. *Knee Surgery, Sport Traumatol Arthrosc*. 1996;4(1):19-21. doi:10.1007/BF01565992.
450. Mandelbaum BR, Silvers HJ, Watanabe DS, et al. Effectiveness of a neuromuscular and proprioceptive training program in preventing anterior cruciate ligament injuries in female athletes: 2-year follow-up. *Am J Sports Med*. 2005;33(7):1003-1010. doi:10.1177/0363546504272261.
451. Pfeiffer R, Shea K, Roberts D, Grandstrand S, Bond L. Lack of Effect of a Knee Ligament Injury Prevention Program on the Incidence of Noncontact Anterior Cruciate Ligament Injury. *J Bone Jt Surg*. 2006;88(8):1769-1774.

452. Hewett TE, Lindenfeld TN, Riccobene J V, Noyes FR. The effect of neuromuscular training on the incidence of knee injury in female athletes. A prospective study. *Am J Sports Med*. 1999;27(6):699-706. doi:10.1177/0363546508322479.
453. Hägglund M, Waldén M, Ekstrand J. Lower reinjury rate with a coach-controlled rehabilitation program in amateur male soccer: a randomized controlled trial. *Am J Sports Med*. 2007;35(9):1433-1442. doi:10.1177/0363546507300063.
454. Engebretsen AH, Myklebust G, Holme I, Engebretsen L, Bahr R. Prevention of Injuries Among Male Soccer Players A Prospective , Randomized Intervention Study Targeting Players With Previous Injuries or Reduced Function. *Am J Sports Med*. 2008;36(6):1052-1060. doi:10.1177/0363546508314432.
455. Grooms DR, Palmer T, Onate JA, Myer GD, Grindstaff T. Soccer-specific warm-up and lower extremity injury rates in collegiate male soccer players. *J Athl Train*. 2013;48(6):782-789. doi:10.4085/1062-6050-48.4.08.
456. Petersen J, Thorborg K, Nielsen M, Budtz-Jorgensen E, Hölmich P. Preventive Effect of Eccentric Training on Acute Hamstring Injuries in Men' s Soccer. *Am J Sports Med*. 2011;39(11):2296-2303. doi:10.1177/0363546511419277.
457. Horst N Van Der, Smits D, Petersen J, Goedhart EA, Backx FJG. The preventive effect of the nordic hamstring exercise on hamstring injuries in amateur soccer players: A randomised controlled trial. *Am J Sports Med*. 2015;43(6):1316-1323. doi:10.1177/0363546515574057.
458. Fredberg U, Bolvig L, Andersen N. Prophylactic Training in Asymptomatic Soccer Players With Ultrasonographic Abnormalities in Achilles and Patellar The Danish Super League Study. *Am J Sports Med*. 2008;36(3):451-460. doi:10.1177/0363546507310073.
459. Junge A, Lamprecht M, Stamm H, et al. Countrywide campaign to prevent soccer injuries in Swiss amateur players. *Am J Sports Med*. 2011;39(1):57-63. doi:10.1177/0363546510377424.
460. Farhan AF, Stephany MJ, Mahammed SK. Prevention of Soccer-Related Ankle Injuries in Youth Amateur Players: a Randomized Controlled Trial. *Movement, Heal Exerc*. 2017;6(1):39-45. doi:http://dx.doi.org/10.15282/mohe.v6i1.83.
461. Arnason A, Engebretsen L, Bahr R. No Effect of a Video-Based Awareness Program on the Rate of Soccer Injuries. *Am J Sports Med*. 2000;33(1):17-20. doi:10.1177/0363546503262688.
462. Elias SR, Roberts WO, Thorson D. Team sports in hot weather: guidelines for modifying youth soccer. *Physician Sport Med*. 1991;19:67-78. doi:http://dx.doi.org/10.1080/00913847.1991.11704845.
463. Thacker SB, Stroup DF, Branche CM, Gilchrist J, Goodman RA, Kelling EP. Prevention of knee injuries in sports: A systematic review of the literature. *J Sports Med Phys Fitness*. 2003;43(2):165-179. doi:10.1097/BLO.0b013e3180e79c6a.
464. Olsen L, Scanlan A, MacKay M, et al. Strategies for prevention of soccer related injuries: a systematic review. *Br J Sport Med*. 2004;38(May 2006):89-94. doi:10.1136/bjsm.2002.003079.
465. Verhagen EALM, Bay K. Optimising ankle sprain prevention: A critical review and practical appraisal of the literature. *Br J Sports Med*. 2010;44(15):1082-1088. doi:10.1136/bjsm.2010.076406.
466. Kirkendall DT, Junge A, Dvorak J. Prevention of football injuries. *Asian J Sports Med*. 2010;1(2):81-92. doi:10.1007/88-470-0419-5_6.
467. Van Beijsterveldt AMC, Van Der Horst N, Van De Port IGL, Backx FJG. How effective are exercise-based injury prevention programmes for soccer players?: A systematic review. *Sport Med*. 2013;43(4):257-265. doi:10.1007/s40279-013-0026-0.
468. Porter T, Rushton A. The efficacy of exercise in preventing injury in adult male football: a systematic review of randomised controlled trials. *Sport Med - Open*. 2015;1(1). doi:10.1186/s40798-014-0004-6.

469. Grimm NL, Jacobs JC, Kim J, Denney BS, Shea KG. Anterior Cruciate Logament and Knee Injury Prevention Programs for Soccer Players A Systematic Review and Meta-analysis. *Am J Sports Med*. 2015;43(8):2049-2056. doi:10.1177/0363546514556737.
470. Steffen K, Myklebust G, Olsen OE, Holme I, Bahr R. Preventing injuries in female youth football--a cluster-randomized controlled trial. *Scand J Med Sci Sports*. 2008;18(5):605-614. doi:10.1111/j.1600-0838.2007.00703.x.
471. FIFA, F-Marc. The "11+" Manual: A complete warm-up programme to prevent injuries. 2007:1-76. http://www.yrsa.ca/pdf/Fifa11/11plus_workbook_e.pdf.
472. Daneshjoo A, Mokhtar AH, Rahnama N, Yusof A. the Effects of Injury Prevention Warm-Up Programmes on Knee Strength in Male Soccer Players. *Biol Sport*. 2013;30(4):281-288. doi:10.5604/20831862.1077554.
473. Barengo N, Meneses-Echávez J, Ramírez-Vélez R, Cohen D, Tovar G, Bautista J. The Impact of the FIFA 11+ Training Program on Injury Prevention in Football Players: A Systematic Review. *Int J Environ Res Public Health*. 2014;11(11):11986-12000. doi:10.3390/ijerph111111986.
474. Fernandes A de A, Silva CD da, Costa IT da, Marins JCB. The "FIFA 11+" warm-up programme for preventing injuries in soccer players: a systematic review. *Fisioter em Mov*. 2015;28(2):397-405. doi:10.1590/0103-5150.028.002.AR01.
475. Bizzini M, Dvorak J. FIFA 11+: an effective programme to prevent football injuries in various player groups worldwide-a narrative review. *Br J Sports Med*. 2015;49(9). doi:10.1136/bjsports-2015-094765.
476. Al Attar WSA, Soomro N, Pappas E, Sinclair PJ, Sanders RH. How Effective are F-MARC Injury Prevention Programs for Soccer Players? A Systematic Review and Meta-Analysis. *Sport Med*. 2016;46(2):205-217. doi:10.1007/s40279-015-0404-x.
477. Thorborg K, Krommes KK, Esteve E, Clausen MB, Bartels EM, Rathleff MS. Effect of specific exercise-based football injury prevention programmes on the overall injury rate in football: a systematic review and meta-analysis of the FIFA 11 and 11+ programmes. *Br J Sports Med*. 2017;51:562-571. doi:10.1136/bjsports-2016-097066.
478. Sadigursky D, Braid JA, De Lira DNL, Machado BAB, Carneiro RJF, Colavolpe PO. The FIFA 11+ injury prevention program for soccer players: A systematic review. *BMC Sports Sci Med Rehabil*. 2017;9(1):1-8. doi:10.1186/s13102-017-0083-z.
479. Soligard T, Nilstad A, Steffen K, et al. Compliance with a comprehensive warm-up programme to prevent injuries in youth football. *Br J Sports Med*. 2010;44(11):787-793. doi:10.1136/bjsm.2009.070672.
480. Drawer S, Fuller CW. Perceptions of retired professional soccer players about the provision of support services before and after retirement. *Br J Sports Med*. 2002;36(1):33-38. doi:10.1136/bjsm.36.1.33.
481. Pfile KR, Curioz B. Coach-led prevention programs are effective in reducing anterior cruciate ligament injury risk in female athletes: A number-needed-to-treat analysis. *Scand J Med Sci Sports*. 2017;(December 2016):1-9. doi:10.1111/sms.12828.
482. McKay CD, Steffen K, Romiti M, Finch CF, Emery C a. The effect of coach and player injury knowledge, attitudes and beliefs on adherence to the FIFA 11+ programme in female youth soccer. *Br J Sports Med*. 2014;48:1-7. doi:10.1136/bjsports-2014-093543.
483. Jang S. The Relationship between High School Coaches â€™ Beliefs about Sports Injury and Prevention Practice Readiness. *Grad Sch Theses Diss*. 2013;(January 2013):125-152.
484. Sharkey, Gaskill. Sports Physiology for Coaches. 2006:Human Kinetics, Champain, USA.
485. Norcross MF, Johnson ST, Bovbjerg VE, Koester MC, Hoffman MA. Factors influencing high school coaches' adoption of injury prevention programs. *J Sci Med Sport*. 2016;19(4):299-304. doi:10.1016/j.jsams.2015.03.009.

486. Sainani K. The Importance of Accounting for Correlated Observations. *Am Acad Phys Med Rehabil*. 2010;2(9):858-861. doi:10.1016/j.pmrj.2010.07.482.
487. Galbraith S, Daniel JA, Vissel B. A Study of Clustered Data and Approaches to Its Analysis. *J Neurosci*. 2010;30(32):10601-10608. doi:10.1523/JNEUROSCI.0362-10.2010.
488. Moher D, Hopewell S, Schulz KF, et al. CONSORT 2010 explanation and elaboration: Updated guidelines for reporting parallel group randomised trials. *Int J Surg*. 2012;10(1):28-55. doi:10.1016/j.ijsu.2011.10.001.
489. Waldén M, Atroshi I, Magnusson H, Wagner P, Hagglung M. Prevention of acute knee injuries in adolescent female football players: cluster randomised controlled trial. *Br Med J*. 2012;344:e3042. doi:10.1136/bmj.e3042.
490. O'Brien J, Finch CF. Injury prevention exercise programmes in professional youth soccer: understanding the perceptions of programme deliverers. *BMJ Open Sport Exerc Med*. 2016;2(1):e000075. doi:10.1136/bmjsem-2015-000075.
491. Shultz SJ, Schmitz RJ, Benjaminse A, Collins M, Ford K, Kulas AS. ACL research retreat VII: An update on anterior cruciate ligament injury risk factor identification, screening, and prevention March 19-21, 2015; Greensboro, nc. *J Athl Train*. 2015;50(10):1076-1093. doi:10.4085/1062-6050-50.10.06.
492. White PE, Otago L, Saunders N, et al. Ensuring implementation success: how should coach injury prevention education be improved if we want coaches to deliver safety programmes during training sessions? *Br J Sports Med*. 2014;48(5):402-403. doi:10.1136/bjsports-2012-091987.
493. Weaver J, Moore C, Howe W. Injury Prevention. In: *Epidemiology of Sports Injuries*. ; 1996:159-163.
494. Reade I, Rodgers W. A Collaboration model for Knowledge Transfer from Sport Science to High Performance Canadian UInteruniversity Caoches. *J Coach Educ*. 2009;2(1):1-18.
495. Grossman R, Salas E. The transfer of training: What really matters. *Int J Train Dev*. 2011;15(2):103-120. doi:10.1111/j.1468-2419.2011.00373.x.
496. Pryor JL, Root HJ, Vandermark LW, et al. Coach-led preventive training program in youth soccer players improves movement technique. *J Sci Med Sport*. 2016:1-6. doi:10.1016/j.jsams.2017.01.235.
497. Olsen O-E, Myklebust G, Engebretsen L, Holme I, Bahr R. Exercises to prevent lower limb injuries in youth sports: cluster randomised controlled trial. *Br Med J*. 2005:1-7. doi:10.1136/bmj.38330.632801.8F.
498. Myklebust G, Engebretsen L, Braekken IH, Skjølberg A, Olsen O-E, Bahr R. Prevention of anterior cruciate ligament injuries in female team handball players: a prospective intervention study over three seasons. *Clin J Sport Med*. 2003;13(2):71-78. doi:10.1097/00042752-200303000-00002.
499. Saunders N, Otago L, Romiti M, Donaldson a, White P, Finch C. Coaches' perspectives on implementing an evidence-informed injury prevention programme in junior community netball. *Br J Sports Med*. 2010;44(15):1128-1132. doi:10.1136/bjsm.2009.069039.
500. Reis I, Rebelo A, Krustrup P, Brito J. Performance Enhancement Effects of Fédération Internationale de Football Association's "The 11+" Injury Prevention Training Program in Youth Futsal Players. *Clin J Sport Med*. 2013;23(4):318-320. doi:10.1097/JSM.0b013e318285630e.
501. Impellizzeri FM, Bizzini M, Dvorak J, Pellegrini B, Schena F, Junge A. Physiological and performance responses to the FIFA 11+ (part 2): a randomised controlled trial on the training effects. *J Sports Sci*. 2013;31(13). doi:10.1080/02640414.2013.802926.
502. Nakase J, Inaki A, Mochizuki T, et al. Whole Body Muscle Activity during the FIFA 11+ Program Evaluated by Positron Emission Tomography. *PLoS One*. 2013;8(9):8-13. doi:10.1371/journal.pone.0073898.
503. Silva JRLDC, Silva JF Da, Salvador PCDN, Freitas CDLR. The effect of "FIFA 11+" on vertical jump

performance in soccer players. *Rev Bras Cineantropometria & Desempenho Hum*. 2015;(April):733-741. doi:10.5007/1980-0037.2015v17n6p733.
504. Bizzini M, Impellizzeri FM, Dvorak J, et al. Physiological and performance responses to the “FIFA 11+” (part 1): is it an appropriate warm-up? *J Sports Sci*. 2013;31(13):1481-1490. doi:10.1080/02640414.2013.802922.
505. Javier Robles-Palazon F, Pomares-Noguera C, Ayala F, et al. Acute and Chronic Effects of the Fifa 11+ on Several Physical Performance Measures in Adolescent Football Players. *Eur J Hum Mov*. 2016;36:116-136.
506. Steffen K, Emery C a, Romiti M, et al. High adherence to a neuromuscular injury prevention programme (FIFA 11+) improves functional balance and reduces injury risk in Canadian youth female football players: a cluster randomised trial. *Br J Sports Med*. 2013;47(12):794-802. doi:10.1136/bjsports-2012-091886.
507. Campbell MK, Piaggio G, Elbourne DR. Consort 2010 statement : extension to cluster randomised trials. *Br Med J*. 2012;e5661(September):1-21. doi:10.1136/bmj.e5661.
508. Gray J, Naylor R. Musculoskeletal assessment form. *BokSmart*. 2009:1-42. doi:10.1016/B978-0-7020-4344-4.00011-0.

APPENDICES

Appendix I: List of players' form

N°	Names	DOB	Playing position	Number of years playing soccer	Number of years in 1st/ 2nd division	Number of years in current club
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Appendix II: Medical record form

Team Code:…….
Player's name:…….
Player's code: …….

1. In the last season, have you sustained any injury during training or competitive match that have resulted in you missing the following session(s)?
   Training Injury ☐ How many
   Match injury ☐ How many ☐

2. Which body parts sustained injury? (One or more answers are possible).

Head: □	Face: □	Neck: □	Shoulder: □	Back: □	Chest: □
Upper arm: □	Elbow: □	Fore arm: □	Wrist: □	Hand: □	Finger: □
Pelvis: □	Buttock: □	Groin: □	Hip: □	Front thigh: □	Back thigh: □
Knee: □	Shin:□	Calf: □	Ankle: □	Foot: □	Toe: □

3. Did you receive any treatment to your injury (ies)

Yes □
No □

4. Is (Are) the injury (ies) completely healed that you can fully take part in training or match?

Yes □
No □

Thank you for your information

Appendix III: Description of the test

Station 1
Anthropometric assessment
Weight
The weight was measured using an electronic weighing scale (Omron HN-283 Digital Body Weight Scale).
Procedure:

- Players were tested without any extra clothing and shoes
- They were requested to stand on the scale erect
- The measurement were recorded to the nearest kilogramme

Height
A tape measure was taped on the wall.
Procedure:

- The players were tested without the shoes standing with feet together facing away from the tape, with heels, back and the occiput against the wall.
- The ruler was used to point the top of the head for easy reading.
- The height was recorded to the nearest centimetre

Station 2
Ankle dorsiflexion lunge for testing the flexibility of ankle dorsiflexors (Figure 4).

- A tape measure was place on the floor from the wall backwards
- A vertical line was drawn on the wall perpendicular to the tape
- The subject stepped over the tape making sure that the straight line between the heel and the big toe was parallel to the tape measure
- The player performed a forward lunge pushing the knee to come in contact with the vertical line and to as far as possible from the wall with the heel remaining in contact with the ground.
- The non-tested leg could assume any position and the subject could hold on the wall for stability
- The distance between the wall and the big toe was recorded to the closest centimetre

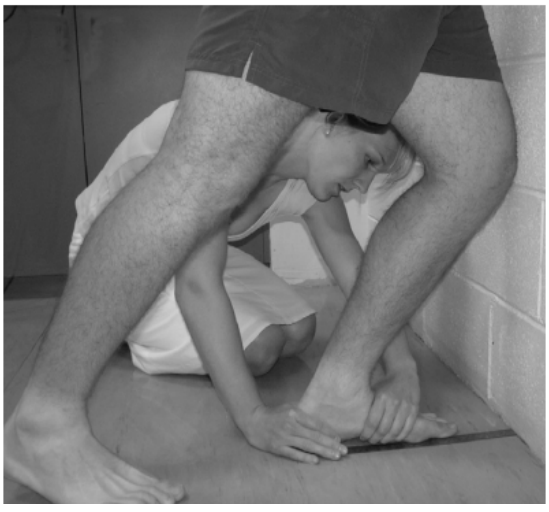


Figure 4: Position of measurement for ankle dorsiflexion lounge (Dennis, Finch, Elliott, & Farhart, 2008)

Flexibility

Active knee extension for measuring hamstring flexibility (Figure 1)

Procedure:

- The subjects werein supine position on the plinth with the tested leg in 90º flexion.
- A support was placed against the posterior thigh to maintain the hip in the flexed position.
- The player was instructed to extend the knee, keeping the foot relaxed in plantar flexion
- The degree of knee extension was measured when the available range of motion is reached

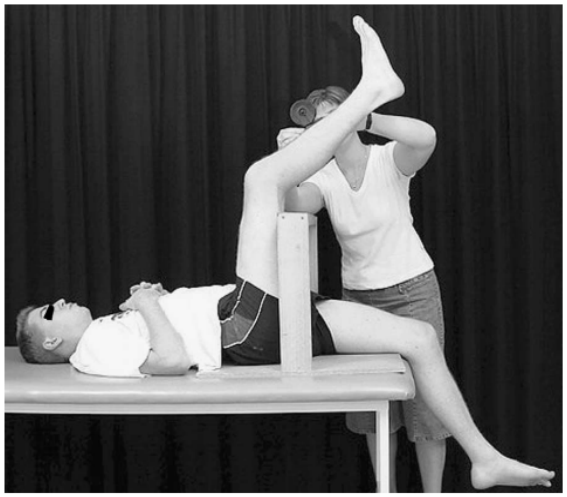


Figure 1: Position of measurement for active knee extension test [276]

Modified Thomas test for measuring iliopsoas flexibility (figure 2)

Procedure:

- The subjectswere positioned in supine lying with legs hanging at the end of the plinth from the hips.
- The non-tested leg was grasped by the subject so that the hip and knee were flexed placing the thigh against the abdomen to allow the lumbar spine to be flat with pelvic posterior tilt.
- The tested leg was left freely hanging while the action of the force of gravity determined the test end point position
- The iliopsoas muscle length was obtained by measuring the angle of hip flexion range of motion
- The quadriceps muscle length was obtained by measuring the angle of knee flexion range of motion to the nearest degree

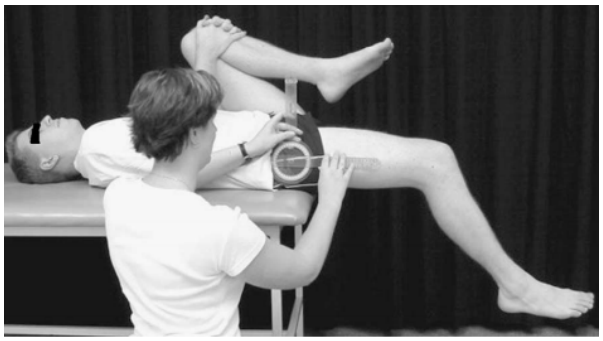
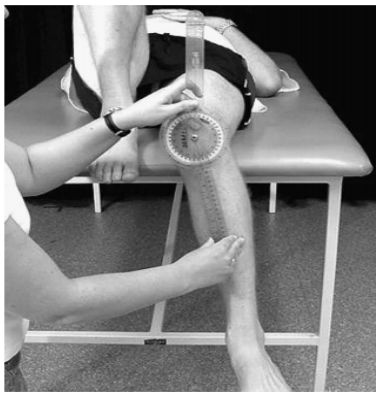


Figure 2: Position for measurement for modified Thomas test [276]

Active hip internal rotation and external rotation range of motion (Figure 3)

- The subject was positioned in supine with lower legs hanging at the end of the plinths.
- The hip joints were in neutral position and the lower leg of the tested leg hanging freely over the edge of the table
- The non-tested leg was flexed at the hip and knee so that the foot rests on the plinth
- For internal rotation, the subject was requested to perform internal rotation without moving the hip
- For external rotation, the subject was requested to perform external rotation without moving the hip
- The measurement was recorded to the nearest degree using the goniometer

A 

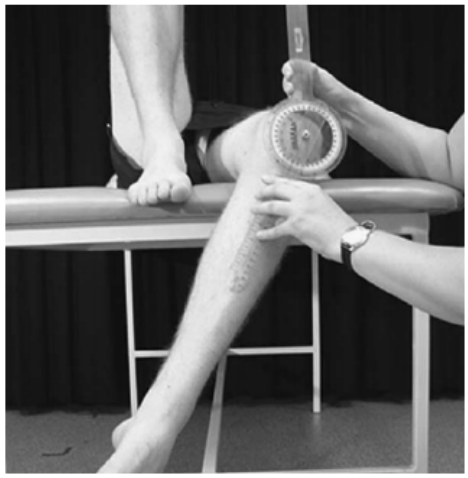
B 

Figure 3: Position of measurement for (A) hip internal rotation and (B) external rotation [276]

Sit and Reach test (Figure 5)

- The players were asked to sit on the mat with the legs extended. The sole of the feet against the Sit and Reach box.
- They were asked to stretch forward as far as possible to reach the toes while keeping the knees straight.
- One hand placed on top of the other
- The end position was held for 1 second
- The distance from the tip of the middle finger and the toe line was measured in centimetres

Figure 5: Position of measurement for Sit and Reach test [276]

Neural mobility test

Active slump test(Figure 9)

- The player were in sitting position at the edge of the plinth with lower legs hanging
- They were instructed to place the arms behind the back, flex the neck, thorax and lower back
- Then they were instructed to do dorsiflexion
- Then they were instructed to perform knee extension till they feel discomfort or stretch
- The knee flexion angle was measured in degrees

Figure 9: Position of measurement for active slump test [276]

Station 3

Stability and strength

Four-point hold (the plank) (Figure 10)

- The participants assumed a prone lying position on the floor resting on the forearms shoulder width apart and feet in push up position
- They were instructed to rise the trunk off the floor, resting on the forearms and toes, holding a neutral lumbopelvic position as long as possible
- A stopwatch was used to determine the length of time the participant held a neutral position, to the nearest second
- The test was terminated if the participant experienced any pain, if the position was no longer be maintained or abandoned

Figure 10: Position of measurement for 4 point hold (Dennis et al., 2008)

Calf endurance test (Figure 11)

- The players were instructed to stand barefooted on the step with the ball of the foot
- They were instructed to alternatively rise and lower the heel in as full range as possible while the knee remain extended
- The heel rise was performed at one cycle per second
- They will be instructed to continue until they are unable to continue, or complete the full cycle or voluntarily stop due to fatigue
- The number of cycles completed by the subjects are recorded

Figure 11: Position of measurement for Calf endurance test[508]

Proprioception

The Y-Balance Test (Figure 12)

A grid with 3 lines extending at 60º from each other. The player was asked to stand on one leg at the centre and try reach as far as possible with the other leg on the three lines. The players was asked to lightly touch the line with the most distal portion of the reaching foot without shifting weight to or coming to rest on the foot of the reaching limb; and then returns the reaching limb to the beginning position in the centre of the grid, reassuming a bilateral stance. If the player touched heavily or came to rest at the touchdown point, had contact with the ground with the reaching foot to maintain balance, or lifting or shifting any part of the foot of the stance limb during the trial, the trial wasnot considered complete. It was then be repeated.

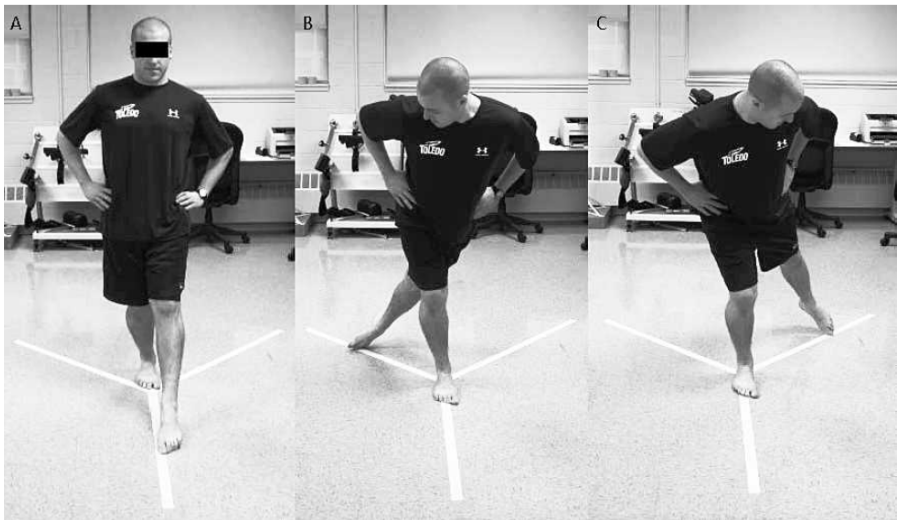


Figure 12: Position of measurement for SEBT [377]

Single leg hop tests (Figure 13)

Single leg hop

- A tape measure was taped straight to the floor
- Players to be tested stood on one leg with the big toe lined at the mark zero
- They were instructed to perform a single hop by trying to reach as far as possible and land on the same leg
- The distance from the zero mark and the point where the heel hit the ground was recorded in centimetres

Timed hop

- A tape measure was taped to the floor for a distance of six meters
- Players to be tested stood on one leg with the big toe lined at the mark zero
- They were instructed to perform the hops on the same leg on a straight line and cross the 6-meter mark
- The time that the subjects used to hop the 6 metreswas recorded to the nearest tenth of the second.

Triple hop

- A tape measure was taped to the floor
- Players stood on one leg with the big toe lined at the mark zero
- They were instructed to perform three consecutive hops on a straight line using the same leg
- The distance from the zero mark and the point where the heel hit the ground on the last hop was recorded in centimetre

Cross over hop

- A tape measure was taped to the floor on a six meter line with 15 cm wide
- Players to be tested stood on one leg with the big toe lined at the mark zero
- They were instructed to perform three consecutive hops crossing the line from one side to another using the same leg
- The distance from the zero mark and the point where the heel hit the ground on the last hop was recorded in centimetres

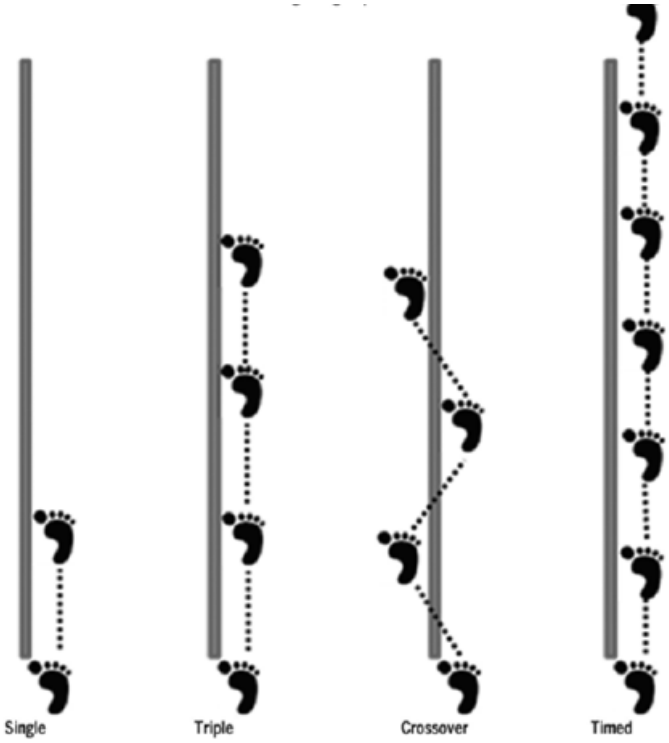


Figure 13: Position of measurement for single leg hop tests

Lower Extremity Functional Test (LEFT)(Figure 14)

The testing area for the LEFT was set at 9.14 meters (m) in a north-south direction and 3.05 m in a west-east direction. The players were instructed to perform forward run, backward run, side shuffle, carioca, figure 8 run, 45^{o} cuts, 90^{o} cuts. The forward run and the backward run were repeated at the end of the sequence (after the 90^{o} cuts). Because of the complexity of the different movements, subjects were instructed in advance of each of the eight agility tasks. Further verbal instructions describing the next task and corresponding direction of movement was provided. Time was recorded in seconds using a standard stop-watch.

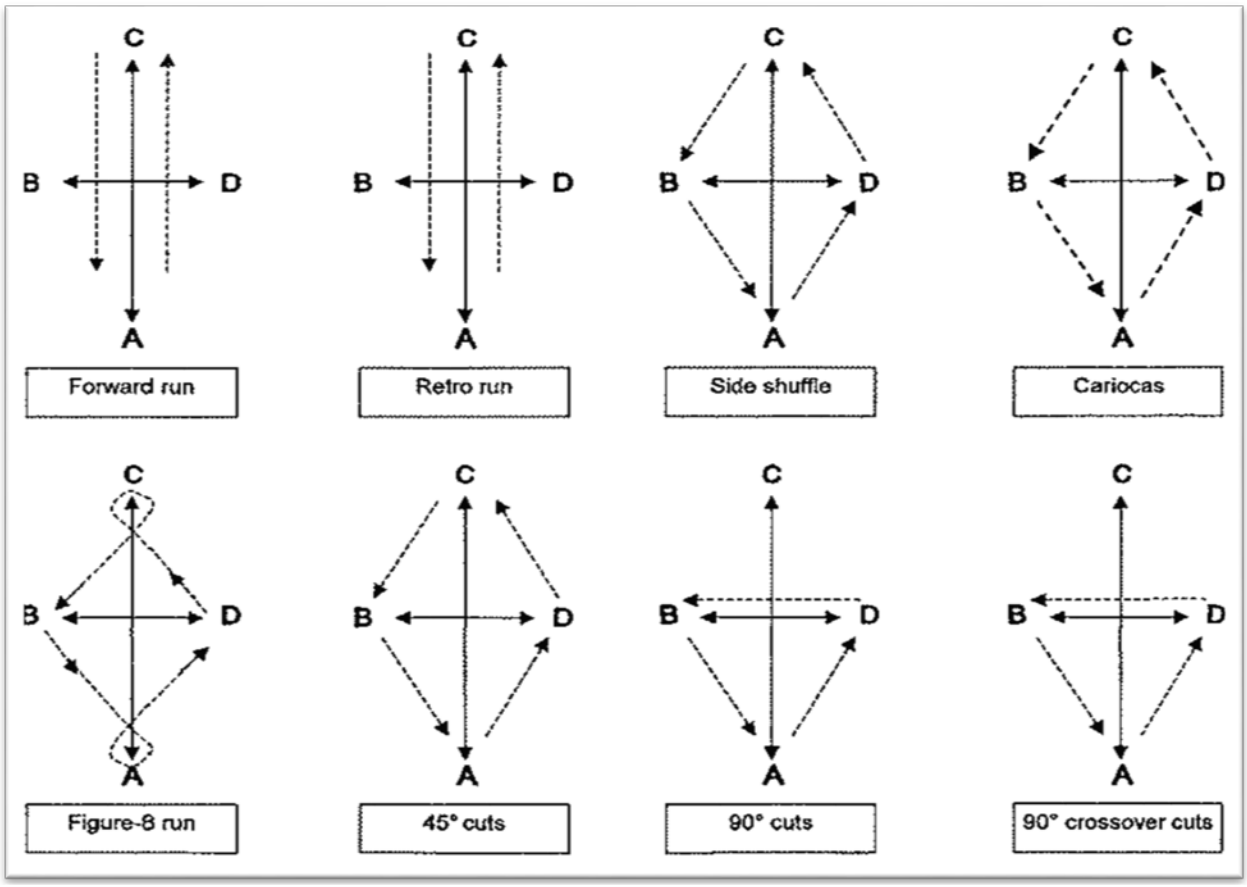


Figure 13: Description of the maneuvers to be completed in during the test.

No permission was required to use the figures[276;377;508].

Appendix IV: Data capture sheet for anthropometrics and functional test results

Number	Player ID	Ankle DF		Sit and Reach	Four-point hold	Calf endurance test		Active knee extension		Thomas test Hip		Thomas test knee		Active Hip IR		Active Hip ER	
		L	R			L	R	L	R	L	R	L	R	L	R	L	R

Hip abduction		Active Slump		SEBT						HOP TEST								
L	R	L	R	Left			Right			Single Leg		Triple hop		Cross over hop		Timed hop		LEFT
				Anterior	Posteromedial	Posterolateral	Anterior	Posteromedial	Posterolateral	Left	Right	Left	Right	Left	Right	Left	Right	

Appendix V: Player exposure form

Exposure Report Form No.:..... Team code:.....

Date								
Training/ Match								
Player code number	Duration of training or match play for each player (Minutes)							

Attendance Report Form No.:..... Team code:……

Date								
Missed session completely (C) / Was at part of session (P)								
Player code number	Reason for missing (1 = football injury; 2 = sick; 3 = non-football related injury; 4 = family commitments; 5 = transport problems; 6 = unsure; 7 = other)							

Appendix VI: Daily injury report for football injuries

Team: _____Match _____/ _____ Date: _____/ _____/ _____

Please report:
All injuries (trauma and overuse) caused by football, **regardless** of the consequences with respect to participation in training or the game. The information provided is for medical and research purposes and will be treated confidentially.

Player	Injury Time	Location	Diagnosis	Severity	Side	Trauma/ Overuse	Circumstances		Consequences	Continue to play	Treatment
n°	Minute of match	Injured body part	Type of injury	Absence in days	Left (L) Right (R)	T(Trauma) O (Overuse)	contact	Foul	Referee's sanction		
							Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □	
							Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □	
							Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □	
							Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □	
							Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □	

No injuries in this team□

Definitions and codes of location, diagnosis, and severity see reverse

DEFINITIONS AND CODES

Location of injury

Trunk

1 head/face
2 neck/cervical spine
3 thoracic spine
4 lumbar spine
5 sternum/ribs
6 abdomen
7 pelvis/sacrum

Upper extremity

11 shoulder
12 upper arm
13 elbow
14 forearm
15 wrist
16 hand
17 finger
18 thumb

Lower extremity

21 hip
22 groin
23 thigh
24 knee
25 lower leg
26 achilles tendon
27 ankle
28 foot
29 toe

Diagnosis

1 concussion with loss of consciousness
2 concussion without loss of consciousness
3 fracture
4 dislocation
5 muscle fibre rupture
6 tendon rupture
7 ligament rupture with instability
8 ligament rupture without instability
9 lesion of meniscus
10 sprain
11 strain
12 contusion
13 bursitis
14 tendinitis
15 laceration / abrasion
16 dental injury
17 other

Severity of injury in days

Estimated duration of absence from training or play
for example:
0 = 0 days
1 = 1 day
2 = 2 days
7 = 1 week
14 = 2 weeks
>30 = more than 4 weeks

Circumstances and **consequences**

Contact with another player or an object (except ground)
Foul judgment of the player, overt and hidden fouls
Referee's sanction of the foul that caused the injury
Treatment by a physician, physiotherapist or dentist (on-pitch or post-match)

Appendix VII: Ethical approval letter

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room E52-24 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492 • **Facsimile** [021] 406 6411
Email: Sumayah.ariefdien@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

18 September 2014

HREC/REF: 683/2014

Dr T Burgess
Division of Physiotherapy
Zone 45
Health & Rehab Sciences
OMB

Dear Dr Burgess

Project Title: SOCCER INJURY SURVEILLANCE AND IMPLEMENTATION OF AN INJURY PREVENTION PROGRAMME IN RWANDA (PhD-candidate-A Nuhu)

Thank you submitting your study to the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review.

It is a pleasure to inform you that the HREC has **formally approved** the above mentioned study

Approval is granted for one year until the 30 September 2015.

Please submit a progress form, using the standardised Annual Report Form, if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.

We acknowledge that the following student:- Assuman Nuhu is also involved in this study.

Please note that the on-going ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the HREC REF in all your correspondence.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, HSF HUMAN ETHICS

Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938

Hrec/ref:683/2014

This serves to confirm that the University of Cape Town Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

The Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

Hrec/ref:683/2014

Appendix VIII: FERWAFA Permission letter

FERWAFA

B.P. 2000
Kigali.

FEDERATION RWANDAISE DE FOOTBALL ASSOCIATION

Kigali, tariki, 22/09/2014

N° 512 / FERWAFA / 2014

To: **Assuman Nuhu**
Division of Physiotherapy
School of Health and rehabilitation
University of Cape Town

RE: Permission to conduct a research study in football clubs in Rwanda

Referring to your letter requesting to conduct the study in football clubs in Rwanda, I am hereby informing you that you are granted the permission to conduct the study entitled **"Soccer injury surveillance and implementation of an injury prevention programme in Rwanda"** as part of your PhD study.

I take this opportunity to request all the football teams to facilitate you in collecting data.

MURINDAHABI K. Jean Olivier
Secretary General,

FEDERATION RWANDAISE DE FOOTBALL ASSOCIATION

Fédération Rwandaise de Football Association

Appendix IX: Coaches' information sheet

Department of Health and Rehabilitation Sciences

Faculty of Health Sciences

Divisions of Communications Sciences and Disorders,
Nursing and Midwifery, Occupational Therapy, Physiotherapy

F45 Old Main Building, Groote Schuur Hospital

PhD Study title: SOCCER INJURY SURVEILLANCE AND IMPLEMENTATION OF AN INJURY PREVENTION PROGRAMME IN RWANDA

INFORMATION SHEET

Dear Participant

I am a PhD student in the Division of Physiotherapy at the University of Cape Town. I will be conducting a study to establish an injury surveillance system in soccer teams in Rwanda and to explore the difference in the coaches' knowledge, perception of, and readiness to accept a sports injury prevention programme. The study also aims at assessing the use of a warm up programme on the reduction of injuries in soccer.You are invited to participate in this research project because as the coach, you are the one who organises and supervises the activities of the of the soccer players. This study has been given an ethical approval by the Human Research Ethics Committee, Faculty of Health Sciences, University of Cape Town (HREC REF 683/2014).

Expectations of participants
All the coaches (first and second division teams)
In this study you are expected to complete the questionnaires administered to you. It will take you 15-20 minutes to complete. In addition you will be provided a form and you are required to fill the form each time you conduct the training to know how many players participated in the training and the amount of time spent. In this study there are measurements and test that will be performed on the players. You are therefore requested to avail them for the convenient time with the research and team's activities.

Coaches in the second division team
Teams in the second division will be randomly divided into two groups. One group will receive training in injury prevention while the other group will not receive any training. If you are selected into the group that will receive training, you will be requested to participate in the training divided into two parts: in the first part you will be taught about injury prevention warm up programme that you will be required to used in your team at least 3 times a weeks. The training will be for 3 days and additional materials about the programme will also be provided to you. In the second part you will be trained on first aid.

The training will be conducted for three days. All the trainings will be conducted at the FERWAFA training room and all the training costs will be covered. Additionally, you will be often visited into your teams for further implementation by the researcher and/ or the research assistants. At the end of the training you will be provided the forms to record each time you conducted one of the exercises provided to you during training. All the forms will be collected by the researcher and/ or the research assistants after every two weeks.
If you are selected into the group that will receive the training on first aid only, you will be required to continue performing warm up as usual. If at the end of the season the results of this study show that the intervention programme prevented injuries, you will also receive the training the subsequent season.
We will do our best to keep your personal information confidential. To help protect your confidentiality, your name will not be included on collected data and codes will be used on data forms. If we write a report or article about this research project, your identity will be protected to the maximum extent possible.
Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify.
This study is supervised by Dr Theresa Burgess from the University of Cape Town. Please take time to read this form thoroughly before signing.

Potential Risks:
All the coaches (first and second division teams)
There are no known risks associated with participating in this research project.
Coaches in the second division team
The risk of sustaining and injury is minimal because the injury prevention programme requires players to perform physical exercises at minimal to moderate intensity. Additionally, the exercises will be performed with your close supervision.

Benefits:
All the coaches (first and second division teams)
This research is not designed to help you personally, but you may gain knowledge of new information and techniques to prevent injuries and the results may help the investigator learn more about the occurrence of injuries among players. The knowledge will be the basis in planning effective injury prevention programme for Rwandan soccer.

Coaches in the second division team
You will benefit from this study as you will gain knowledge about first aid, return to play decision making and specific injury prevention. Subsequently, we hope that injuries will be reduced in your team as players perform the prevention exercises. Unfortunately no financial compensation is available for participation in this study.

What if Something Goes Wrong?
The University of Cape Town (UCT) has insurance cover for the event that research-related injury or harm results from your participation in the trial. The insurer will pay all reasonable medical expenses in accordance with the South African Good Clinical Practice Guidelines (DoH 2006), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI) in the event of an injury or side

effect resulting directly from your participation in the trial. You will not be required to prove fault on the part of the University.
The University **will not be liable** for any loss, injuries and/or harm that you may sustain where the loss is caused by

- The use of unauthorised medicine or substances during the study
- Any injury that results from you not following the protocol requirements or the instructions that the study doctor may give you
- Any injury that arises from inadequate action or lack of action to deal adequately with a side effect or reaction to the study medication✸
- An injury that results from negligence on your part✸

[✸Researchers must bear in mind that it is unacceptable to impose a burden on participants who may not recognize symptoms or have the ready means to take action.]

"By agreeing to participate in this study, you do not give up your right to claim compensation for injury where you can prove negligence, in separate litigation. In particular, your right to pursue such a claim in a South African court in terms of South African law must be ensured. Note, however, that you will usually be requested to accept that payment made by the University under the SA GCP guideline 4.11 is in full settlement of the claim relating to the medical expenses. "
An injury is considered trial-related if, and to the extent that, it is caused by study activities. You must notify the researcher immediately of any side effects and/or injuries during the trial, whether they are research-related or other related complications.
UCT reserves the right not to provide compensation if, and to the extent that, your injury came about because you chose not to follow the instructions that you were given while you were taking part in the study. Your right in law to claim compensation for injury where you prove negligence is not affected. Copies of these guidelines are available on request.

If at any time you have any questions about the study, please feel free to contact any of the individuals listed below. You are assured that all inquiries will remain confidential.

AssumanNuhu
P.o.Box: 2000 Kigali
Tel number: 0788761109
Email: nuhu.assuman@khi.ac.rw
Dr. Theresa Burgess
Physical Address: Division of Physiotherapy
School of Health and Rehabilitation
University of Cape Town
Groote Schuur Hospital
Anzio Road
Observatory
7725
Tel number: 021 406 6171
Fax number: 021 406 6323
E-mail: theresa.burgess@uct.ac.za

If you have any concerns about your rights and welfare as research participant, please contact
Prof. Marc Blockman
Email: marc.blockman@uct.ac.za
Tel: +27214066338

By placing your signature on the consent form, it serves as confirmation that you have had adequate time to read through the study information, that you have understood the consent form and that you are willing to participate in this study. You have the right to withdraw at any time and you may ask questions at any time during the study. All information recorded during this study will remain confidential, and no participants will be identified in the event of future publication. Your signature is further confirmation that you are aware of the possible risks involved in this study.

Department of Health and Rehabilitation Sciences

Faculty of Health Sciences

Divisions of Communications Sciences and Disorders,
Nursing and Midwifery, Occupational Therapy, Physiotherapy

F45 Old Main Building, Groote Schuur Hospital

Appendix X: Players' information sheet

PhD Study title: SOCCER INJURY SURVEILLANCE AND IMPLEMENTATION OF AN INJURY PREVENTION PROGRAMME IN RWANDA
INFORMATION SHEET
Dear Participant
I am a PhD student in the Division of Physiotherapy at the University of Cape Town. I will be conducting a study to establish an injury surveillance system in soccer teams in Rwanda and to explore the difference in the coaches' knowledge, perception of, and readiness to accept a sports injury prevention programme. The study also aims at assessing the use of a warm up programme on the reduction of injuries in soccer.You are invited to participate in this research project because as the players, you are the ones who physically participate in the training and matches and you are at risk of sustaining injuries. This study has been given an ethical approval by the Human Research Ethics Committee, Faculty of Health Sciences, University of Cape Town (HREC REF 683/2014).

Expectations of participants
All the players (first and second division teams)
In this study you are expected to report any injury that you might incur during the season either in training or matches or whether it is minor or severe. Some measurements will be taken by assessing your stature, flexibility, and some test will be performed to check your balance, coordination and strength.
You will be asked to remove any extra clothing and shoes and then stand erect on the weighing to measure your weight. You will also be asked to stand the back against the taped wall or the goalpost to measure your height.
For the flexibility of your joints you will be asked to lie on your back on the bed where the angle of joint movement will be measured. The angle of your knee joint will be measured when you will be asked to straighten it as far as possible while the hip will be bent. You will then be positioned at the edge of the bed while your legs will be hanging. You will be asked to grasp one leg with your hands and letting the other leg hanging. Then measurements of the hip and knee angles will be taken in that position. You will then release the grasped leg where the foot will rest on the bed hip and knee bent. In that position you will be asked to move the leg inwards and then outwards and the angles will be measured for both movements.
You will be asked to stand shoulder width apart. You will then be asked to extend the spine without bending the knees and reach the back of the thigh as far as possible with your hand. The distance between the tip of the middle finger and the middle of the popliteal crease will be measured.

You will then be asked to step over the tape that is fixed on the ground against the wall making sure that the straight line between the heel and the big toe is parallel to the tape measure. You will be asked to lunge forward pushing the knee to come in contact with the vertical line and to as far as possible from the wall while the heel remain in contact with the ground. The distance between the wall and the big toe will be measured.
You will then be asked to sit on the mat with the legs extended the sole of the feet against a box. They will be asked to stretch forward as far as possible to reach the toes while keeping the knees straight one hand placed on top of the other. The distance from the tip of the middle finger and the toe line will be measured.
You will be asked to sit at the edge of the plinth with lower legs hanging, the arms behind the back. Then you will be asked to bend the neck, thorax and lower back forward. You will then be asked to lift your foot and straighten you toes and then slowly straighten your knee. Measurements of the angle of your knee will be taken at the point where it will be limited.
The stability and strength will be assessed when you will be asked to rest on your forearms and toes while the trunk is off the floor. You will be asked to hold the position as long as possible.
You will then be asked to stand barefooted on the step with the ball of the foot. And then alternatively rise and lower the heel in as full range as possible while the knee remain extended till when you feel tired. The number of full cycles performed will be recorded.
You will be asked to stands at the centre of a grid with 3 lines extending from it at 90º from each other. On one leg, you will try reach as far as possible with the other leg on the three lines.
Another test will also be performed where you will be asked to hop on one leg. The distance for one single hop will be measured as well as for three. And also the time that it will take you to hop on one leg on the distance of six meters.
Finally you will be asked to run in the diamond shaped course designed with with the cones. You will be asked to run forward, backwards, side shuffle, carioca, figure 8 run, 45º cuts, 90º cuts) the time you will take to run the full circuit will be recorded.
Measurements done on one leg will also be done for other leg.
Players in the second division team
Teams in the second division will be randomly divided into two groups. Coaches of one group will receive training in warm up injury prevention while the other group will not receive the training. If your coach (es) is (are) selected into the group that will receive training, they will plan the warm up training at least 3 times a week that you will be need to perform. If your coach (es) is (are) selected into the group that will not receive the training, you will be required to continue performing warm up as usual as directed by your coach. If at the end of the season the results of this study show that the intervention programme prevented injuries, your coach will also receive the training the subsequent season and you will be able to perform them.

We will do our best to keep your personal information confidential. To help protect your confidentiality, your name will not be included on collected data and codes will be used on data forms. If we write a report or article about this research project, your identity will be protected to the maximum extent possible.
Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify.
This study is supervised by Dr Theresa Burgess from the University of Cape Town. Please take time to read this form thoroughly before signing.
Potential Risks:

Players in the first division teams
There are no known risks associated with participating in this research project. Some of the tests that require physical performance present minimal risks because they will be performed with moderate intensity and under close supervision from the research team.
Players in the second division team
There is a risk of sustaining an injury, but the risk is minimal because the injury prevention programme requires that you perform physical exercises under close supervision from the coach and at minimal to moderate intensity.You are also asked to inform the coach and the medical personnel in your team if you feel any discomfort during the warm up exercises, so that you can stop performing them immediately. Although every effort will be taken to minimise injury, should you sustain an injury during the exercise, you will receive the appropriate medical care.
Benefits:
Players (first and second division teams)
This research is not designed to help you personally, but you may gain knowledge of new information and techniques to prevent injuries and the results may help the investigator learn more about the occurrence of injuries among players. The knowledge will be the basis in planning effective injury prevention programme for Rwandan soccer.
Players in the second division team
You will benefit from this study as you will gain knowledge about the warm up injury prevention programme. Subsequently, we hope that injuries will be reduced in your team when you perform the prevention exercises. Unfortunately no financial compensation is available for participation in this study.
What if Something Goes Wrong?
The University of Cape Town (UCT) has insurance cover for the event that research-related injury or harm results from your participation in the trial. The insurer will pay all reasonable medical expenses in accordance with the South African Good Clinical Practice Guidelines (DoH 2006), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI) in the event of an injury or side effect resulting directly from your participation in the trial. You will not be required to prove fault on the part of the University.
The University **will not be liable** for any loss, injuries and/or harm that you may sustain where the loss is caused by

- The use of unauthorised medicine or substances during the study
- Any injury that results from you not following the protocol requirements or the instructions that the study doctor may give you
- Any injury that arises from inadequate action or lack of action to deal adequately with a side effect or reaction to the study medication✸
- An injury that results from negligence on your part✸

[✸Researchers must bear in mind that it is unacceptable to impose a burden on participants who may not recognize symptoms or have the ready means to take action.]
“By agreeing to participate in this study, you do not give up your right to claim compensation for injury where you can prove negligence, in separate litigation. In particular, your right to pursue such a claim in a South African court in terms of South African law must be ensured. Note, however, that you will usually be requested to accept that payment made by the University under the SA GCP guideline 4.11 is in full settlement of the claim relating to the medical expenses. “
An injury is considered trial-related if, and to the extent that, it is caused by study activities. You must notify the researcher immediately of any side effects and/or injuries during the trial, whether they are research-related or other related complications.
UCT reserves the right not to provide compensation if, and to the extent that, your injury came about because you chose not to follow the instructions that you were given while you were taking part in the

study. Your right in law to claim compensation for injury where you prove negligence is not affected. Copies of these guidelines are available on request.

If at any time you have any questions about the study, please feel free to contact any of the individuals listed below. You are assured that all inquiries will remain confidential.

AssumanNuhu
P.o.Box: 2000 Kigali
Tel number: 0788761109
Email: nuhu.assuman@khi.ac.rw
Dr. Theresa Burgess
Physical Address: Division of Physiotherapy
School of Health and Rehabilitation
University of Cape Town
Groote Schuur Hospital
Anzio Road
Observatory
7725
Tel number: 021 406 6171
Fax number: 021 406 6323
E-mail: theresa.burgess@uct.ac.za

If you have any concerns about your rights and welfare as research participant, please contact

Prof. Marc Blockman
Email: marc.blockman@uct.ac.za
Tel: +27214066338

By placing your signature on the consent form, it serves as confirmation that you have had adequate time to read through the study information, that you have understood the consent form and that you are willing to participate in this study. You have the right to withdraw at any time and you may ask questions at any time during the study. All information recorded during this study will remain confidential, and no participants will be identified in the event of future publication. Your signature is further confirmation that you are aware of the possible risks involved in this study.

Department of Health and Rehabilitation Sciences

Faculty of Health Sciences

Divisions of Communications Sciences and Disorders,
Nursing and Midwifery, Occupational Therapy, Physiotherapy

F45 Old Main Building, Groote Schuur Hospital

Appendix XI: Information sheet for players' parents or legal guardians

PhD Study title: SOCCER INJURY SURVEILLANCE AND IMPLEMENTATION OF AN INJURY PREVENTION PROGRAMME IN RWANDA
INFORMATION SHEET
Dear Parent/ Legal guardian
I am a PhD student in the Division of Physiotherapy at the University of Cape Town. I will be conducting a study to establish an injury surveillance system in soccer teams in Rwanda and to explore the difference in the coaches' knowledge, perception of, and readiness to accept a sports injury prevention programme. The study also aims at assessing the use of a warm up programme on the reduction of injuries in soccer. I hereby request your consent for the participation of your son in this study as he physically participates in the training and matches and is at risk of sustaining injuries. This study has been given an ethical approval by the Human Research Ethics Committee, Faculty of Health Sciences, University of Cape Town (HREC REF 683/2014).
In this study he is expected to report any injury that he might incur during the season either in training or matches or whether it is minor or severe. He will undergo some measurements of the body and will also perform some physical tests.
He will be asked to remove any extra clothing and shoes and then stand erect on the weighing to measure his weight. He will also be asked to stand the back against the taped wall or the goalpost to measure his height.
For the flexibility of his joints he will be asked to lie on his back on the bed where the angle of joint movement will be measured. The angle of his knee joint will be measured when he will be asked to straighten it as far as possible while the hip will be bent. He will then be positioned at the edge of the bed while his legs will be hanging. He will be asked to grasp one leg with his hands and letting the other leg hanging. Then measurements of the hip and knee angles will be taken in that position. He will then release the grasped leg where the foot will rest on the bed hip and knee bent. In that position he will be asked to move the leg inwards and then outwards and the angles will be measured for both movements.
He will be asked to stand shoulder width apart. He will then be asked to extend the spine without bending the knees and reach the back of the thigh as far as possible with his hand. The distance between the tip of the middle finger and the middle of the popliteal crease will be measured.
He will then be asked to step over the tape that is fixed on the ground against the wall making sure that the straight line between the heel and the big toe is parallel to the tape measure. He will be asked to lunge forward pushing the knee to come in contact with the vertical line and to as far as possible from the wall while the heel remain in contact with the ground. The distance between the wall and the big toe will be measured.

He will then be asked to sit on the mat with the legs extended the sole of the feet against a box. He will be asked to stretch forward as far as possible to reach the toes while keeping the knees straight one hand placed on top of the other. The distance from the tip of the middle finger and the toe line will be measured.
He will be asked to sit at the edge of the plinth with lower legs hanging, the arms behind the back. Then he will be asked to bend the neck, thorax and lower back forward. He will then be asked to lift his foot and straighten the toes and then slowly straighten his knee. Measurements of the angle of his knee will be taken at the point where it will be limited.
The stability and strength will be assessed when he will be asked to rest on his forearms and toes while the trunk is off the floor. He will be asked to hold the position as long as possible.
He will then be asked to stand barefooted on the step with the ball of the foot. And then alternatively rise and lower the heel in as full range as possible while the knee remain extended till when he feels tired. The number of full cycles performed will be recorded.
He will be asked to stands at the centre of a grid with 3 lines extending from it at 90º from each other. On one leg, he will try reach as far as possible with the other leg on the three lines.
Another test will also be performed where he will be asked to hop on one leg. The distance for one single hop will be measured as well as for three hops. And also the time that it will take him to hop on one leg on the distance of six meters will be recorded.
Finally he will be asked to run in the diamond shaped course designed with the cones. He will be asked to run forward, backwards, side shuffle, carioca, figure 8 run, 45º cuts, and 90º cuts. The time he will take to run the full circuit will be recorded.
Teams in the second division will be randomly divided into two groups. Coaches of one group will receive training in warm up injury prevention while the other group will not receive the training. If his coach (es) is (are) selected into the group that will receive training, they will plan the warm up training at least 3 times a week that he will be need to perform. If his coach (es) is (are) selected into the group that will not receive the training, he will be required to continue performing warm up as usual as directed by the coach. If at the end of the season the results of this study show that the intervention programme prevented injuries, his coach will also receive the training the subsequent season and he will be able to perform them.
The risks associated with participating in this research project are minimal as the exercises are of moderate intensity and are supervised by the coaches. The knowledge generated will be the basis in planning effective injury prevention programme for Rwandan soccer.
What if Something Goes Wrong?
The University of Cape Town (UCT) has insurance cover for the event that research-related injury or harm results from your participation in the trial. The insurer will pay all reasonable medical expenses in accordance with the South African Good Clinical Practice Guidelines (DoH 2006), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI) in the event of an injury or side effect resulting directly from your participation in the trial. You will not be required to prove fault on the part of the University.
The University **will not be liable** for any loss, injuries and/or harm that you may sustain where the loss is caused by

- The use of unauthorised medicine or substances during the study
- Any injury that results from you not following the protocol requirements or the instructions that the study doctor may give you
- Any injury that arises from inadequate action or lack of action to deal adequately with a side effect or reaction to the study medication✸
- An injury that results from negligence on your part✸

[✸Researchers must bear in mind that it is unacceptable to impose a burden on participants who may not recognize symptoms or have the ready means to take action.]
"By agreeing to participate in this study, you do not give up your right to claim compensation for injury where you can prove negligence, in separate litigation. In particular, your right to pursue such a claim in a South African court in terms of South African law must be ensured. Note, however, that you will usually be requested to accept that payment made by the University under the SA GCP guideline 4.11 is in full settlement of the claim relating to the medical expenses. "
An injury is considered trial-related if, and to the extent that, it is caused by study activities. You must notify the researcher immediately of any side effects and/or injuries during the trial, whether they are research-related or other related complications.
UCT reserves the right not to provide compensation if, and to the extent that, your injury came about because you chose not to follow the instructions that you were given while you were taking part in the study. Your right in law to claim compensation for injury where you prove negligence is not affected. Copies of these guidelines are available on request.

If at any time you have any questions about the study, please feel free to contact any of the individuals listed below. You are assured that all inquiries will remain confidential.

AssumanNuhu
P.o.Box: 2000 Kigali
Tel number: 0788761109
Email: nuhu.assuman@khi.ac.rw
Dr. Theresa Burgess
Physical Address: Division of Physiotherapy
School of Health and Rehabilitation
University of Cape Town
Groote Schuur Hospital
Anzio Road
Observatory
7725
Tel number: 021 406 6171
Fax number: 021 406 6323
E-mail: theresa.burgess@uct.ac.za

If you have any concerns about the rights and welfare of your child as research participant, please contact

Prof. Marc Blockman
Email: marc.blockman@uct.ac.za
Tel: +27214066338

By placing your signature on the consent form, it serves as confirmation that you have had adequate time to read through the study information, that you have understood the consent form and that you are willing that your child participate in this study. You have the right to withdraw at any time and you may ask questions at any time during the study. All information recorded during this study will remain confidential, and no participants will be identified in the event of future publication. Your signature is further confirmation that you are aware of the possible risks involved in this study.

Department of Health and Rehabilitation Sciences

Faculty of Health Sciences

Divisions of Communications Sciences and Disorders,
Nursing and Midwifery, Occupational Therapy, Physiotherapy

F45 Old Main Building, Groote Schuur Hospital

Appendix XII: Informed consent form

INFORMED CONSENT FORM
PhD Study title: SOCCER INJURY SURVEILLANCE AND IMPLEMENTATION OF AN INJURY PREVENTION PROGRAMME IN RWANDA

I _____ have read (or had read to me by _____) the Information Sheet. I understand what is required of me (my child/legal ward) and I have had all my questions answered. I do not feel that I am forced to take part in this study and I am doing so of my own free will. I know that I can withdraw at any time if I so wish and that it will have no bad consequences for me.

Signed:

_____ _____
Participant Date and place

_____ _____
Researcher Date and place

_____ _____
Witness (if necessary) Date and place

Appendix XIII: Questionnaire for coaches

Section A – Demographic Characteristics

1. Age: _____
2. In which year did you start coaching football? _____
3. In which year did you start coaching football in the first division?_____
4. In which year did you start coaching your current club?_____
5. What is the highest level of education have you completed?
    a. Primary school ☐
    b. Secondary school ☐
    c. University ☐
6. What is your highest license level in coaching?_____

Section B – Injury prevention belief and practice readiness

Please check only one choice for each question that best describes your current injury prevention practices

1. Injury prevention programme		
I am not currently providing my athletes with injury prevention programmes on regular basis	⇨ ☐ ⇨ ☐	And I have no intention to start in the next 6 months But I have thought about starting it regular injury prevention education for athletes in the next 6 months
I am currently providing my athletes with injury prevention programmes	⇨ ☐ ⇨ ☐ ⇨ ☐	Occasionally And I have been doing it regularly for less than 6 months And I have been doing it regularly for 6 months or more
I do not provide my athletes with regular injury prevention programme(s) regularly	⇨ ☐	Because we have an assigned person such as an athletic trainer to do this task
2. Protective equipment check		
I am not currently checking if athletes' protective equipment is in good condition on a regular basis	⇨ ☐ ⇨ ☐	And I have no intention to start in the next 6 months But I have thought about starting it in the next 6 months
I am currently checking if athletes' protective equipment is in good condition	⇨ ☐ ⇨ ☐ ⇨ ☐	Occasionally And I have been doing it for less than 6 months on a regular basis And I have been doing it for 6 months or more on a regular basis
I do not check if athletes' protective equipment is in good condition	⇨ ☐	Because we have an assigned person such as an equipment manager to do this task
3. Checking playing field and facilities		
I am not currently checking if playing fields and facilities are well maintained without hazard every time I use them	⇨ ☐ ⇨ ☐	And I have no intention to start in the next 6 months But I have thought about starting it in the next 6 months
I am currently checking if playing fields and facilities are well maintained without hazard	⇨ ☐ ⇨ ☐ ⇨ ☐	Occasionally Every time I use them, and I have been going it for less than 6 months Every time I use them, and I have been going it for 6 months or more
I do not check if playing fields and facilities are well maintained without hazard	⇨ ☐	Because we have an assigned person to do this task
4. Emergency care procedures		
I do not have a written emergency action plan for injured athletes	⇨ ☐ ⇨ ☐ ⇨ ☐	And I have no intention to prepare for it in the next 6 months But I have thought about preparing for it in the next 6 months But I intend to prepare for the written emergency action plan in the next 6 months
I prepared a written emergency action plan for injured athletes	⇨ ☐ ⇨ ☐	And I have applied it for less than 6 months And I have applied it for 6 months or more
I have a written emergency action plan	⇨ ☐	Prepared by an assigned to do this task
5. Checking up-to-date information		

Currently I do not dedicate time to review up-to-date information about injury prevention	⇨ ⇨	☐ ☐	And I have no intention to start it in the next 6 months and I have thought about dedicating time in the next 6 months
Currently I am dedicating time to review up-to-date information about injury prevention	⇨ ⇨ ⇨	☐ ☐ ☐	Occasionally And I have been doing it for less than 6 months on a regular basis And I have been doing it for 6 months or more on a regular basis
I do not dedicate any time to review up-to-date information about injury prevention	⇨	☐	Because we have an assigned person such as an athletic trainer in charge of injury prevention

THANT YOU FOR YOUR TIME

Appendix XIV: FIFA 11+ warm up exercises

Appendix XV: Notification letter to the FIFA Medical Assessment and Research Center

Assuman Nuhu
University of Cape Town
School of Health and Rehabilitation Sciences
Faculty of Health Sciences
Division of Physiotherapy
Tel: 0788761109
Email: nuhu.assuman@khi.ac.rw

Kigali, 30/09/2015

To:

FIFA medical assessment and research Center
C/o: medical@fifa.org

Through:

Federation Rwandaise de Football Association (FERWAFA)
P o BOX: 2000 Kigali
Kigali Rwanda

RE: Expression of interest to implement the 11+ injury prevention programme in Rwanda

I am a PhD student in the Division of Physiotherapy at the University of Cape Town. I wish to conduct the study aiming at establishing an injury surveillance system in soccer teams in Rwanda and to assess the use of the 11+ warm up programme on the reduction of injuries in soccer.

Following the guidelines that you published informing the member associations on the steps to follow on the implementation of the 11+ injury prevention programme. We are writing to show the interest to implement the 11+ injury prevention programme in Rwanda in order to sign the licence agreement.

This study has been given an ethical approval by the Human Research Ethics Committee, Faculty of Health Sciences, University of Cape Town and registered in the Pan African Clinical Trial Registration (PACTR). We believe that it is the turn of Rwanda to join the others to reduce the incidence of injuries among soccer players leading to better performance. You will find attached the study protocol and other supporting documents.

Thanking you for your kind consideration.

Regards,

Assuman Nuhu

FEDERATION RWANDAISE DE FOOTBALL ASSOCIATION

B.P. 2000 Kigali
Tél : 250 - 788 77 47 43

Kigali, 2nd October 2015
N°...../FERWAFA/2015

TO WHOM IT MAY CONCERN

We, the Federation Rwandaise de Football Association (FERWAFA), confirm that we are informed about the research entitled **"Soccer injury surveillance and implementation of an injury prevention programme in Rwanda"** whose principle investigator is **Assuman Nuhu** currently pursuing PhD studies at the University of Cape Town. He has been working as the Physiotherapist of the Rwanda football national team for more than years. He is the leading figure in the welfare of athletes and soccer players in particular. We believe that the implementation of the 11+ injury prevention programme in soccer clubs in Rwanda might be beneficial for players. The Federation is ready to collaborate with and support the study team in the implementation of the programme. Any service rendered to him will be appreciated.

Me MULINDAHABI K.Jean Olivier
Secretary General

Fédération Rwandaise de Football Association

Appendix XVI: FIFA 11+recording form

TEAM CODE:..... WEEK
NUMBER:.....

N°	Dates								
	Exercise	Repetition	Time	Repetition	Time	Repetition	Time	Repetition	Time
Running exercises									
1	Straight ahead								
2	Hip out								
3	Hip in								
4	Circling partner								
5	Shoulder contact								
6	Quick forwards and backwards								
Strength, plyometrics, balance									
7	The bench								
8	Sideways bench								
9	Hamstring								
10	Forward bend in single-leg stance								
11	Squat								
12	Jumping								
Running exercises									
13	Across the pitch								
14	Bounding								
15	Plant and cut								

Appendix XVII: PACTR trail registry

SOUTH AFRICAN COCHRANE CENTRE

PO Box 19070, Tygerberg, 7505, South Africa;
Francie van Zijl Drive, Parow Valley, Cape Town
Tel: +27 21 938 0438; Fax: +27 21 938 0836
E-mail: cochrane@mrc.ac.za

11 May 2015

To Whom It May Concern:

RE: Effect of the FIFA 11 plus warm up programme on the incidence of injuries in soccer Clubs in Rwanda.

As project manager for the Pan African Clinical Trial Registry (www.pactr.org) database, it is my pleasure to inform you that your application to our registry has been accepted. Your unique identification number for the registry is **PACTR201505001045388**

Please be advised that you are responsible for updating your trial, or for informing us of changes to your trial.

Additionally, please provide us with copies of your ethical clearance letters as we must have these on file (via email, post or fax) at your earliest convenience if you have not already done so.

Please do not hesitate to contact us at +27 21 938 0835 or email epienaar@mrc.ac.za should you have any questions.

Yours faithfully,

Elizabeth D Pienaar
www.pactr.org Project Manager
+27 021 938 0835

PACTR
PAN AFRICAN CLINICAL TRIALS REGISTRY