Intrinsic risk factors for lower limb injuries in university-level female soccer players

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FOREWORD

I would like to take this opportunity to thank the following people for their continuous support, guidance and unconditional love while I was writing my dissertation:

Firstly, thanks to the greatest of them all, our God the Almighty, for the talent, love, strength, determination and courage that he has blessed me with. All of this would not have been possible if it wasn't for him. I offer all the praise to you.

To Miss Erna Bruwer, thank you for all your guidance and support in the planning of my research study.

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Lastly, to my late parents, this one is for you. Thank you for bringing me up to be the strong woman that I am today. I wish you were here to share my joy and achievements with me. In your absence you still push me to become the best version of myself. You will always be in my heart. I love and miss you always.

Matthew 21:21–22

DECLARATION

The primary author of this dissertation is Miss T.E. Masenya. The contributions of all the co-authors are listed below:

Author	**Contribution**
Miss T.E. Masenya (Author)	Planning and designing the manuscript, compilation and execution of testing procedures, literature review, data extraction, writing of manuscript, and interpretation of results.
Dr T.J. Ellapen (Supervisor)	Conceptualisation of the study, co-author, assistance and guidance in planning and writing the manuscript, interpretation of results, and critical review of articles 1 and 2.
Prof C. Pienaar (Co-supervisor)	Co-reviewer, conceptualisation of the study, co-author, assistance and guidance in planning and writing the manuscript, interpretation of results, and critical review of articles 1 and 2.
Dr M. Sparks (Project leader)	Planning of project, liaising with the teams, analysis of results, and critical review of articles 1 and 2.

The co-authors of the two manuscripts hereby confirm their individual roles in each study and give permission that Miss Tsholofelo Masenya may include the manuscripts as part of a master's dissertation. The contribution of the authors was kept within reasonable limits in assisting with planning and execution of the study as well as supervising and guiding the author in completing the dissertation. The dissertation therefore serves as fulfilment of the requirements for the M.Sc. Degree in Biokinetics within the School of Biokinetics, Recreation and Sport Science in the Faculty of Health Sciences at the North-West University, South Africa.

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Dr Terry Jeremy Ellapen

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SUMMARY

The game of soccer or football is known for its competitive nature, complex movement patterns and high intensity. There are frequent lower limb injuries because of the high demands of the game and the complex movement patterns that the game requires. This intensity and complexity of movements furthermore result in a variety of intrinsic factors that contribute to the occurrence of lower limb injuries. The first objective of the study was to determine the injury prevalence among university-level female soccer players. This was determined through the completion of an injury history questionnaire that was used to profile the nature of injuries sustained in the past six months in preparation for the 2016 University Sports South Africa (USSA) National Football Championships. The second objective was to determine the intrinsic risk factors associated with lower limb injuries in university-level female soccer players. Measurements of ankle dorsiflexion, plantarflexion, inversion and eversion ROM, the flexibility of both quadriceps and hamstrings, quadriceps-angle (Q-angle) and lower limb stability on the Biodex Stability System was used to determine this.

Fifty-three female soccer players (aged 18 to 25 years) from North-West University and Tshwane University of Technology voluntarily participated in the study during preparation for the 2016 USSA National Football Championships.

The results for the first objective indicated the significant prevalence of sport injuries according to the number of injuries that were reported ($p<0,0001$). The most vulnerable anatomical sites of injury were the ankle (28,6%) and knee (22,2%) ($p<0,001$). While all playing positions were vulnerable to injuries, the most vulnerable were the defenders, goalkeepers and strikers ($p<0,05$).

The second objective's results indicated that the intrinsic risk factors significantly associated with lower limb injuries were decreased flexibility of ankle dorsiflexors ($p<0,071$) and lower limb stability medial lateral index ($p<0,001$). A strong correlation was also found between ankle invertors and injured players ($r=0,251$**).** The age, body mass, stature, body mass index (BMI), ankle eversion ankle plantarflexion ROM, hamstring and rectus femoris flexibility and Q-angle were not associated with an increased risk of lower limb injuries ($p>0,05$).

The study concludes that the majority of soccer injuries occurred in the lower extremities with the ankle and knee as the most vulnerable anatomical sites. Moreover, decreased flexibility in the dorsiflexors, ankle invertors and lower limb stability are intrinsic risk factors that predisposed players to lower limb injuries. With the high prevalence of knee and ankle injuries in female players, more focus should be placed on preventing and reducing the incidence of such injuries. It is therefore recommended that neuromuscular and flexibility exercises be incorporated into training programmes to improve the neuromuscular function of the invertors and dorsiflexors and lower limb stability and thereby preventing lower limb injuries.

Keywords: female players, intrinsic risk factors, injuries, soccer, lower limbs

OPSOMMING

Sokker is ‘n sport wat bekend is daarvoor dat dit baie mededingend en intens is en bestaan uit ingewikkelde bewegingspatrone. Daar is gereelde laer ledemaat beserings as gevolg van die fisiese vereistes van die spel en die ingewikkelde bewegingspatrone wat die spel vereis. Hierdie intensiteit en ingewikkelde bewegings lei ook tot 'n verskeidenheid intrinsieke faktore wat bydra tot die voorkoms van laer ledemaat beserings. Die eerste doelwit van die studie was om die voorkoms van beserings onder universiteitsvlak vroulike sokkerspelers te bepaal. Dit is bepaal deur die voltooiing van 'n beseringsgeskiedenis-vraelys wat gebruik is om die aard van beserings wat die afgelope ses maande opgedoen is ter voorbereiding van die 2016 University Sports South Africa (USSA) se Nasionale Sokker Kampioenskappe te rapporteer. Die tweede doelwit was om die intrinsieke risiko faktore wat verband hou met onderste ledemaat beserings in universiteitsvlak vroulike sokkerspelers te bepaal. Dit is bepaal deur die dorsifleksie, plantaarfleksie, inversie en eversie van die enkel, die soepelheid van beide kwadriseps en hampese, kwadriseps - hoek, en onderste ledemaat stabiliteit te meet op die Biodex Stability System.

Drie-en-vyftig vroulike sokkerspelers (18 tot 25 jaar oud) van die Noordwes-Universiteit en die Tshwane Universiteit van Tegnologie het vrywillig deelgeneem aan die studie gedurende die voorbereiding vir die 2016 USSA Nasionale Sokker Kampioenskappe.

Die resultate vir die eerste doelwit het die belangrikheid van sportbeserings aangedui volgens die aantal beserings wat gerapporteer is ($p<0,0001$). Die mees kwesbare anatomiese liggings vir beserings was die enkel (28,6%) en knie (22,2%) ($p<0,001$). Alle spel posisies is kwesbaar vir beserings, maar die mees kwesbare posisies is die verdedigings- en doelwagposisies ($p<0,05$).

Die tweede doelwit se resultate het aangedui dat die intrinsieke risikofaktore wat aansienlik verband hou met laer ledemaat beserings is verminderde soepelheid van die enkel dorsifleksors ($p<0,071$) en van die onderste ledemaatstabiliteits mediale laterale indeks ($p<0,001$). Daar is ook ‘n sterk korrelasie gevind tussen inversie van die enkel en beseerde spelers ($r=0,251$). Die ouderdom, liggaamsmassa, postuur, liggaamsmassa-indeks, eversie van die enkel, enkel plantarfleksie, soepelheid van die hampese en rectus femoris, en Q-hoek was nie geassosieer met 'n verhoogde risiko van laer ledemaat beserings nie ($p> 0,05$).

Die gevolgtrekking van die studie is dat die meeste sokkerbeserings in die onderste ledemate voorkom en dat die enkels en knieë die kwesbaarste anatomiese liggings is. Daarbenewens is die intrinsieke risikofaktore wat spelers vatbaar maak vir laer ledemaat beserings die volgende: verminderde soepelheid in die dorsifleksore, inversie van die enkel en onderste ledemaatstabiliteit. Met die hoë voorkoms van knie- en enkelbeserings by vroulike spelers, moet meer klem geplaas word op die voorkoming en vermindering van sulke beserings. Daar word dus aanbeveel dat neuromuskulêre en strek oefeninge deel word van oefenprogramme om die neuromuskulêre funksie van die inversore en dorsifleksore sowel as die onderste ledemaat stabiliteit te verbeter en sodoende laer ledemaat beserings te voorkom.

Sleutelwoorde: intrinsieke risikofaktore, beserings, sokker, onderste ledemate, vroulike spelers

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LIST OF ABBREVIATIONS

%	percentage
<	less than
>	greater than
≥	greater than or equal to
±	plus-minus
°	degrees
ACL	Anterior cruciate ligament
BMI	body mass index
FIFA	Federation Internationale de Football Association
kg	kilograms
kg/m^2	kilograms per metre squared
PFPS	Patellofemoral pain syndrome
Q-angle	Quadriceps-angle
ROM	range of motion
USSA	University Sports South Africa

CHAPTER 1

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Soccer is a sport known worldwide and enjoyed by players of both genders. It is a competitive, high intensity sport that can result in a high incidence of injury, especially in the lower extremities (Muller *et al.*, 2016:371; Nessler *et al*., 2017:2). The increasing prevalence of soccer injuries has become of great concern to players, coaches and medical staff. The prevalence and incidence of lower limb injuries, especially in the knee and ankle joints, in female soccer players have been on the rise, resulting in substantial financial implications for the players and teams when players are unable to compete (Junge & Dvorak, 2007:5; Larruskain *et al*., 2017:3; Nilsson *et al*., 2016:85). It is clear that an investigation of associated risk factors should be conducted to effectively prevent injuries (Tegnander *et al*., 2008:196). Local and international studies have mostly focussed on male soccer players; therefore, this study will help increase knowledge for coaches concerning soccer injuries and the associated risk factors among South African female players (Junge & Dvorak, 2007:3; Muller *et al*., 2016:367; Nilstad *et al*., 2014:940).

The main objectives for the current study were:

1. To determine the prevalence of injuries among university-level female soccer players; and
2. To determine the intrinsic risk factors associated with lower limb injuries in university-level female soccer players.

The researcher was responsible for data collection from two teams preparing for the 2016 University Sports South Africa (USSA) National Football Championships.

The following chapter will give a brief overview of the literature review conducted concerning soccer injuries among female soccer players and the risk factors associated with lower limb injuries.

1.2 CONCEPTUAL FRAMEWORK OF THE STUDY

This master's thesis research was part of a larger soccer study (**NWU-00055-15-A1**) that attained ethical approval from the North-West University Health Research Ethical Committee. The primary investigator of this larger study was Dr M. Sparks. The larger study had many objectives that allowed the completion of two PhD dissertations and one master's thesis (Figure 1). The current study only dealt with soccer injuries and intrinsic risk factors contributing to lower limb injuries among female university players and was governed by the methodology of the larger study.

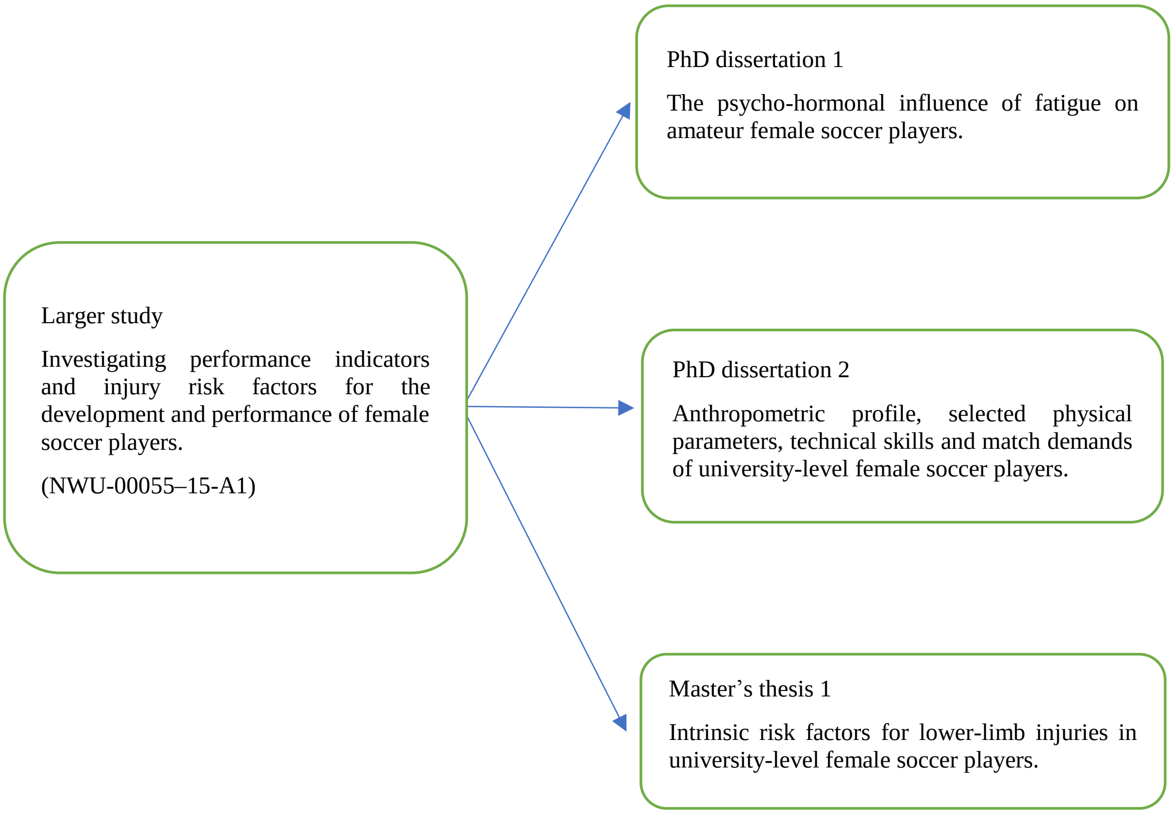

Figure 1. The conceptual framework of the study

1.3 PROBLEM STATEMENT

Soccer, also known as football, is among the most popular organised sports worldwide (Kerr *et al*., 2017:2; Mufty *et al*., 2015:289), and as its popularity has grown, it has become characterised by increased physical contact, high intensity and intermittent movements (Faude *et al*., 2006:785; Pedrinelli *et al*., 2013:132; Wong & Hong, 2005:473). Soccer is played by males and females of different ages and skill levels. The popularity of soccer among female players has increased over the years (Faude *et al*., 2005:1694; Jacobson & Tegner, 2007:84; Mufty *et al*., 2015:289; Steffen *et al*., 2008:700; Tegnander *et al.*, 2008:194). In the first Women's World Cup in 1991 in China, only 12 countries participated; this number increased to 16 in the 2003 Women's World Cup in the United States (Faude *et al*., 2005:1694). According to the sport's governing body *Federation Internationale de Football Association* (FIFA), 24 teams participated in the 2015 Women's World Cup in Canada and about 30 million women and girls play football worldwide (FIFA, 2010). The increase in the popularity of women's soccer over the years has gone without corresponding epidemiological surveillance. That is to say that a paltry number of empirical papers have been published about female soccer players and risk factors for injuries compared to studies focusing on their male counterparts (Heidt *et al.*, 2000:659; Junge & Dvorak, 2007:3; Nilstad *et al*., 2014:940; Warden *et al*., 2007:38).

Soccer is characterised by complex movement patterns such as sprinting, jumping, kicking and sudden changes of direction and this leads to a high prevalence of lower limb injuries (Kucera *et al*., 2005:465; Nessler *et al*., 2017:2;

Valderrabanno *et al*., 2014:98). Over a single season, 80% to 82% of female soccer players have lower limb injuries (Faude *et al*., 2005:1696; Jacobson & Tegner, 2007:86). Given the complexity and high physical demands of the sport as well as the manner in which the sport is played, the vulnerable anatomical sites for soccer injuries include the thigh, the knee, the lower leg (tibia and fibula), the ankle, the foot, the head, the neck, the spine and the upper extremities (Giza *et al*., 2003:553; Jacobson & Tegner, 2007:86; Junge & Dvorak, 2007:5; Larruskain *et al*., 2017:3; Nilsson *et al*., 2016:85; Tegnander *et al*., 2008:196). The various types of soccer injuries include muscle and tendon strains, ligament sprains, meniscus tears, contusions, skeletal fractures (Kerr *et al*., 2017:5; Svensson *et al*., 2016:2293; Wong & Hong, 2005:476), patellofemoral pain syndrome (PFPS) (Tumia & Maffulli, 2002:69), and nerve injuries (Cho *et al*., 2011:1; Svensson *et al*., 2016:2293). Unfortunately, no detailed information exists regarding the prevalence and distribution of injuries among female South African university soccer league players, and the aforementioned information is drawn from studies that have predominantly targeted male players. The lack of information specific to female players in general and to female players within the South African university soccer league requires a greater epidemiological survey specific to this understudied population.

The mechanisms that cause muscle strains during soccer include sudden acceleration, deceleration, kicking the ball at high velocity, and the forceful contraction of a muscle when it is overstretched (Anderson *et al*., 2001:522–523; Croisier *et al*., 2008:1469; Eckard *et al*., 2017:479; Ernlund & De Almeida Vieira, 2017:376; Schultz *et al*., 2016:487). Muscle injuries constitute almost 30,7% to 31% of all soccer injuries and the most common injury locations are the hamstrings, hip adductor, quadriceps and gastrocnemius muscle groups (Ekstrand *et al*., 2011:1228; Giza *et al*., 2005:213).

Lower limb ligamentous sprains occur mostly in the ankle and knee joints and account for roughly 15,3% to 19,1% of all soccer injuries (Dick *et al*., 2007:280; Giza *et al*., 2005:213; Rossler *et al*., 2016:313; Tucker, 1997:29). Ankle ligament sprains can constitute 7,5% to 16,7% of soccer injuries, and commonly occur on the lateral side due to forced foot inversion while in plantarflexion (Giza *et al*., 2005:213; Hootman *et al*., 2007:316; Schultz *et al*., 2016:418; Tucker, 1997:29). The ligaments commonly sprained are the anterior talofibular and the calcaneal fibular (Schultz *et al*., 2016:418; Tucker, 1997:29; Valderrabanno *et al*., 2014:99). Medial ankle sprains of the talonavicular and tibionavicular ligaments resulting from eversion and external rotation of the ankle and foot are seldom seen (Schultz *et al*., 2016:418; Tucker, 1997:29).

Ligament sprains affect the anterior, posterior, medial, and lateral ligaments of the knee joint (Tucker, 1997:27). Female soccer players are more susceptible to anterior cruciate ligament (ACL) injuries than male players because of anatomical, hormonal and neuromuscular factors (Besier *et al*., 2001:1173; Boden *et al.*, 2000:57; Hewett, 2000:315; Larruskain *et al*., 2017:3). Female soccer players have more than double the amount of ACL injuries than their male counterparts (Augustsson & Ageberg, 2017:3; Arendt *et al*., 1999:88; Larruskain *et al*., 2017:3). Most ACL injuries occur without contact with another player and are associated with increased knee joint loads (Besier *et al*., 2001:1173; Boden *et al*., 2000:58). The mechanisms of non-contact ACL injuries in soccer include a sudden change of direction/pivoting combined with sudden deceleration, poor landing technique from a jump, as well as a change of direction with a fully extended knee and planted foot (the application of a valgus force) (Brophy *et al*., 2010:694; Fauno *et al*., 2006:78; Nessler *et al*., 2017:2; Schultz *et al*., 2016:472). Posterior cruciate ligament injuries are less common in soccer than ACL injuries (Tucker, 1997:28). They usually result from a blow to the anterior tibia with the knee in a flexed position or from falling on a flexed knee with the foot plantar flexed (application of a varus force) (Schultz *et al*., 2016:477; Tucker, 1997:27).

Medial collateral ligament injuries are also common in soccer and can result from a direct blow to the lateral aspect of the thigh or leg with a planted foot (valgus force). During this type of mechanism there can be minimal tibial rotation/translation involved that depends mostly on the knee's flexion angle (Marchant Jr *et al*., 2011:1104). The other mechanism of injury involves a valgus force combined with tibial external rotation that happens in pivoting sports such as soccer (Marchant Jr *et al*., 2011:1105; Schultz *et al*., 2016:481). Lateral collateral ligament injuries are less common in soccer and result from a varus stress on the knee (Schultz *et al.,* 2016:481; Tucker, 1997:29).

Meniscus injuries usually occur with twisting or cutting movements on a loaded knee joint whereby the menisci are pinched between the femur and tibia and are torn due to femoral rotation on the joint surface (Schultz *et al*., 2016:485; Tucker, 1997:29). Menisci tears can also accompany ACL and medial collateral ligament sprains when these ligaments fail to resist the excessive translation forces of the femur on the tibia (Schultz *et al*., 2016:485).

Lower limb fractures in soccer occur mostly in the ankle, foot, tibia, fibula and femur (Boden *et al*., 1999:263; Larsson *et al*., 2016:760; Valderrabanno *et al*., 2014:100). Most ankle fractures in soccer occur because of supination and external rotation of the foot; a process that differs from the mechanism of ligament injury (Valderrabanno *et al*., 2014:100). Fractures of the tibia and fibula occur because of direct trauma such as slide tackles or miskicks (Boden *et al.*, 1999:262). Femoral fractures are rare in soccer and result from direct trauma to the mid-thigh (Schultz *et al*., 2016:493). The femoral neck and proximal femur are nevertheless more susceptible to stress fractures in contact sports such as soccer (Tucker, 1997:27).

Contusions to the thigh and lower leg muscles are common soccer injuries and result from a direct blow to a muscle by an opponent's foot or knee (Tucker, 1997:24–25; Valderrabanno *et al*., 2014:100) and is characterised by swelling, pain, tenderness, and hindered muscle function (Valderrabanno *et al*., 2014:100).

Patella-femoral pain syndrome (PFPS) is a cluster of overuse injuries characterised by anterior knee pain (Schultz *et al*., 2016:495; Tumia & Maffulli, 2002:69). Intrinsic risk factors for PFPS include lower limb malalignment and muscle imbalances (Clement *et al*., 1981:83; Krivickas, 1997:133; Tumia & Maffuli, 2002:70). These intrinsic risk factors are further influenced by the individual, anatomic or physiological attributes of the player (Valderrabanno *et al*., 2014:98).

Lower limb malalignment factors that contribute to PFPS are a deviant quadriceps-angle, excessive foot pronation and muscle imbalances (Krivickas, 1997:133; Schultz *et al*., 2016:495; Tumia & Maffuli, 2002:70). The normative quadriceps-angle value for females is 15° (Prentice, 2004:560), and a higher than normal quadriceps-angle can lead to greater knee valgus, therefore pulling the patella laterally and increasing pressure on the lateral aspect of the patella. This in turn can lead to patella subluxation and cartilage softening that can subsequently predispose the knee to PFPS (Tumia & Maffulli, 2002:70). An asymmetric strength ratio between the vastus lateralis and vastus medialis oblique muscles can furthermore produce patella maltracking and result in PFPS (Schultz *et al*., 2016:495; Tumia & Maffulli, 2002:70; Witvrouw *et al*., 2000:486). Overtraining or a sudden change in training habits, overloading the patellofemoral joint, and exceeding adaptive structural responses can also predispose the knee to PFPS (Schultz *et al*., 2016:495).

Other intrinsic risk factors that will be discussed below that can result in lower limb injuries in soccer include previous injury (Hägglund & Walden, 2016:740; Hertel, 2000:364; Kofotolis *et al*., 2007:462), inadequate rehabilitation (Ekstrand & Gillquist,1983:269; Ekstrand *et al*., 2011:555), an increased body mass index (Fousekis *et al*., 2012:1847; Hägglund & Walden, 2016:739; Nilstad *et al*., 2014:944), range of motion or flexibility limitations (Kaufman, *et al*., 1999:592; Weaver & Relph, 2017:407), joint instability (Soderman *et al*., 2001:316, Munn *et al*., 2010:3), poor landing technique and rapid rotational movements (Hewett *et al*., 2005: 493).

Previous injury and inadequate rehabilitation of lower limb injuries can account for about 12% to 28% of all soccer injuries (Ekstrand *et al.*, 2011:555; Ernlund & De Almeida Vieira, 2017:374; Jacobson & Tegner, 2007:87). Players who are not properly rehabilitated or who are not ready to return to play are at increased risk of re-injury due to muscle weakness or imbalance and ligament impairment that is the result of a previous injury (Chomiak *et al*., 2000:60; Murphy *et al*., 2003:18–19). Inadequate rehabilitation among female players is due to lower levels of medical care and an unprofessional attitude to their care by coaches or parents (Steffen *et al.*, 2008:702).

High body mass index (>23,1kg/m^2) in professional soccer players can increase the risk of ankle injuries (Fousekis *et al*., 2012:1847), and this is coupled to a high knee injury incidence due to the increased amount of forces that are placed on the joint during sport-specific actions such as landing from a jump (Hägglund & Walden, 2016:739; LaBella *et al*., 2014:1441).

Inadequate muscle flexibility is also one of the intrinsic risk factors for lower limb muscle injuries (hip, hamstring, and ankle) in soccer (Schultz *et al*., 2016:418; Weaver & Relph, 2017:407; Witvrouw *et al*., 2003:44). A decreased flexibility can increase the risk of injury of a given musculotendinous unit when a muscle is overstretched beyond its elasticity capabilities (Prentice, 2004:122).

Joint instability is attributed to both mechanical and functional limitations (Munn *et al*., 2010:3). Mechanical instability occurs in the joint due to laxity resulting from a loss of mechanical static ligamentous restraint (Hertel, 2000:362) and dynamic muscle weakness (Clark & Burden, 2005:182). Functional instability is the feeling of the ankle giving way and the feeling that it is weaker, more painful and/or possesses less functional abilities following an injury because of sensorimotor, mechanical and muscular deficiencies (Lentell *et al*., 1990:605; Kaminski *et al*., 2003:410). A disrupted proprioception system delays muscle activity, lessens joint stability, and decreases postural awareness (kinaesthesia) (Clark & Burden, 2005:182). Proprioceptive deficits that usually occur following an injury have been used as a predictor of ankle joint injuries (Payne *et al*., 1997:223).

Poor landing technique and rapid rotational movements can lead to knee injuries when the soft tissue within the knee joint insufficiently absorb the associated forces during activity (Hewett *et al*., 2005:493). Most ACL injuries among female athletes are due to episodes of poor landing, cutting and quick changes in direction, all of which are movement patterns that characterise soccer (Brophy *et al*., 2010:694; Faude *et al*., 2005:1699; Hewett *et al.*, 2005:493; Valderrabanno *et al*., 2014:98). Increased knee valgus or varus stress during landing creates a less stable knee joint and increases anterior translation of the tibia and loads onto the ACL, which then in turn increases the risk of injury (Fukuda *et al*., 2003:1111; Hewett, 2000:316).

Extrinsic risk factors are environment related and are influenced by external forces that can compromise a player's safety (Valderrabanno *et al*., 2014:98), including direct contact/foul play (Andersen *et al*., 2004:629; Woods *et al*., 2003:234) and inadequate playing surface (Williams *et al*., 2011:909; Wong & Hong, 2005:475).

Soccer was previously viewed as a male dominated sport and a lot of focus was placed on male players in previous research (Heidt *et al*., 2000:659; Junge & Dvorak, 2007:3; Muller *et al*., 2016:365; Nilstad *et al*., 2014:940). An investigation of injuries and predisposing risk factors particular to female players will increase the knowledge of how these injuries occur, especially due to the anatomical, hormonal and biomechanical factors that differentiate women from men. This may aid in the prevention of such injuries and thereby ensure the frequent participation of all players, as opposed to instances where players spend most of the season on the side line or are unable to compete because of their injuries (Faude *et al*., 2005:1699; Soderman *et al.*, 2002:67; Tegnander *et al*., 2008:196).

Therefore, the research questions to be answered by this study are, firstly, what is the injury prevalence among university-level female soccer players, and secondly, which selected intrinsic risk factors are associated with lower limb injuries among university-level female soccer players?

1.4 OBJECTIVES

To reach the aim of this study the following objectives were formulated:

1. To determine the injury prevalence among university-level female soccer players; and
2. To determine the selected intrinsic risk factors associated with lower limb injuries among university-level female soccer players.

The first aim of the study is describing the prevalence of soccer related injuries among selected university-level female players, and the second aim reviews the relationship between selected intrinsic predisposing risk factors and soccer related injuries among the selected university-level female players.

1.5 HYPOTHESES

1. There will be a significantly high ($p<0,05$) injury prevalence among university-level female soccer players.
2. A higher body mass index, limited flexibility and lower limb instability ($p<0,05$; $r=0,1$) will be significantly associated with lower limb injuries among university-level female soccer players.

1.6 STRUCTURE OF DISSERTATION

- **Chapter 1:** Introduction. A reference list will be provided at the end of the chapter in accordance with the North-West University guidelines.

- **Chapter 2:** Literature review: Prevalence and incidence of soccer injuries among female players. A reference list will be provided at the end of the chapter in accordance with the North-West University guidelines.
- **Chapter 3:** Article 1: The prevalence of soccer injuries among trained female university students in their preparation for the USSA 2016 tournament. This article will be written according to the guidelines of and submitted to the *African Journal for Physical Activity and Health Sciences*.
- **Chapter 4:** Article 2: Selected intrinsic risk factors associated with lower limb injuries among trained female soccer university players in South Africa. This article will be written according to the guidelines of and submitted to the *African Journal for Physical Activity and Health Sciences.*
- **Chapter 5:** Summary, conclusions, limitations and recommendations.

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CHAPTER 2

CHAPTER 2

LITERATURE REVIEW: PREVALENCE AND INCIDENCE OF SOCCER INJURIES AMONG FEMALE PLAYERS

2.1 INTRODUCTION

In this chapter, the occurrence of common soccer injuries plaguing female players will be presented. The narrative method that was used for literature review was narrowed to the past 37 years (1981 to 2018) and presented the following: (i) the prevalence and incidence of soccer injuries among female players, (ii) vulnerable anatomical sites of injury, (iii) the most common soccer injuries experienced by female players, (iv) predisposing intrinsic risk factors of soccer injuries to the lower limb, and (v) most vulnerable playing positions. The literature review searches included investigations of soccer injuries and predisposing risk factors.

The following search engines were used: Google Scholar, Science Direct, Sport Discuss, Scopus, and Web of Science. Key search words and phrases that were adopted included: "soccer injuries", "male and female players of all levels and ages", "injury prevalence", "injury incidence" and "intrinsic risk factors". The inclusion criteria were all types of articles that focused on soccer injuries and predisposing risk factors related to both female and male soccer players. Articles that were not in English, or partial English text and grey literature were excluded from the search.

Participation in soccer requires various abilities and skills, including but not limited to endurance, speed, agility, as well as a tactical and technical understanding of the game. This demanding combination of skills and ability requirements leads to a high incidence of injuries (Bizzini & Dvorak, 2015:35). Women's soccer has gained popularity in recent years with an increase in participation and professionalism observed in several countries that have introduced national leagues (Eirale, 2015:7; Junge, 2015:21). According to *Federation Internationale de Football Association* (FIFA) there are more than 30 million female soccer players globally (FIFA Women's football survey, 2014:17).

The dramatic increase in the popularity of women's soccer is reflected in the fact that internationally the number of competitive players has increased by 23 million between the years 2001 and 2009 (Alentorn-Geli *et al*., 2009:706). The increased popularity and participation in soccer provides several health benefits but is simultaneously associated with a high incidence of injury due to the complex movement patterns, high physical demands, trauma, and competitiveness among opponents (Kerr *et al*., 2017:2; Valderrabanno *et al*., 2014:98). The high incidence of injuries is the biggest concern to coaches and players because it can hamper the players' ability to perform and reduce the available players to be selected for the team (Bizzini & Dvorak, 2015:35). The injuries can also have an economic impact on the clubs because of health-related costs such as treatment and rehabilitation of injuries (Bizzini & Dvorak, 2015:35). These concerns are well founded and are seen in literature where the rate of anterior cruciate ligament (ACL) sprains among female soccer players are two to nine times higher than among their male counterparts (Cug *et al*., 2016:31; Hewett, 2000:314; Konopka *et al*., 2016:2384; Walden *et al*., 2011:4; Wahlstedt & Rasmussen-Barr, 2015:3202).

2.2 PREVALENCE AND INCIDENCE OF SOCCER INJURIES

Injury prevalence surveillance describes the retrospective number of injuries sustained in a population over a certain period, while injury incidence surveillance follows the prospective number of injuries over a certain period (Doherty *et al*., 2014:125; Ekstrand *et al*., 2011a:555; Jacobson & Tegner, 2007:85).

The incidence of injury among female and male soccer players is higher during matches/competition than it is during regular training (Agel *et al*., 2007:270; Dick *et al*., 2007:279; Nilsson *et al*., 2016:87; Roos *et al*., 2017:1030; Walden *et al*., 2007:1157). An injury incidence of 16,4/1000 hours of player exposure in matches was reported as compared to an injury incidence of 5,2/1000 hours of player exposure in training among varsity women's soccer programme over a period of 15 years (Dick *et al*., 2007:279). Walden *et al*. (2007:1157) reported an injury incidence of 11,3/1000 hours of player exposure during matches as compared to 2,4 injuries per 1000 hours of training among male soccer players in three European championships. A total of 2271 injuries were reported in women compared to 1554 in men over a period of six seasons (Roos *et al*., 2017:1030). These studies indicated a higher injury incidence in females than in male soccer players.

The prevalence of injuries among female soccer players is most common to their lower extremities, followed by head injuries (Dick *et al*., 2007:282; Jacobson & Tegner *et al*., 2007:86; Junge & Dvorak, 2007:4; Roos *et al*., 2017:1031), and the same distribution of injuries was reported among male soccer players (Agel *et al*., 2007:270). In the lower extremities, the ankle, knee, and thigh are the most vulnerable with an injury prevalence of 25%, 19% and 18,3% respectively, in female soccer players (Dick *et al*., 2007:282; Jacobson & Tegner, 2007:86), whereas among male soccer players a prevalence of 17% for ankle injuries and 11% for knee injuries was reported (Agel *et al.*, 2007:273). Head injuries account for 7,1% to 16% of all soccer injuries in female players (Dick *et al*., 2007:282; Junge & Dvorak, 2007:4; Tegnander *et al*., 2008:196) and account for 5,8% of all injuries in male soccer players (Agel *et al*., 2007:273). Lower limb injuries occur both due to contact or without any contact with a player (Agel *et al*., 2007:271; Junge & Dvorak, 2007:4), while head injuries are mostly concussions that can be caused by collision with another player, with the ball or with the playing surface (Agel *et al*., 2007:272; Dick *et al*., 2007:282).

2.3 VULNERABLE ANATOMICAL SITES OF INJURY

The lower extremities are the most vulnerable anatomical sites for soccer injuries, recording a 65% to 83% prevalence of injuries (Bizzini & Dvorak, 2015:36; Faude & Rossler, 2015:12; Junge, 2015:23; Muller *et al*., 2016:371; Roos *et al*., 2017:1031; Sentsomedi & Puckree, 2016:301). The most affected anatomical sites include the ankle (9% to 35%) (Junge, 2015:23; Mohib *et al*., 2014:373), the thigh (11 % to 27%) (Junge, 2015:23; Lee *et al*., 2014:121; Nilsson *et al*., 2016:85), the knee (12% to 34%) (Junge, 2015:23; Sentsomedi & Puckree, 2016:301; Verrelst *et al*., 2017:4) and the lower leg (9% to 15%) (Lee *et al*., 2014:121; Mohib *et al*., 2014:373; Sentsomedi & Puckree, 2016:301). During major international soccer tournaments such as the Olympic Games and the FIFA World Cup, the number of injuries is far greater than normal because of the auspiciousness of the occasion, which fuels greater competitiveness among players (Engebretsen *et al*., 2013:409; Junge & Dvorak, 2015:599). The 2014 FIFA World Cup recorded the greatest number of injuries to the lower extremities, with quadriceps muscle strains being the most frequent (Junge & Dvorak, 2015:599). The most common types of non-contact injuries include muscle strains and ligament sprains affecting the knee and ankle joints (Del Coso *et al*., 2016:3; Delextrat *et al*., 2013; Lee *et al*., 2014:121; Muller *et al*., 2016:371).

2.4 MOST COMMON SOCCER INJURIES AMONG FEMALE PLAYERS

The most common soccer injuries and their mechanisms of injury will be presented. The injuries are classified into muscle strains and ligamentous injuries.

2.4.1 Muscle strains

Muscle strains are among the most common injuries among professional soccer players (Lee *et al*., 2014:122; Rossler *et al*., 2016:313). The muscles that are particularly vulnerable to strains include the hamstrings, hip adductors, quadriceps, and gastrocnemius (Eckard *et al*., 2017:476; Ernlund & De Almeida Vieira, 2017:374; Lee *et al*., 2014:122; Mohib *et al*., 2014:373).

A high number of hamstring muscle strains in soccer result from non-contact mechanisms that occur because of explosive movements (Troyer & Dunn, 2014:29), such as high intensity kicking and sprinting, which requires rapid change in the type of muscle contraction from eccentric to concentric (Ernlund & De Almeida Vieira, 2017:375; Lee *et al*., 2014:123). The most vulnerable part of the muscle is the myotendinous junction, the tendon and the tendon-bone junction (Ernlund & De Almeida Vieira, 2017:376). Proximal muscle attachment injuries have a longer recovery time (Ernlund & De Almeida Vieira, 2017:376). The incidence of hamstring strains is higher during in-season than pre-season because of the high intensity of matches, the explosive actions of players and the competitive nature of the game that encourages players to perform (Troyer & Dunn, 2014:30).

Hip adductor muscle injury mechanisms in soccer include tackling, pivoting and kicking actions as well as the muscles' rapid change of contraction type (Karlsson *et al*., 2014:40). Most hip adductor muscle strains result from maximal kicking effort during which the muscle reaches its peak muscle activity and maximal rate of stretch at the time of hip extension in the swing phase of kicking (Charnock *et al*., 2009:230; Serner *et al*., 2015:1860).

Quadriceps muscle strains result from explosive movements such as repetitive sprinting/acceleration (Eckard *et al*., 2017:479; Mendiguchia *et al*., 2013:362) and kicking efforts (Ekstrand *et al*., 2011b:1228; Pierce & LaPrade, 2014:63) that commonly occur during a soccer game. Most quadriceps muscle strains occur via a non-contact mechanism or are the result of overuse and occur during competition rather than during practice (Eckard *et al*., 2017:476 & 478). The rectus femoris is the most frequently injured muscle due to the muscle contracting eccentrically during sprinting (Mendiguchia *et al*., 2013:361; Pierce & LaPrade, 2014:63), with the injury being more common on the dominant or preferred kicking leg (Ekstrand *et al*., 2011b:1228; Hägglund *et al*., 2012:330). The high volume of passing and shooting using the dominant leg's rectus femoris muscle precipitates injury (Ekstrand *et al*., 2011b:1230; Hägglund *et al*., 2012:331). During jumping in a soccer game, the quadriceps muscle group moves from hip and knee flexion to hip and knee extension, producing upward propulsion. However, during landing, the hips and knees are flexed again, to absorb the landing forces, which decrease the risk of injury (Prentice, 2004:229). Players who land with their knees and hips in an extended position increase the risk of injury to these joints (Eckard *et al*., 2017:479; Pierce & LaPrade, 2014:63).

Proximal gastrocnemius muscle strains can constitute 12,6% to 13% of all muscle injuries in soccer (Ekstrand *et al*., 2011b:1228; Volpi *et al*., 2004:483). The gastrocnemius muscles together with soleus and plantaris form the calf muscle group, and of the three muscles the gastrocnemius is the most vulnerable to injury (Dixon, 2009:74; Hayashi *et al*., 2014:592; Wiegerinck *et al*., 2014:82). The proximal musculotendinous junction of the medial gastrocnemius is the most frequently injured site as a result of sudden change of direction, acceleration and eccentric contraction of a muscle when the ankle is forced in dorsiflexion with an extended knee (Barreira *et al*., 2016:63; Wiegerinck, *et al*., 2014:83). The gastrocnemius muscles are bi-articulate muscles spanning over two joints (knee and ankle) that must rapidly change from a state of eccentric contraction to concentric contraction, in addition to adapting to the almost instantaneous proprioceptive demands of sudden change in direction thereby succumbing to injury (Dixon, 2009:74; Prentice, 2004:139; Wiegerinck, *et al*., 2014:83).

2.4.2 Ligamentous injuries

The most frequently occurring lower extremity ligament injuries among female soccer players include ankle (18,3% to 55,1%) (Dick *et al*., 2007:280; Rossler *et al*., 2016:313) and knee sprains (15,9% to 16,3%) (Dick *et al*., 2007:280; Rossler *et al.*, 2016:313). Female players' ACL sprain rate is at least twice as high as that of male soccer players (Agel *et al*., 2005:529; Augustsson & Ageberg, 2017:4; Beynnon, Vacek *et al*., 2014:1809; Dick *et al*., 2007:174; Giza *et al*., 2005:213; Mykleburst & Steffen, 2015:1358; Stanley *et al*., 2016:1567). A high ACL incidence rate of 2,21 sprains per 1000 hours of player exposure among female soccer players can be compared to a baseline rate of 0,79 sprains per 1000 hours of player exposure among male soccer players, as was recorded among college and high school soccer players (Stanley *et al*., 2016:1567). The high incidence of ACL injuries in females could be attributed to poor landing techniques (Muller *et al*., 2016:371) and to the sudden pivoting skills required in soccer (Niyonsenga & Phillips, 2013:1024). Injuries of the medial collateral ligament are also common in female soccer players and are primarily due to the exposure of the knee to valgus forces (contact) or to valgus moments (non-contact) during cutting or pivoting actions in soccer (Stanley *et al*., 2016:1570). A medial collateral ligament incidence rate of 2,08 sprains per 1000 player exposure for female soccer players compared to 1,47 sprains per 1000 player exposure for male soccer players was recorded among college and high school soccer players (Stanley *et al*., 2016:1569). Several factors play a role in the high prevalence of ligament injuries in female soccer players; these include biomechanical (Muller *et al.*, 2016:372), hormonal (Hewett, 2000:315), and neuromuscular factors (LaBella *et al*., 2014:1441). These predisposing risk factors will be discussed in the subsequent sections of this chapter.

Ankle ligament injuries, which can result in mechanical instability, are also common in soccer when torn ligaments fail to return to its normal length during the post-recovery period, thereby affecting joint normative range of motion (ROM) (Walls *et al*., 2016:9). This can be attributed to failure by athletes to complete their final-phase functional rehabilitation before returning to play (Eirale *et al.*, 2013:115). The common mechanisms of ankle injury include quick rotational movements and poor landing from a jump (Muller *et al*., 2016:371). This can consequently result in overstretching or tearing of soft tissues in the ankle joint capsule during injury, leading to disruptions in the proprioceptive fibres that pass through them (Walls *et al*., 2016:9). The prevalence of ankle ligamentous injuries range between 15,6% and 17,9%, while anterior talofibular and calcaneofibular ligaments are most commonly injured (Del Coso *et al*., 2016:4; Muller *et al*., 2016:371).

2.5 PREDISPOSING INTRINSIC RISK FACTORS FOR LOWER LIMB INJURIES IN SOCCER PLAYERS

Intrinsic risk factors act from within the human body and potentially predispose players to injuries due to biomechanical, anatomical (Hewett *et al*., 2006:304), and hormonal components (Ahmad *et al*., 2006:372; Hewett *et al*., 2006:304; Wetters *et al*., 2015:4). Such factors include previous injury (Ekstrand *et al*., 2011a:555; Ernlund & De Almeida Vieira, 2017:377), age (Allen *et al*., 2016:2495; Ekstrand *et al*., 2011b:1230; Hägglund *et al*., 2012:330; Hägglund & Walden, 2016:740), increased body mass index (BMI) (Hägglund & Walden, 2016:739; Nilstad *et al*., 2014:944), gender (Kraemer & Knobloch, 2009:1389; Soderman *et al*., 2002:67), limb dominance, muscle imbalances and weaknesses (Blache & Monteil, 2012:7; Ernlund & De Almeida Vieira, 2017:377; Hägglund *et al*., 2012:330), deviant quadriceps-angle (Q-angle) (Devan *et al*., 2004:266; Wetters *et al*., 2015:4), limited ROM/flexibility, and generalised joint laxity (Konopinski *et al*., 2012:767; Weaver & Relph, 2017:407).

2.5.1 Previous injury

Previous injuries can account for about 15% to 28% of re-injuries in sports (Eirale *et al*., 2013:116; Ekstrand *et al*., 2011b:1230). Hamstring and hip adductor muscle injuries have one of the highest recurrent rates estimated at between 12% and 33% (Elliot *et al*., 2011:845; Ernlund & De Almeida Vieira, 2017:374; Hägglund *et al*., 2012:329). An inadequately rehabilitated previous injury reduces both strength and ROM/flexibility, adversely impacting on functional stability and proprioception, and thereby increasing the risk of re-injury (Eirale *et al*., 2013:115; Engebretsen *et al*., 2010:2055). Previously injured players have a four to seven-fold increased risk of re-injury compared to those who have not previously been injured, and such re-injuries are mostly observed in the knee and ankle ligaments and in the hamstring and groin muscles (Engebretsen *et al*., 2010:1155; Hägglund *et al*., 2012:330). This is further supported by the findings of Nilstad *et al*. (2014:944) who reported that elite female soccer players with a previous ACL injury had a nine-fold increased risk of injury in the same knee compared to players with no previous injury, while Hägglund & Walden (2016:740) reported a five-fold increased risk of ACL injury.

Inadequate or incomplete rehabilitation are the predominant factors that contribute to injury reoccurrence (Eirale *et al*., 2013:115). An enormous amount of pressure is placed on the medical staff to allow players to return to play before the injury has been completely rehabilitated, and this often leads to re-injury that can result in a longer absence from play than what was initially required (Ekstrand *et al*., 2011b:1231). It is therefore important for the team's medical staff to ensure players' readiness to return to play by performing both medical and sport-specific functional testing in addition to more standard functional screening tests (Cook *et al*., 2006:62; Eirale *et al*., 2013:116).

2.5.2 Age

Age has also been identified as an intrinsic risk factor for lower limb injuries among soccer players, with a higher prevalence among older players (Allen *et al*., 2016:2495; Arnason *et al*., 2004:10; Ekstrand *et al*., 2011b:1230; Hägglund *et al*., 2012:330; Hägglund & Walden, 2016:740). Increased age is associated with high injury prevalence for gastrocnemius (Ekstrand *et al*., 2011b:1230; Hägglund *et al*., 2012:330), hamstrings, and groin/hip adductor muscle strains (Arnason *et al*., 2004:10). The increased risk of injury in older players is due to the accumulative high volume of training and competition and a reduced rate of healing and recovery (Del Coso *et al*., 2016:5). Another physiological explanation is the decreased muscle strength, skeletal muscle fibre size, and muscle force output; limited flexibility; decreased bone mass; and slower reaction time during voluntary movements; all of which are associated with ageing (Adams *et al*., 1999:70; Del Coso *et al*., 2016:5; Fatouros *et al*., 2002:112; Holland *et al*., 2002:169; Van Doormaal *et al*., 2016:122).

The physiological changes associated with ageing include a decrease in muscle strength and force output, which can be attributed to the loss of motor units (Saxon *et al*., 2014:52), as well as to neuromuscular system alterations and reductions in the intrinsic force-generating capabilities of muscle fibres (Miljkovic *et al*., 2015:156). Muscle mass is dependent on muscle fibre size and number; therefore, a decline in muscle strength can be attributed to a decline in muscle fibre size (Nilwik *et al*., 2013:496). A 30% to 40% decrease in type II muscle fibres are most commonly seen between the second and eighth decade of life (Miljkovic *et al.*, 2015:157). These changes in the motor unit system and the decrease in muscle mass lead to decreased functional capacity and a slow gait and speed, especially in the lower extremities (Miljkovic *et al.*, 2015:158). These phenomena, due to progressive loss of muscle strength and mass, are the root cause of the slow reaction times seen in older soccer players, especially concerning voluntary movements (Miljkovic *et al.*, 2015:158; Nilwik *et al*., 2013:496).

Muscle flexibility declines with ageing and has been indicated to decline by 20% to 50% between the ages of 30 to 70 years old (Adams *et al*., 1999:70; Fatouros *et al*., 2002:112; Holland *et al*., 2002:169). Factors contributing to a decline in muscle flexibility with ageing include tendon stiffening and joint capsule changes that result in elastin-age related changes such as fibre fraying, calcification and increased number of cross-linkages with other muscle fibres (Adams *et al*., 1999:70; Holland *et al*., 2002:178). Collagen becomes more cross-linked and increases in solubility and muscle content, which leads to a reduction in ROM (Adams *et al*., 1999:70). These physiological changes can be best explained by shorter strides in older people, reduced hip flexion, hip extension and ankle joints ROM (Adams *et al*., 1999:70).

The loss of bone mass that occurs as part of the ageing process also plays a role in the changes in physical function (Miljkovic *et al*., 2015). In the course of the ageing process, there is a gradual loss of calcium in the bones due to disturbances in the new bone formation and re-absorption processes, which ultimately results in a general decrease in bone mass (Saxon *et al*., 2014:38). A low bone mass can predispose players to risk of stress fractures due to the high intensity and complex movement patterns, such as repetitive jumps, in soccer where the joints and soft tissue structures fail to absorb external loads (Walden *et al*., 2007:39).

2.5.3 Increased body mass index

An increased BMI has been associated with lower limb injuries in female soccer players due to the increased amount of internal stress placed on the ligamentous, articular cartilage, peri-articular connective tissue, and muscular structures during activities (Giacchino & Stesina, 2013:278; Hägglund & Walden, 2016:739; Nilstad *et al*., 2014:944). Non-contact ankle sprains were also observed in soccer players whose BMI was above 23,1kg/$m^{2,}$ and such players were at an almost eight-fold increased risk of non-contact ankle sprains compared to those with a lower BMI (Fousekis *et al*., 2012:1845). A high incidence of ACL injuries was also reported in overweight youth female soccer players or those with a high BMI (Hägglund & Walden, 2016:739). It has been postulated that an increase in BMI is associated with increased joint forces and internal stress that makes it difficult to restrain and maintain balance during high tempo sports-specific actions (LaBella *et al*., 2014:1441).

2.5.4 Gender

An alarming increase from as early as the 1980s in non-contact ACL injuries in female soccer players have been reported in previous studies (Augustsson & Ageberg, 2017:3; Larruskain *et al*., 2017:3; Walden *et al*., 2011:4). ACL injury incidence is higher during competition compared to training: It occurs in about 6% of all matches and 2% of training sessions in female soccer players, but the ACL injury incidence of male soccer players is less than 1% (Walden *et al*., 2011:4). Female soccer players are at a four to six-fold increased risk of ACL injury compared to their male counterparts (Konopka *et al*., 2016:2384; Wahlstedt & Rasmussen-Barr, 2015:3202; Walden *et al*., 2011:4). Common mechanisms of non-contact ACL injury in female athletes include a combination of sudden change of direction with deceleration, landing on a fully extended knee, and turning with the knees in an extended position with the foot planted (Alentorn-Geli *et al*., 2009:705; Brophy *et al*., 2010: 694; Fox *et al.*, 2014:816).

There are anatomical/structural differences between male and female knees that contribute to the increased risk of non-contact ACL injuries in female players. Women have a smaller femoral intercondylar notch width that can lead to ACL being impinged during external rotation and abduction of the tibia relative to the femur with the knee flexed at 30° or more (Sturnick *et al*., 2015: 843). Men who have a smaller ACL volume and wedge angle of the posterior lateral meniscal horn have 1,76 times bigger risk of ACL injury than their peers (Sturnick *et al*., 2015:843).

An increased posterior-inferior directed slope of the lateral tibial slope in female players has also been associated with the risk of non-contact ACL injury (Beynnon, Hall *et al*., 2014:1045). This leads to anterior translation and internal rotation of the tibia on the femur especially in activities that involve landing from a jump and pivoting, such as soccer that put a lot of strain on the ACL (Beynonn *et al*., 2014:1045). The other contributing factor to ACL injuries in males is the height of the lateral compartment articular cartilage-subchondral bone (Sturnick *et al*., 2014:1491). These structural differences between males and females should not be overlooked when studying the predisposing risk factors to ACL injuries because the mechanisms may be different.

As mentioned earlier in the chapter, several intrinsic risk factors will be discussed in the chapter, and both neuromuscular (Hewett *et al*., 2006:304) and hormonal risk factors play a role in the escalated number of ACL injuries experienced by female athletes (Ahmad *et al*., 2006:372; Hewett *et al*., 2006:304; Wetters *et al*., 2015:4).

2.5.5 Neuromuscular control deficits

Neuromuscular control deficits can be defined as muscle power and strength and activation patterns that can potentially lead to increased loads on the knee joints (Myer *et al*., 2011:2). These deficits lead to a failure to control sagittal plane motion in the lower extremities during cutting and landing actions (Myer *et al.*, 2011:2). Neuromuscular control deficits in the joint increase the load placed on the ligaments that may therefore exceed their strength limit and affect their stability; this in turn increases the risk of ACL injury (Myer *et al*., 2011:2). The neuromuscular control deficits that can lead to ACL injuries in female athletes include ligament and quadriceps dominance and will be discussed below (Kaux *et al*., 2013:3; La Bella *et al*., 2014:1441; Myer *et al*., 2011:2).

2.5.5.1 Ligament dominance

Ligament dominance can be defined as the reliance on ligaments to absorb excessive forces that are transmitted through the body, especially when landing from a jump, and particularly in the knee and hip joints (Orishimo *et al*., 2014:1083). This is indicative of an imbalance between ligamentous and neuromuscular control of dynamic knee joint stability (Myer *et al*., 2011:2). A pattern of ligament dominance can be observed during landing and cutting actions in soccer when a player is unable to control lower extremity frontal plane movement, making the ACL dominant and increasing the risk of injury (Myer *et al.*, 2011:2). Female athletes who perform dynamic landing tasks with a lower degree of knee stability are at increased risk of non-contact ACL injury due to increased knee valgus, and an increased load on the knee ligaments can increase the risk of ACL injury (Ireland, 2002:637; Read *et al*., 2016:1062).

2.5.5.2 Quadriceps dominance

Quadriceps dominance can be defined as preferential use of the quadriceps muscles to stabilise a knee joint during landing (Orishimo *et al*., 2014:1083). This occurs when there is an imbalance in the recruitment patterns, coordination between the force-couple, and the muscle strength and endurance of the quadriceps and hamstring muscles (Myer *et al*., 2011:2). During soccer, movement patterns such as pivoting and landing as well as quick acceleration and decelerations are often required, and these movements involve greater eccentric muscle force from the quadriceps, thus increasing the risk of non-contact ligamentous injuries of the ACL (Simonsen *et al*., 2000:78; LaBella *et al*., 2014:1441; Nessler *et al*., 2017:2). A tendency of increased quadriceps muscle activation over hamstrings (Boham *et al*., 2014:2) while executing sports movement patterns such as pivoting and landing has been observed in female athletes (Kaux *et al*., 2013:2), and this increases the anterior shear forces placing the ACL under a lot of stress (LaBella *et al*., 2014:1441). Decreased hamstring muscle activation can also result in the inability of the muscles to perform their function, which is to prevent or decelerate anterior translation of the tibia on to the femur, resulting in less knee stability during explosive actions such as running, sprinting or kicking the ball, and thereby increasing the risk of ACL injury (Delextrat *et al*., 2013:484; Kaux *et al*., 2013:3; Orishimo *et al*., 2014:1083). If hamstring muscle strength is exceeded by the quadriceps muscles strength, potential damage to the muscle may occur. This, along with the failure of the hamstring muscles to act as knee stabilisers by preventing anterior translation of the tibia on the femur, can place the ACL under a substantial amount of stress, predisposing it to injury (Daneshjoo *et al*., 2013:50; Delextrat *et al*., 2013:484; Orishimo *et al*., 2014:1083).

2.5.6 Hormonal fluctuations

Hormonal fluctuations among female players increase their ligament laxity and their muscle extensibility, thereby augmenting their joint ROM, all of which adversely impact their susceptibility to proprioception precipitating injuries (LaBella *et al*., 2014:1440; Wetters *et al*., 2015:4). Despite this, there have been conflicting reports on the association between hormonal level changes during menstrual cycles and the risk of non-contact ACL injury in female athletes.

During the three phases of the menstrual cycle there is a fluctuation of the sex hormones oestrogen (Adachi *et al*., 2008:475), progesterone (Zazulak *et al*., 2006:848) and relaxin (Konopka *et al*., 2016:2390), which are believed to play a role in the increased number of ACL injuries in female athletes. During the follicular phase (day 1 to 9) of the menstrual cycle, oestrogen concentration rises, peaking just before the ovulatory phase (day 10 to 14) (Adachi *et al*., 2008:475) and decreasing during the luteal phase (day 15 until end of the cycle) (Zazulak *et al*., 2006:848). Progesterone levels reach their peak during the luteal phase of the menstrual cycle (Zazulak *et al*., 2006: 848). Wojtys *et al*., (2002:184) reported an increase in ACL injuries during the ovulatory phase of the menstruation cycle and a lower rate of injury during the follicular phase. These findings are contradicted by Slauterbeck *et al*. (2002:276), who reported the contrary.

During the ovulatory phase, oestrogen levels are at their peak and have been associated with increased knee joint laxity that may predispose female athletes to an increased risk of ACL injury (Alentorn-Geli *et al*., 2009:713; Laible & Sherman, 2014:72). This increased joint laxity can contribute to ACL injuries in females as the joint neuromuscular control and stability of a lax knee joint are affected during landing activities, therefore, putting the ACL under a substantial amount of strain (Hewett *et al*., 2007:660). As mentioned, Slauterbeck *et al*. (2002:2760) reported the contrary, citing an increase in ACL injuries during the follicular phase of menstruation and fewer in the ovulatory phase. A high level of serum relaxin hormone in the ACL cells of female athletes has been associated with a decrease in the integrity of the ACL, thereby increasing the risk of injury (Konopka *et al*., 2016:2390).

2.5.7 Leg dominance, muscle imbalance and weakness

Leg dominance refers to the leg that is commonly used or most preferred by the player for passing or for kicking the ball (Daneshjoo *et al*., 2013:45). Leg dominance in soccer can lead to muscle strength as well as control and coordination imbalances between the dominant and non-dominant leg due to the greater volumes of passing, crossing and shooting that are undertaken with the preferred limb (Hägglund *et al*., 2012:330; Myer *et al*., 2004:358). Reliance on the dominant leg can place a substantial amount of stress and significant forces on the knee joint, while increasing the risk of injury on the weaker side due to the weaker side's inability to effectively absorb forces associated with sporting activities/movements (Delextrat *et al*., 2013:484). This concurs with a study that reported an increased risk of ACL injuries in the non-dominant leg in female soccer players with the contrary reported in male soccer players (Brophy *et al*. 2010:2; Hägglund & Walden, 2016:744). An explanation for the difference may lie in the weaknesses in the non-dominant side in females and its inability to absorb forces during movements such as defective landing techniques, as well as in deceleration and cutting movements with the increased anterior knee shear forces (Kaux *et al*., 2013:2; LaBella *et al*., 2014:1441).

Muscle imbalance refers to strength deficits between the two extremities or the variation of hamstring strength to ipsilateral quadriceps strength (Ernlund & De Almeida Vieira., 2017:376). Strength deficits of more than 10% to 15% between similar muscles of the dominant and non-dominant legs (Daneshjoo *et al.*, 2013:50) or differences in the concentric strength ratio between hamstrings and quadriceps <0,6 can increase the risk of injury (Ernlund & De Almeida Vieira., 2017:376; Yeung *et al*., 2009:591). Imbalances between the hamstring and quadriceps muscle groups during concentric action increase the risk of lower limb injuries, and players with weaker muscles have a four times increased risk of new muscle injuries (Engebretsen *et al*., 2010:2055).

A study that was undertaken on youth athletes investigated the influence of lower extremity strength to traumatic knee injuries in youth female and male athletes (Augustsson & Ageberg, 2017:3). The athletes were categorised into weaker and stronger groups after performing the one-repetition maximum strength test. A comparison was done on lower extremity muscle strength between the two groups (weaker and stronger), and a high prevalence of 42% knee injuries in females and only 21% for males was reported. ACL injuries accounted for 17% of all traumatic knee injuries in females and only 2% in males. The majority of the injured females were from the weaker group and there were no differences in male athlete groups. A 9,5 times higher probability of traumatic knee injury and a seven times higher probability of ACL injury was reported in the weaker group. The study found that an increase in muscle strength was accompanied by a decrease in the incidence of knee injuries (Augustsson & Ageberg, 2017:5).

Another factor that was used to identify imbalances that could predispose muscles to injuries is the functional hamstring to quadriceps ratio (H_{ecc}/Q_{con}) (Yeung *et al*., 2009:590). This ratio is indicative of the ratio of peak eccentric hamstring torque to peak concentric quadriceps torque that reflects the hamstrings' ability to eccentrically decelerate the concentric contraction of the quadriceps at the late swing phase of gait cycle (Croisier *et al*., 2008:1473; Delextrat *et al*., 2013:478; Yeung *et al*., 2009:593). During sprinting the hamstring muscles work eccentrically to decelerate the knee extension and oppose the quadriceps muscles' powerful concentric contraction, which can potentially put the weaker hamstrings at risk of injury (Yeung *et al*., 2009:589). A lower functional hamstring to quadriceps ratio of <1,40 was identified in players with muscle imbalances and those with a ratio >1,40 did not sustain any hamstring injuries (Croisier *et al*., 2008:1474; Delextrat *et al*., 2013:478).

Muscular strength imbalances have also been associated with non-contact ligament ankle sprains among professional soccer players. Players with eccentric strength asymmetries of ≥15% in the ankle joint have an 8,8 times bigger chance of sustaining a non-contact ankle sprain injury than those with no eccentric strength asymmetries (Fousekis *et al*., 2012:1845). The strength deficits may be due to the preference of the dominant foot by soccer players during explosive actions such as landing, kicking and cutting (Fousekis *et al*., 2012:1847; Hägglund & Walden, 2016:744). The asymmetries therefore predispose the weaker side to injuries during the absorption of forces and stresses placed on the ankle (Fousekis *et al*., 2012:1847).

2.5.8 Deviant quadriceps-angle

There have been conflicting reports about a deviant Q-angle association with knee pathologies (Mohammed *et al*., 2012:177; Wetters *et al*., 2015:4). An excessive Q-angle was reported in collegiate athletes with genu recurvatum and in most collegiate athletes with overuse knee injuries (Devan *et al*., 2004:266). It has been postulated that greater dynamic knee valgus and decreased muscular control can result from an excessive Q-angle in jumping athletes with the patella being pulled laterally, resulting in increased pressure on the lateral side of the patella (Tumia & Maffulli, 2002:70; Wetters *et al*., 2015:4). However, Mohammed *et al*., (2012:177) reported no association between deviant Q-angles and knee injuries in female soccer players.

2.5.9 Decreased flexibility and range of motion (ROM)

Range of motion (ROM) is the arc of motion through which a joint moves in a specific plane of motion (Schultz *et al*., 2016:76). Muscle flexibility is the neuromuscular system's ability to allow a joint or joints to efficiently move through a full, pain-free and non-restricted ROM (Prentice, 2004:121). The desirable flexibility of muscles is very important in soccer because it provides protection for the muscle's tissues to tolerate stress easily, therefore allowing players to perform effective and adequate movements (Giacchino & Stesina, 2013:281). Flexibility deficits have also been associated with overuse injuries in sports, and such deficits can be identified in rectus femoris, hamstrings, gastrocnemius, soleus muscle groups as well as the iliotibial band (Krivickas, 1997: 134). Limited ankle dorsiflexion ROM was found to be associated with ankle sprains due to the tightness of gastrocnemius muscles that places the foot in greater plantarflexion (Willems *et al*., 2005: 421). Two studies have reported an association between pre-season decreased hamstring flexibility (Henderson *et al*., 2010:401) and hip adductor (Ibrahim *et al*., 2007:47) muscle strains in elite soccer players, whereas Van Doormaal *et al*. (2016:124) did not find any significant relationship between limited hamstring flexibility and the risk of injury among male amateur soccer players. A limited hip ROM in the dominant side was also indicated as a potential risk factor for lower limb injuries in female soccer players (Weaver & Relph, 2017:407). It is therefore important to include flexibility/ROM exercises in the pre-season training programme to help prevent injuries (Weaver & Relph, 2017:407).

2.5.10 Joint laxity

Hypermobility of a joint has been described as a condition whereby the normal ROM is exceeded without any musculoskeletal pain (Russek, 1999:592). Konopinski *et al*., (2012:767) reported that soccer player's joint hypermobility is an intrinsic injury risk factor, predominantly for the knee and ankle joints. An increased risk of ACL injury in female athletes has been reported in those with knee joint laxity as demonstrated by excessive knee hyperextension (Konopinski *et al*., 2012:767; Myer *et al*., 2008:1077).

2.6 MOST VULNERABLE PLAYING POSITION

Literature provide controversial evidence as to which position is most susceptible to injury (Le Gall *et al*., 2008: 280; Tegnander *et al*., 2008:196; Tscholl *et al*., 2007:10). Tegnander *et al*. (2008:196) reported that midfielders sustained most injuries with an incidence of 42,4 injuries per 1000 playing hours, followed by defenders with an incidence of 23,5 injuries per 1000 playing hours, strikers with an incidence of 22,7 injuries per 1000 playing hours and lastly goalkeepers with the smallest injury incidence of 12,1 injuries per 1000 playing hours.

Le Gall *et al*. (2008:280) oppose these findings of Tegnander *et al*. (2008:196). Le Gall *et al*. (2008:280) reported that strikers have an injury incidence of 2,0 injuries per player, followed by goalkeepers and defenders with an injury incidence of 1,8 per player, and lastly midfielders with the least injury incidence of 1,5 per player. Tscholl *et al*. (2007:10) also reported a high injury rate in strikers (49,3 injuries per 1000 playing hours), followed by goalkeepers (46,9 injuries per 1000 playing hours), and defenders (46,4 injuries per 1000 playing hours), and with the midfielders (34,6 injuries per 1000 playing hours) having the least injuries in six women's top-level tournaments that were analysed. The fundamental limitation of Tegnander *et al*.'s (2008:196) and Le Gall *et al*.'s (2008:280) findings were their method of reporting incidence of injury. Tegnander *et al*. (2008:196) adopted injuries per 1000 hours per playing position, while Le Gall *et al.* (2008:280) reported number of injuries per player per playing position. This makes it difficult for the reader to compare the findings. Further research needs to be conducted to resolve this conflicting dilemma.

2.7 CONCLUSION

A high injury incidence has been reported in matches compared to training due to the high demands and the nature of competition between teams; furthermore, studies have shown that most injuries are sustained in the lower extremities. The knee, ankle, thigh and lower leg are the most vulnerable sites of injury, and the common types of injuries are muscle strains (hamstrings, quadriceps, adductor and gastrocnemius) and ligament sprains (knee and ankle). Soccer injuries are multi-factorial, with their cause lying between both intrinsic risk factors and extrinsic mechanisms, which require a comprehensive evaluation of a player to be undertaken to determine the aetiology of the injury. Intrinsic risk factors such as an inadequately rehabilitated previous injury, increasing age, increased BMI, leg dominance; muscle asymmetry and weakness as well as hormonal fluctuations predispose female players to injury.

Inadequately rehabilitated prior injuries lead to re-injury due to weaknesses in the muscular and ligamentous structures that were not properly rehabilitated before returning to play. Older players showed a greater risk of injury compared to younger players due to the high volumes of training and competition and decreased recovery.

Increased BMI can lead to an increased risk of non-contact injuries as it places a lot of stress on the joints during landing, jumping, and pivoting actions in soccer. Similarly, females are at an increased risk of injury compared to male counterparts, especially on the ACL site, because of hormonal and neuromuscular factors. Sex hormone fluctuations during the menstrual cycle have been associated with an increased risk of ACL injury as they affect the ligaments' integrity and lead to knee joint laxity. These gender differences need to be taken into consideration when investigating risk factors contributing to ACL injuries as the mechanisms of injury may differ between males and females.

Leg dominance can also lead to muscle imbalance and weakness between the preferred and non-preferred limbs due to the high demands of soccer such as passing, shooting and crossing the ball. The risk of injury is increased in the weaker limb as it is placed under a lot of stress during demanding actions in soccer.

Conflicting results have been reported regarding an association between a deviant Q-angle and knee injuries in female athletes. One study did not indicate an association between the two, whereas two other studies postulated the contrary; this requires further investigation.

Injuries categorised according to playing positions indicated that midfielders and strikers have a higher incidence of injury than goalkeepers and defenders.

It is important to identify the predisposing intrinsic risk factors of lower limb injuries in female soccer players before one can attempt to prevent them. An understanding of the intrinsic risk factors by team physicians will assist in their planning and adapting of the teams' conditioning and training regimes, aiding in the prevention of lower limb injuries.

The above-mentioned risk factors have been identified in previous literature and play a role in lower limb injuries among female soccer players, and proper measures should therefore be taken to address and prevent them. Inadequate rehabilitation, which is a major factor in re-injuries, should be attended to by ensuring proper rehabilitation among players before they return to play. A desirable BMI should also be maintained by female soccer players to avoid non-contact ankle and knee injuries. Scientifically designed conditioning programmes should also be incorporated in training sessions to address muscle imbalances that could predispose the players to injuries. Finally, proprioception exercises should be part of training sessions, thereby addressing neuromuscular deficits that also play a role in a high number of ACL injuries in female soccer players. This knowledge can be applied by other university, local and professional teams as well as by national teams in the South African context.

The assessment and prescription of exercise programmes for teams are highly recommended as this will help prevent injuries and aid in returning injured players to the field. Pre-season screening will assist in identifying factors that need to be addressed such as muscle weakness and imbalances, weak proprioception, and a limited ROM/flexibility, among other risk factors, and this will ensure individualised programmes for players, allowing them to prevent and combat injuries. Scientific rehabilitation will furthermore assist in preventing re-injuries by ensuring that proper return-to-play guidelines are followed.

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CHAPTER 3

CHAPTER 3

Title page

Title:

THE PREVALENCE OF SOCCER INJURIES AMONG TRAINED FEMALE UNIVERSITY STUDENTS IN THEIR PREPARATION FOR THE USSA 2016 TOURNAMENT

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CHAPTER 3

THE PREVALENCE OF SOCCER INJURIES AMONG TRAINED FEMALE UNIVERSITY STUDENTS IN THEIR PREPARATION FOR THE USSA 2016 TOURNAMENT

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Abstract

Soccer has attracted many female players during the last 20 years; however, there is limited research that identifies the nature and mechanisms of injuries among female South African players. This study investigated the prevalence of soccer injuries among female university students during their preparation for the University Sports South Africa (USSA) 2016 tournament (October 2015 to March 2016). First team players (n=53) from the North-West University and Tshwane University of Technology consented to participate. All players completed an exercise and injury prevalence questionnaire that probed the nature and mechanisms of the injuries. Forty-three players sustained 63 injuries ($p<0,0001$), with 79,3% of the injuries being on the lower limbs ($p<0,001$) and 20,6% on the upper extremities. The ankle (28,6%) and knee (22,2%) were the most vulnerable sites of injury ($p<0,001$). Defenders and goalkeepers were found to be the positions that are most prone to injury ($p<0,05$). The overall injury prevalence for training and matches was 328,1 injuries sustained per 1000 playing hours.

Keywords: ankle sprains, female soccer injuries

CHAPTER 3

INTRODUCTION

Soccer is the most popular sport in the world and attracting 40 million female players (Tegnander, Olsen, Moholdt, Engebretsen & Blair, 2008; Pedrinelli, Rodrigues da Cunha Filho, Thiele & Kullak, 2013). Despite the popularity of female soccer there is a disparity between the research conducted on male and female players (Muller, Masenya, Ellapen & Swanepoel, 2016). Muller et al. (2016) reported that from 2007 to 2016 there were 11320 scientific papers published related to male soccer players and only 308 scientific papers related to female players. Furthermore, only seven papers reviewing soccer injuries among female players on the African continent were published from 2007 to 2016 compared to 13 papers reviewing male players' injuries (Muller et al. 2016).

Soccer injuries occur at various anatomical sites, including the head, shoulders, forearm, lower back, thigh, knee, tibia, fibula, ankle and foot (Valderrabanno, Barg, Paul, Pagenstert & Wiewiorski, 2014; Giza, Mithöfer, Farrell, Zarim & Gill, 2005). Lower limb musculoskeletal injuries occur often, ranging between 70% and 82% of all soccer injuries (Jacobson & Tegner, 2007, Mtshali, Stewart & Musenge, 2015; Muller et al., 2016). Among these lower limb injuries, the ankle (15,6% to 23,7%) and knee (15,5% to 16,5%) joints are the most prevalent female soccer injuries (Muller et al., 2016; Niyonsenga & Phillips, 2013; Richardson & Stubbe, 2015; Sentsomedi, 2015). Mechanisms of injury include rapid rotational movements, poor landing after jumping, illegal tackles by opponents, and uneven playing surfaces (Mtshali et al., 2015; Sentsomedi, 2015; Williams, Hume & Kara, 2011). The intrinsic predisposing mechanisms of female soccer injuries include a body mass index (BMI) greater than $23kg/m^2$ (Fousekis, Tsepis & Vagenas, 2012); asymmetrically stronger quadriceps than hamstring muscle group (Delextrat, Baker, Cohen & Clarke, 2013); the limited flexibility of rectus femoris, the hamstrings, the hip adductors, hip abductors and the calf muscles; inadequate rehabilitation of previous injuries (Ekstrand, Hägglund & Walden, 2011); and poor proprioception (Koenig & Puckree, 2015). There have been contrasting findings concerning the association between deviant quadriceps-angles and knee injuries (Mohammed, Useh & Mtshali, 2012; Stearns & Pollard, 2013). Mohammed et al. (2012) reported that there was no association between deviant quadriceps-angles and knee injuries, while both Stearns and Pollard (2013) and Nilstad, Andersen, Bahr, Holme and Steffen (2014) reported the contrary.

With the high prevalence of soccer injuries already mentioned in literature, the aim of this study was to profile the soccer injury prevalence during the six-month preparation period (October 2015 to March 2016) for the 2016 University Sports South Africa (USSA*)* Soccer tournament among university-level female soccer players. This study's findings are applicable to the South African university context and can also be applied to professional South African and African soccer teams.

METHODOLOGY

Ethical approval was obtained from the Health Research Ethical Committee of the Faculty of Health Sciences at North-West University (NWU 00055–15-A1–02). Fifty-three female players aged 18 to 25 years participated in this retrospective study with voluntary informed consent. The players were from the North-West University and Tshwane University of Technology. Each tertiary institution fielded 30 players in each squad. The number of participants in the study, represents 88,3% of this population (n=60=100%). This sample size meets the statistic rule of thumb defined by Terre-Blanche, Durrheim and Panter (2008) that requires a minimum 30% of the population to participate in a study in order to yield a power of significance.

This study used an exercise history and injury profile questionnaire adapted from Fuller, Ekstrand, Junge, Andersen, Bahr, Dvorak, Hägglund and McCrory (2006), Evans, Walker-Bone and Otter (2015), Ekstrand et al. (2011) and Ellapen, Dermatinis, Hughes, Hansen, and Van Heerden (2009). The questionnaire was completed two weeks before the USSA National Football Championships when data for the study was collected. The injury definition employed in the study reads: "Any physical complaint, which exceeded the structural and functional integrity that was sustained by a player during a soccer match or training, irrespective of the need for medical attention or time-loss from soccer" (Fuller et al., 2006; Evans et al., 2015, Ekstrand et al., 2011).

Players were requested to identify only soccer related injuries sustained during practice or matches in the six months period prior the National Football Championships and not injuries sustained from other sports and/or recreational activities. Players who had sustained injuries in other sport and/or recreational activities were excluded from the study.

The authors also applied Brukner & Khan's (2012) classification of injuries, which is "anatomical site of injury, symptom and predisposing mechanism of injury", to establish the prevalence of musculoskeletal injuries. Each player completed the self-report questionnaire, which was drafted in English; however, the researcher was also fluent in Setswana and IsiZulu and could respond in these languages to any queries posed by the players while they were completing the questionnaire. The inclusion criteria for participation in the study were:

(i) Female soccer players aged 18 to 25 years;

(ii) Registered students of North-West University or Tshwane University of Technology who were selected to represent the university's senior team in the USSA National Football Championships; and

(iii) Completed voluntary signed informed consent.

Players' body mass and stature were recorded. It should be noted that a limitation of the study is player recall bias, and it should also be noted that neither team had a medical doctor assigned to them in an official capacity to treat and record injuries sustained during the six-month tournament preparation period. Nevertheless, this is the first study to profile the prevalence of soccer injures among female players during their preparation for the USSA soccer tournament.

Statistical analyses

Statistica 13, (2018 TIBCO STATISTICA version 13,3) software system was used for data analysis. The data was analysed descriptively (mean, mode, frequency and percentages), inferentially applying chi-square, a t-test and Spearman rank correlation tests. The chi-square statistical test was employed to determine the significance of injury prevalence ($p<0,05$). The chi-square test is a statistical test that can be used to indicate the association between categorical variables (Thomas, Nelson & Silverman, 2005). A t-test was used to determine if there are differences between injured and non-injured players' BMI, flexibility and lower limb stability. Spearman rank correlation test is a non-parametric version of Pearson product-moment correlation test, which was used to measure the direction and strength of association between two ranked values or variables (Thomas et al., 2005). The significance level for Spearman rank correlation was set at 10% (r=0,1) and not 5% (r=0,05) because of the small sample size. The injury prevalence per 1000 playing hours was calculated as follows: The total number of injuries sustained/the number of documented player hours multiplied by 1000 hours (Ekstrand et al., 2011; Nilstad et al., 2014).

RESULTS

The results are presented in the following sequence: demographic characteristics of players, exercise history, sports injuries, prevalence of injuries in relation to playing position, mechanisms of injury, and severity of injury.

The statistical comparison of the injured and non-injured players' age, body mass, stature, and BMI showed negligible differences (p>0,05), indicating that these risk factors did not predispose the players to injury (Table 1).

Table 1. Demographics of injured (n=43) versus non-injured players (n=10)

Variables	Injured (n=43)	Non-injured (n=10)	P-value (t-test)	Spearman Rank Correlation
Body mass (kg)	55,5±7,2	57,4±7,2	0,6	-0,036
Stature (cm)	152,9±3,4	159,9±5,1	0,2	-0,030
BMI (kg/m^2)	21,5±2,1	22,3±1,1	0,5	-0,074
Age (years)	21,6±2,4	22,1±2,5	0,5	-0,106

The statistical comparison of the exercise history of the injured and non-injured players also proved to be negligible by the chi-squared test comparison and a weak correlation by the Spearman rank order correlation (Table 2). Both university teams had three soccer training sessions per week that last two hours per session.

Table 2. Exercise history of injured (n=43) versus non-injured players (n=10) (October 2015 to March 2016)

Variables	Injured (n=43)	Non-injured (n=10)	P-value (t-tests)	Spearman Rank Correlation
Number of years playing soccer	8,1±4,7	9,7±6,2	0,4	-0,064
Numbers of months practising/playing soccer per year	9,8±1,8	9,4±1,8	0,4	0,010
Number of years playing soccer for the university	2,8±2,1	3,1±2,0	0,7	-0,070

Sports injuries

The total number of players who reported injuries was 43 (81,1%) with 63 injuries (p<0,0001) in total (Table 3). The lower extremities sustained 79,3% of the injuries (50/63) (p<0,001) compared to 20,6% (13/63) in the upper extremities. The lower extremity injuries included the following anatomical sites: thigh, knee, lower leg, ankle and foot. The most vulnerable anatomical site for injury was the ankle (28,6%), followed by the knee (22,2%) (p<0,001).

Table 3. Prevalence of anatomical site of injury

Anatomical site	Number of Injuries (n=63)	Percentage (%)
Head/neck	1	1,6
Shoulder	3	4,8
Forearm	1	1,6
Hand	1	1,6
Elbow	0	0
Lower back	5	7,9
Hip	2	3,2
Thigh	7	11,1
Knee	14	22,2
Lower leg	8	12,6
Ankle	18	28,6
Foot	3	4,8
Sum	63	100

[1] Percentage was calculated using frequency tables to determine the cumulative percentage.

The total number of training sessions and matches in the six-month preparation period was 96, with each lasting 2 hours. Therefore, the total number of hours documented in six months was 192 hours (96 x 2 hours) and 63 injuries were sustained during this period. Therefore, the total number of injuries recorded per 1000 playing hours was 328,1 injuries as per the equation employed by Ekstrand et al. (2011) and Nilstad et al. (2014) (Table 4).

Table 4: Injuries per 1000 playing hours

Injury Characteristics	Players Characteristics
Number of injuries	63
Number of documented player hours (Oct 2015 to March 2016)	192 hours
Injuries per 1000 playing hours	328,1

The types of injuries sustained indicated that ligament sprains had the highest injury prevalence (43,3%), followed by muscle strains (32,0%), bone injuries (18,9%), tendon injuries (3,8%), and lastly, nerve injuries (1,9%) (Table 5). Most of the ligament sprains sustained were on the ankle (56,5%) and the knee (43,5%) joints. The thigh (41,2%) sustained most of the muscle strain injuries, followed by the lower back (23,5%), lower leg (23,5%), and hip (11,8%). The knee (40%) sustained most of the bone injuries, followed by the lower leg (20%), foot (20%), ankle (10%) and hand (10%). The total percentage of tendon injuries sustained were 3,8% mostly on the ankle and lower leg, and one nerve injury was sustained on the neck (1,9%) (Table 5).

Table 5. The types of injuries sustained (n=53)

Type of Injury	Number of Injuries (n=)	Percentage (%)
Ligaments	23	43,3
Muscle	17	32,0
Bone	10	18,9
Tendon	2	3,8
Nerve	1	1,9

[2] Percentage was calculated using frequency tables to determine the cumulative percentage

There were 51 causes of injury that included tackling by an opponent (31,4%; 16/51), rapid rotational movements (3,9%; 2/51), overuse injuries (31,4%; 16/51), re-injury (17,6%; 9/51) and poor landing technique (15,7%; 8/51). Most of the injuries that resulted from tackling by an opponent were recorded on the knee joint (13,7%), followed by the ankle (9,8%), lower leg (3,9%), foot (2,0%) and thigh (2,0%). The injuries that resulted from rapid rotational movements were sustained on the hip (1,9%) and lower back (1,9%). The overuse injuries were sustained mostly on the lower leg (7,8%) and thigh (7,8%), followed by the lower back (5,9%), shoulder (3,9%), and lastly, the hip, hand and knee (1,9% each). The injuries that resulted from poor landing technique were sustained mostly on the ankle (11,8%) and knee (3,9%). The most re-occurring injuries were sustained on the ankle (9,8%), knee (5,9%) and thigh (1,9%).

Forty-three players playing various positions sustained injuries, indicating that all playing positions are vulnerable to injury (Table 6). Nevertheless, the most vulnerable playing positions were the defender (100%) and goal keeper (100%) positions, followed by the striker (77,8%) and mid-field playing positions (60%) (Table 6). All the defenders and goal keepers in both teams sustained injuries during their preparations for the USSA football championships.

Table 6. Comparative review of the number of injuries sustained per playing position

Playing Position	Injured (n=43)	Non-injured (n=10)	P-value (t-test)	Spearman Rank Correlation
Strikers	14 (77,8%)	4 (22,3%)	0,01	-0,061
Midfielders	9 (60%)	6 (40%)	0,4	-0,339
Defenders	15 (100%)	0 (0%)	0,0001	0,302
Goalkeepers	5 (100%)	0 (0%)	0,02	0,155

The most injured anatomical site for strikers was the ankle (12,7%), knee (7,9%), thigh (3,2%), shoulder (3,2%), lower leg (3,2%), and lastly, the lower back (1,6%) (Table 7). The midfielders sustained most of their injuries on the knee (7,9%), ankle (4,8%), lower back (3,2%) and thigh (3,2%), and lastly, the neck, shoulder, and lower leg (1,6% each). The defenders sustained most of their injuries on the ankle (9,5%), knee (6,3%), lower leg (4,8%), thigh (3,2%), hip (3,2%), and the foot and lower back (1,6% each). The goalkeepers sustained most of their injuries on the lower leg and foot (3,2% each); and the forearm, hand, lower back, thigh and ankle (1,6% each). A strong correlation was found between defenders and risk of injury (r=0,302) and the strikers (r=-0,061), midfielders (r=0,339) and goalkeepers (r=0,155) indicated a weak correlation.

Table 7. Prevalence of anatomical site of injury in relation to playing position

Anatomical Site	Strikers (n=14)	Midfielders (n=9)	Defenders (n=15)	Goal Keepers (n=5)
Head/neck	0	1	0	0
Shoulder	2	1	0	0
Forearm	0	0	0	1
Hand	0	0	0	1

Lower back	1	2	1	1
Hip	0	0	2	0
Thigh	2	2	2	1
Knee	5	5	4	0
Lower leg	2	1	3	2
Ankle	8	3	6	1
Foot	0	0	1	2
Sum	20	15	19	9

Fifty-two (98,1%) of the fifty-three players were right dominant, and only one (1,9%) was left dominant with no injury recorded on the left dominant leg. Forty-four (69,8%) injuries were recorded on the right side and 19 (30,1%) on the left side. Fifteen (34,8%) players reported multiple injuries.

Eighteen players reported a time-loss from soccer that varied from 1 day (7,5%), 2 days (3,8%), 3 days (1,9%), 4 days (1,9%), 5 days (1,9%), 7 days (1,9%), 14 days (3,8%), 21 days (1,9%), 31 days (1,9%), 62 days (1,9%) and 186 days (5,7%); whereas 25 players (47,1%) reported that the injuries did not prevent them from participating in soccer training or matches. Ten players (18,8%) were not injured.

The 28 of injured players who continued playing through the pain was 65,1%. Of these players only 38% reported that the pain increased with play.

DISCUSSION

The discussion will describe the nature and the mechanisms of injuries. Intrinsic predisposing risk factors (age, body mass, stature and BMI) and training exercise history did not differ significantly between the injured and non-injured players, indicating that these factors did not predispose players to injury. Weak correlations were found between age, body mass, stature and BMI of the non-injured versus the injured players.

Injuries

The injuries will be discussed in terms of the categorisation of the anatomical sites of injury, mechanism of injury, player positions, dominant vs non-dominant side and severity of injuries.

Anatomical sites of injury and type of injury

The injury prevalence (training and match hours) indicated a total of 328,1 injuries per 1000 playing hours. The findings from the current study differed from those of Nilstad et al. (2014) and Ekstrand et al. (2011), who reported an overall incidence of 3,8 injuries and 8,0 injuries per 1000 hours, respectively. The current study’s findings possibly were higher than those of Nilstad et al. (2014) and Ekstrand et al. (2011) because of the limited number of hours that the cohort played and trained. Nilstad et al. (2014) reported 44,831 exposure hours in one soccer season and Ekstrand et al. (2011) reported 566000 exposure hours in seven soccer seasons, whereas the current study only reported 192 exposure hours in the six-month preparation period for the USSA National Football Championships. Mtshali et al. (2015) reported 52,9 injuries per 1000 playing hours in female soccer players who participated in the USSA soccer tournament. The difference between that study and the current study is that Mtshali et al. (2015) recorded the injury incidence of matches as they happened during the tournament, whereas the current study recorded the injury prevalence in the six-month preparation period for the USSA tournament.

The lower limb sustained the more injuries than the upper extremities, which is consistent with previous findings (Tegnander et al., 2008; Cross, Gurka, Saliba, Conaway & Hertel, 2013; Mtshali et al., 2015; Niyonsenga & Phillips, 2013; Muller et al., 2016; Sentsomedi & Puckree, 2016). The most vulnerable anatomical site of injury was the ankle, followed by knee, which is consistent with findings of Junge (2015) and Niyonsenga and Phillips (2013). This result differs from Mtshali et al. (2015) and Sentsomedi and Puckree's (2016) findings who identified the knee as the most vulnerable site among male and female players. Mtshali et al. (2015) reported that the high prevalence of lower extremity injuries, especially to the ankle and knee, was attributed to movement patterns such as pivoting, jumping and landing, which are characteristics of soccer. Mtshali et al.'s (2015) findings are very applicable to this study as their findings are based on a similar female cohort participating in the same USSA tournament, but in different years.

The current study reported ligament sprains as the most common type of injury, followed by muscle strains, which concurs with findings from Mtshali et al. (2015) and Steffen, Myklebust, Andersen, Holme and Bahr (2008). The study differs from findings by Giza et al. (2005) and Sentsomedi and Puckree (2016) who reported a high occurrence of muscle strains in female soccer players. The high prevalence of ligament sprains and muscle strains can be attributed to movement patterns in soccer that require quick changes in direction, landing from a jump, high volume of kicking and passing, explosive sprinting and deceleration, which places joints, muscles and ligaments under a lot of stress (Ernlund & De Almeida Viera, 2017; Niyonsenga & Phillips, 2013, Stanley, Kerr, Dompier & Padua, 2016; Troyer & Dunn, 2014). The current study's finding is supported by other African continental literature (Jellad, Salah, Bouaziz, Boudoklane & Salah, 2011 (Tunisia); Niyonsenga & Phillips, 2013 (Rwanda); Lislevand, Andersen, Junge, Dvorak & Steffen, 2013 (Kenya).

The mechanisms of injury

The mechanisms producing injuries included tackling by an opponent/foul play, rapid rotational movements, poor landing after jumping, overuse, and re-occuring injuries. Each of these specific mechanisms of injuries will be further elaborated on.

Tackling an opponent/foul play was the main cause of injury, with the knee joint being most vulnerable, which concurs with previous findings from Sentsomedi and Puckree (2016) and Mtshali et al. (2015).

The rapid rotational movements that are evident in soccer were reported to have caused injuries in the hip joint and the back. These movements happen when a player must suddenly change direction in pursuit of the ball (Karlsson, Dahan, Magnusson, Nyquist & Rosengren, 2014).

The players also reported poor landing after jumping as a common mechanism that mostly leads to ankle injuries. When the players initiate a jumping movement the ankle is maximally dorsi-flexed and moves into plantar flexion (Lai, Schache, Brown & Pandy, 2016); plantar flexion is maintained while the player is in the air, which again places the talar dome in an open-packed position; upon landing, the players' toes touch the ground first, eventually loading all the weight onto the lateral aspect of the heel as is the common scenario in the swing phase of the gait cycle (Mansfield & Neumann, 2009; Stuelecken, Greene, Smith & Van Wanseele, 2013; Hall, 2015). As a result, the ankle goes into supination, a combination of inversion, adduction and plantar flexion replicating the pathomechanism of an inversion ankle sprain (Mansfield & Neumann, 2009).

Overuse injuries were most sustained on the lower leg, which concurs with Steffen et al.'s (2008) findings. Mahieu, Witvrouw, Stevens, Van Tiggelen and Roget (2006) reported that overuse injuries occurred due to abnormal repetitive training load and high training intensity without adequate recovery from these excessive training regimes. Proper recovery, minimising overtraining and progressive increase in intensity are crucial factors to be considered to allow the body structures to adapt to new activity without abnormal overloading and preventing overuse injuries (Mahieu et al. 2006). Re-occurring injuries were sustained mostly on the ankle and knee joints; a finding that is consistent with that of Engebretsen, Myklebust, Holme, Engebretsen and Bahr (2010) and Hägglund, Walden and Ekstrand (2012). Injuries that are not adequately rehabilitated increase the risk of re-injury because of instabilities, decreased strength, and affected range of motion/flexibility that resulted from the initial injury (Eirale, Farooq, Smiley, Tol & Chalabi, 2013).

Player position

The defenders and goal keepers were most susceptible to injury. This finding differs from that of Giza et al. (2005), Tegnander et al. (2008) and Niyonsenga and Phillips (2013), who cited midfielder as the player position more prone to injury. Although Mtshali, Mbambo-Kekana, Stewart and Musenge (2009) did not find defender and goal keeper to be the most vulnerable playing position, they found injuries to the same anatomical sites, which are the lower leg, ankle and foot, when analysing these specific positions in regard to injury. Mtshali et al. (2009) reported that the high prevalence of lower leg, ankle and foot injuries were due to the fact that these anatomical sites make the initial contact with the ball during soccer.

Dominant vs. non-dominant side

Most players were right dominant and have a higher number of injuries on their dominant side than on their non-dominant side; this finding concurs with that of Ekstrand and Gillquist (1983) and Hawkins and Fuller (1999). Hägglund et al. (2012) reported that the high prevalence of injuries on the dominant leg is because the dominant leg is used more often in passing, kicking and shooting, thereby placing a substantial amount of stress on the muscles and joints.

Severity of injury

The severity of injury was classified according to time-loss from participating in soccer practice or matches (186 days). A longer absence indicated a more severe injury (Ekstrand, Walden & Hägglund, 2004). The current study concurs with Nilstad et al.'s (2014) finding that serious injuries lead to a greater leave of absence from practice and play.

CONCLUSION

A high prevalence of lower limb injuries among the university-level female soccer players was reported, with the ankle and knee as the most vulnerable anatomical sites of injuries. An overall injury prevalence of 328,1 injuries per 1000 hours was reported in the six-month preparation period for the 2016 USSA National Football Championships. Tackling an opponent was the main contributor to injuries. Defenders and goal keepers reported the highest percentage of injuries. Injured players' dominant side sustained more injuries than their non-dominant side. The longest stay of absence from participation was six months (186 days), indicating the seriousness of the injury.

In an attempt to reduce the high lower limb injury status, it is recommended that all players and coaching staff use the services of a complete medical team to prevent, effectively treat and rehabilitate all injuries. Further sports injury workshops should be conducted to educate players and coaching staff on the role of each member of the medical multidisciplinary team.

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CHAPTER 4

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Title page

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SELECTED INTRINSIC RISK FACTORS ASSOCIATED WITH LOWER LIMB INJURIES AMONG TRAINED FEMALE SOCCER UNIVERSITY PLAYERS IN SOUTH AFRICA

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SELECTED INTRINSIC RISK FACTORS ASSOCIATED WITH LOWER LIMB INJURIES AMONG TRAINED FEMALE SOCCER UNIVERSITY PLAYERS IN SOUTH AFRICA

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Abstract

Globally, female soccer participation has increased by 40 million participants over the past two decades. While a high prevalence of lower extremity injuries among female soccer players has been reported, limited studies have investigated the intrinsic risk factors associated with the injuries. To better understand this association, 53 university-level female soccer players from the North-West University and Tshwane University of Technology female football teams voluntary participated in this descriptive observational study. The selected intrinsic risk factors assessed were hamstrings, rectus femoris, ankle plantarflexors and dorsiflexors, ankle evertors and invertors flexibility as well as lower limb stability. Forty-three players were injured, reporting 63 injuries ($p<0,0001$). The most vulnerable anatomical sites of injury were the ankle (28,6%) and knee (22,2%) ($p<0,001$). Decreased flexibility of the ankle evertors ($r=0,251$), plantarflexors ($p<0,071$) and lower limb instability were significantly associated with lower limb injuries. It is recommended that coaches and medical staff assess ankle ROM and lower limb stability to determine any deficiencies that can then be addressed in training programmes to prevent injuries.

Keywords: female players, soccer, intrinsic risk factors, lower limb injuries

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INTRODUCTION

Participation in sport rewards the athlete and/or player with better quality of life through improved physiological and psychological health as well as improved well-being (Van Beijsterveldt, Van de Port, Krist, Schimkli, Stubbe, Fredericks & Backx, 2012). Unfortunately, participation in sport is associated with risk of injury (Van Beijsterveldt et al., 2012), and the game of soccer is no exception. Soccer has been associated with a high injury incidence, primarily to the lower extremities (Van Beijsterveldt et al., 2012; Del Coso, Herrero & Salinero, 2016), due in no small part to the sports' competitive nature, complex movement patterns and game dynamics (Van Beijsterveldt et al., 2012; Sentsomedi & Puckree, 2016).

Female soccer has steadily grown in popularity over the years with approximately 40 million players registered with the *Federation Internationale de Football Association* (FIFA) (Tegnander, Olsen, Moholdt, Engebretsen & Bahr, 2008; Mufty, Bollars, Vanlommel, Van Crombrugge, Corten & Bellemans, 2015). This popularity has led to research measuring both baseline sport performance and ergogenic strategies to enhance performance, as well as investigations about the nature of sport injuries.

There have being 34 papers investigating soccer injuries among female players (Muller, Masenya, Ellapen & Swanepoel, 2016). Most of this soccer injury literature (82,3%) focus on descriptive injury profiles, including information such as the number of players injured, their injury rate, the common injuries, the type of injuries and the most vulnerable playing position. Only six papers (17,7%) reviewed selected intrinsic risk factors associated with soccer injuries.

Intrinsic risk factors are internal mechanisms in the body that predisposes the person to injury (Valderrabanno, Barg, Paul, Pagenstert & Wiewiorski, 2014). Intrinsic risk factors can be modifiable and non-modifiable. Modifiable intrinsic risk factors are those that can be changed, which include flexibility, joint stability, proprioception, muscle weakness, and body mass (Prentice, 2011). Non-modifiable risk factors cannot be changed as they are naturally embedded in one's anatomical and biomechanical structures and they include age, gender, injury history, and anatomical/biomechanical structures such as quadriceps-angle (Q-angle) and foot morphology (Prentice, 2011).

Some intrinsic risk factors are associated with overuse injuries in soccer as a result of movement patterns or activities that characterise the sport (Kaufman, Brodine, Shaffer, Johnson & Cullison, 1999). Running is one of the characteristics of soccer that involves repetitive loading on the lower extremities, where majority of injuries occur due to the impact between the foot and the surface (Kaufman et al., 1999). The repetitive loading produces continuous impact on the lower extremities and may lead to overuse or chronic injuries (Yang, Tibbettes, Covassin, Chen, Nayar & Heiden, 2012). Although most soccer injuries are acute in nature, such as ligament sprains and muscle strains due to body contact and high-speed activities, overuse or chronic injuries also occur as a result of excessive training load on a joint or tissue together with limited recovery time (Yang et al., 2012; Krivickas, 1997). These types of injuries are associated with a gradual increase in the severity of symptoms, which are sometimes ignored or only recognised once the seriousness of the injury is clear or as the injury progressively worsens (Schuer & Dietrich, 1997; Yang et al., 2012). Examples of lower extremity overuse injuries in soccer include bursitis, stress fractures, patellofemoral pain syndrome, patella tendinitis and quadriceps tendinitis (Krivickas, 1997; Yang et al., 2012). Selected intrinsic risk factors investigated include body mass index (BMI) (Fousekis, Tsepis & Vagenas, 2012; Nilstad, Andersen, Bahr, Holme & Steffen, 2014; Hägglund & Walden, 2016), proprioception (Butler, Southers, Gorman, Kiesel & Plisky, 2012; Bhat & Moiz, 2013), Q-angle (Mohammed, Useh & Mtshali , 2012), and flexibility (Bradley & Portas, 2007; Ibrahim, Murrell & Knapman, 2007; Henderson, Barnes & Portas, 2010).

This paper increases the body of knowledge regarding the selected intrinsic risk factors (ankle ROM, hamstrings and rectus femoris flexibility and lower limb proprioception) associated with lower limb injuries among female soccer players. The findings of this paper can be used during the prescription of both preventive and rehabilitative exercise programmes to curtail the incidence of lower limb injuries among female soccer players.

METHODOLOGY

Ethical approval for the study was obtained from the Health Research Ethical Committee of the Faculty of Health Sciences at the North-West University (NWU 00055–15-A1–02). The sample was comprised of 53 university-level female soccer players aged 18 to 25 years from the North-West University and Tshwane University of Technology soccer first teams. The players voluntarily participated in the study and gave informed consent. A briefing session was held with the players, coaches and managers to explain the procedures of the study in detail.

Injury prevalence over a six-month period prior to the 2016 University Sports South Africa (USSA) National Football Championships was recorded through a validated questionnaire adapted from Fuller, Ekstrand, Junge, Andersen, Bahr, Dvorak, Hägglund and McCrory (2006), Evans, Walker-Bone and Otter (2015), Ekstrand, Hägglund and Walden (2011), and Ellapen, Dermatinis, Hughes, Hansen, and Van Heerden (2009). The Fuller et al. (2006) soccer injury definition was used: “Any physical compliant, which exceeded the structural and functional integrity that was sustained by a player during a soccer match or practise session (training), irrespective of the need for medical attention or time-loss from soccer activities”. The questionnaire was drafted in English and the researcher was available to answer any questions by players in Setswana and IsiZulu (Masenya, Ellapen, Pienaar & Sparks, 2018).

The inclusion criteria for the participation was:

- Participants must be registered students at North-West University or Tshwane University of Technology.
- Participant had to be selected to be in the university’s senior team that participated at the USSA National Football Championships 2016.
- Participants must be female.
- Participant’s age must fall within 18 to 25 years.
- Participation was voluntary and an informed consent form had to be signed.

The selected intrinsic risk factors measured were hamstring and rectus femoris muscles’ flexibility, ankle eversion and inversion ROM, ankle dorsiflexion and plantarflexion ROM, Q-angle, and lower limb stability.

Hamstrings flexibility

The hamstring muscle group's flexibility was measured using a Baseline goniometer (Fabrication Enterprises Inc., U.S.A) following the protocol by Schultz, Houglum and Perrin (2016) and using a straight leg raise test. The player was instructed to lay supine on the plinth with their arms crossed over their chest, knees extended and pelvis parallel against the plinth. The axis of rotation of the goniometer was centralised on the greater trochanter, with the stationary arm positioned parallel to the midline of the trunk, while the movable arm positioned along the long axis of the femur. The player was requested to actively flex the hip of the ipsilateral femur with their knee joint in extension and foot relaxed without flexing the contralateral hip. The player was furthermore requested to keep their pelvis against the plinth for the duration of the test. The player was given two trials and the average of the two trials was recorded. The measurements were recorded in degrees.

Rectus femoris flexibility

The rectus femoris muscle's flexibility was measured according to the protocol defined by Schultz et al. (2016). A Baseline goniometer (Fabrication Enterprises Inc., U.S.A) was used for measurement. The player was instructed to lay supine on the plinth with their knees flexed over the edge of the plinth. The player was instructed to flex one knee, bringing the limb to the chest and holding it in that position, while maintaining the pelvis against the plinth. The axis of rotation of the goniometer was positioned over the lateral epicondyle of the ipsilateral knee, with the stationary arm in alignment with the long axis of the femur and the movable arm aligned with the lateral aspect of the tibia. The player was given two trials and the average of the two trials was recorded. The measurements were recorded in degrees.

Ankle eversion (flexibility) ROM

Ankle eversion was measured according to the protocol defined by Menadue, Raymond, Kilbreath, Refshange and Adams (2006) using a Baseline goniometer (Fabrication Enterprises Inc., U.S.A). The player was instructed to lay supine on the plinth, feet hanging off the plinth in a comfortable and relaxed position. The anterior aspect of the ankle between the medial and lateral malleoli, the midline on the anterior tibia using the crest of tibia as reference point, and the longitudinal midline on the anterior surface of the second metatarsal were marked. The axis of rotation of the goniometer was placed on the midpoint of the anterior aspect of the ankle; the stationary arm was placed on the midline of the anterior tibia, while the movable arm was aligned with the longitudinal midline of the anterior surface of the second metatarsal. The player was requested to maximally evert their ankle. The unit of measure was degrees. Players were given two trials and the average of the two trials was recorded.

Ankle inversion (flexibility) ROM

Ankle inversion was recorded using a Baseline goniometer (Fabrication Enterprises Inc., U.S.A) according to Menadue et al.'s (2006) protocol. The player lay supine on the plinth with their feet hanging off the plinth in a relaxed position. The anterior aspect of the ankle between the medial and lateral malleoli, the midline on the anterior tibia using the crest of tibia as reference point as well as the longitudinal midline on the anterior surface of the second metatarsal were marked. The player was requested to maximally invert their ankle (Menadue et al., 2006). The unit of measure was degrees. Players were given two trials and the average of the two trials was recorded.

Ankle dorsiflexion (flexibility) ROM

Ankle dorsiflexion was measured using the protocol by Schultz et al. (2016), using a Baseline goniometer (Fabrication Enterprises Inc., U.S.A). The player was in a supine position on the plinth, knee flexed at 30° and gastrocnemius muscles in a relaxed position. The axis of rotation of the goniometer was centred over the lateral malleolus and the arms aligned with the fibula shaft and the head of the fifth metatarsal. The goniometer's neutral position reading was 90° and the player was requested to actively dorsiflex the ankle to the limit of motion. The measurements were recorded in degrees. Players were given two trials and the average of the two trials was recorded.

Ankle plantarflexion(flexibility) ROM

Ankle plantarflexion was measured with the player in supine position, knee flexed at 30° and gastrocnemius muscles in a relaxed position, according to the protocol by Schultz et al. (2016). A Baseline goniometer (Fabrication Enterprises Inc., U.S.A) was used for the measurement. The goniometer's axis of rotation was centred over the lateral malleolus and the arms aligned with the fibula shaft and the head of the fifth metatarsal. The goniometer's neutral position reading was at 90° and the player was requested to actively plantarflex the ankle to the limit of motion. Two trials were given to the players and the average of trials was recorded in degrees.

Quadriceps-angle (Q-angle)

Quadriceps-angle was measured using a Baseline goniometer (Fabrication Enterprises Inc., U.S.A) with the player in supine position, knee extended and the hip and foot in neutral position (Schultz et al., 2016). A line was drawn from the anterior superior iliac spine to the midpoint of the patella. Another line was drawn from the tibial tuberosity to the midpoint of the patella. The axis of rotation of the goniometer was on the midpoint of the patella, the stationary arm was in line with the anterior superior iliac spine, and the movable arm in line with the tibial tuberosity. The angle between the two lines was measured twice and the average measurement was taken. The measurements were recorded in degrees.

Lower limb stability

Lower limb proprioception/stability was measured according to the protocol defined by Finn, Alvarez, Jett, Axtell and Kemler (1999). A Biodex Stability System static and dynamic (Biodex System 2) (Biodex Medical Systems, Inc.) was used and the 'athlete single leg stability test' protocol was administered. In this study, lower limb stability is synonymous with the concept of lower limb proprioception.

The player was requested to stand with her preferred leg on the Biodex Stability System, making sure that the supporting knee was flexed at 10° and maintained an upright position. The player was instructed to maintain a comfortable knee angle with the unsupported leg and keep their hands at their sides during testing (Finn et al., 1999). The stability platform was unlocked to allow movement while the player maintained the same position. The player adjusted the position of the supporting foot until a stable platform was established. The player was instructed to maintain the foot position for testing while the stability platform was locked.

The testing protocol consisted of a one-minute test using the eight resistances provided by the Biodex Stability System. The effects of fatigue and leaning were reduced by using a single leg, and the player could touch down briefly with the toe of the opposite foot or held onto the handrails to regain her balance if it was lost. The values for the anterior posterior index, medial lateral index and overall stability index were recorded on the left and right legs. The player had two trials and the better of the two trials was recorded.

Statistical analyses

Statistica 13, 2018 TIBCO STATISTICA version 13,3 software system was used for data analyses. The data was analysed descriptively (mean, mode, frequency and percentages), inferentially applying an independent t-test and Spearman rank correlation tests. An independent t-test was used to determine if there is a difference between injured and non-injured players' BMI, flexibility, Q-angle and lower limb stability (Thomas, Nelson & Silverman, 2005). Spearman rank correlation test, which is a non-parametric version of Pearson product-moment correlation test, was used to measure the direction and strength of association between two ranked values/variables (Thomas et al., 2005). The significance level for Spearman rank correlation was set at 10% (r=0,1) and not 5% (r=0,05) because of the small sample size. The Cohen's effect size was also used to determine practical significance (Cohen, 1988). The effect size was used to determine whether a relationship between two standard variables is significant (Steyn, 2002). The formula used was: d=difference between two means divided by estimate for deviation (Ellis & Steyn, 2003). The guidelines for interpretation of effect size are: Small size: d=0, 2; medium size: d=0, 5; and large size: d=0,8 (Ellis & Steyn, 2003).

RESULTS

The results will be presented in the following sequence: the demographics of players (Table 1); and the selected intrinsic risk factors associated with lower limb injury including ankle inversion and eversion, ankle dorsiflexion and plantarflexion, Q-angle, rectus femoris and hamstring muscle groups' flexibility as well as lower limb stability (Table 2).

The statistical comparison of the injured and non-inured players' age, body mass, stature and BMI indicated negligible difference (p>0,05), indicating that these intrinsic risk factors did not predispose players to injury (Table 1) (Masenya et al., 2018). A weak correlation was found between injured and non-injured players' body mass, stature, BMI and age (Table 1).

Table 1. Demographics of injured (n=43) versus non-injured players (n=10)

Variables	Injured (n=43)	Non-injured (n=10)	P-value (t-test)	Spearman Rank Correlation
Body mass (kg)	55,5±7,2	57,4±7,2	0,6	-0,036
Stature (cm)	152,9±3,4	159,9±5,1	0,2	-0,030
BMI (kg/m^2)	21,5±2,1	22,3±1,1	0,5	-0,074
Age (years)	21,6±2,4	22,1±2,5	0,5	-0,106

The injured players' ankle dorsiflexion ROM significantly differed from that of the non-injured players (p=0,07 and d=0,28) (Table 2). Similarly, the injured players' lower limb's medial lateral stability index in the frontal plane significantly differed from that of the non-injured players (p>0,001, d=0,75) (Table 2). A strong correlation was found between the injured players' ankle inversion ROM and the ankle injuries sustained (r=0,251), suggesting that ankle inversion ROM predispose these players to injury.

The other risk factors (ankle eversion ROM, ankle plantarflexion ROM, hamstring and rectus femoris flexibility, and Q-angle) of injured and non-injured players proved to be negligible by the dependent t-test, effect sizes and weak correlation by the Spearman rank order correlation; therefore, indicating that they did not predispose players to risk of injury (Table 2).

Table 2: The intrinsic risk factors of injured (n=43) versus non-injured (n=10)

Variable (unit of measure)	Means		Independent t-test (p-value)	Cohan's effect size (d-values)	Spearman Rank order correlations	
	Injured (n=43)	Non-injured (n=10)			Injured (n=43)	Non-injured (n=10)
Hamstring flexibility (°)	84,48	84,39	0,936	0,01	-0,123	-0,091
Rectus femoris flexibility (°)	55,65	55,2	0,611	0,07	0,078	-0,028
Ankle eversion ROM (°)	19,16	18,20	0,395	0,13	0,211	0,165
Ankle inversion ROM (°)	26,72	27,16	0,642	0,07	0,251*	0,208
Ankle dorsiflexion ROM (°)	15,95	16,95	0,071*	0,28*	-0,142	-0,143
Ankle plantarflexion ROM (°)	58,48	58,34	0,875	0,02	-0,069	-0,052
Q-angle (°)	14,39	13,20	0,201	0,19	-0,210	-0,125
Lower limb stability (overall index)	1,45	1,61	0,311	0,15	0,026	0,197
Lower limb stability (anterior posterior index)	1,20	1,27	0,689	0,05	-0,021	0,075
Lower limb stability (medial lateral index)	0,65	0,89	0,001*	0,75*	0,041	0,194

*indicate significant findings

DISCUSSION

The discussion will follow a presentation of the selected intrinsic factors associated with lower limb soccer injuries.

A strong correlation between reduced ankle inversion ROM and ankle injury was found. This finding suggests that limited ankle inversion ROM may be related to ankle inversion injury. Static lateral ligaments and dynamic evertor muscle restraints are responsible for controlling the amount of ankle inversion. A popular pathomechanical predisposition is lax lateral ligaments and weak evertor muscles, which increase ankle inversion ROM and instability that may result in ankle inversion injury (Mansfield & Neumann, 2014). Also, poor lateral ligament and evertor muscle flexibility of rigid inflexible ankle joints may not be capable of allowing adequate ankle inversion because of excessive tightness that can rupture and also lead to inversion ankle injury (Mansfield & Neumann, 2014).

A strong correlation between the limited ankle inversion ROM among the injured players was found. This finding indicates greater medial displacement in the frontal plane as well as limited lateral ligament and evertor muscle group restraint. Hypomobile ankle flexibility due to inflexible surrounding ligaments and musculature has being associated with occurrence of ankle injuries, due to their inability to accommodate dynamic rear foot varus stress (Schultz et al., 2016; Weaver & Relph, 2017).

The injured players' ankle dorsiflexion ROM significantly differed from the non-injury players', which concurs with Willems, Witvrouw, Delbaere, Mahieu, De Bourdeaudhuij and De Clercq, (2005) who reported that decreased ankle dorsiflexion ROM in physically active male subjects increased their risk of ankle sprains. This finding suggested that limited flexibility in gastrocnemius muscles may place the foot in greater plantarflexion and predispose the ankle to risk of inversion sprains, especially in sports tasks such as pivoting and landing from a jump, all which characterise soccer (Willems et al., 2005).

The injured players' lower limb medial lateral stability index in the frontal plane significantly differed from that of the non-injured players, which supports the findings of Tropp, Ekstrand and Gillquist, (1984). Tropp et al. (1984) reported that poor postural control or inability to balance (proprioception) in the frontal plane contributes to the risk of ankle sprains. This study's findings is also supported by Wang, Chen, Shiang, Jan and Lin (2006), who reported that the inability to maintain medial lateral balance (proprioception) or stability contributes to inversion ankle sprains.

It is recommended that further research be conducted to verify these findings because of the paucity of literature examining the selected intrinsic predisposing risk factors and soccer injuries among females.

CONCLUSION

Female players' decreased ankle inversion and dorsiflexion ROM and decreased lower limb stability of the medial lateral index were associated with lower limb soccer injuries. It is therefore recommended that pre-season ROM measurements of ankle inversion and dorsiflexion and lower limb stability be conducted to address any discrepancies or restrictions that may hamper the players' performance and predispose them to lower limb injuries. It is intended that the findings of this study will encourage coaching staff and medical support staff to also include flexibility/ROM and lower limb stability exercises in their training programmes for the benefit of players and the prevention of lower-limb injuries in soccer.

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CHAPTER 5

CHAPTER 5

SUMMARY, CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

5.1 SUMMARY

This chapter will consolidate the findings of each preceding chapter to give an overview of the main findings of the study. The literature review identified few injury studies that focused on female soccer players compared to the large volume of studies that focused on their male counterparts. Subsequently, fewer studies were found on female players' associated intrinsic risk factors to injury, such as body mass index, quadriceps-angle and hormonal fluctuations, which is associated with lower limb injuries in female players. The South African studies conducted on female university soccer players did not do a comparative review of injured versus non-injured players' ankle and knee flexibility. This indicated a gap in the empirical literature of selected intrinsic risk factors associated with lower limb injuries and motivated this study. A further objective of this chapter is to identify the limitations of this study and make recommendations for prospective empirical investigations.

The purpose of this study was, firstly, to determine the injury prevalence among university-level female soccer players and, secondly, to determine whether selected intrinsic risk factors are associated with lower limb injuries among university-level female soccer players.

Chapter One provided a summary of the problem statement and indicated the research questions, objectives, hypotheses, the conceptual framework of the study, and then described the structure of the investigation. This cross-sectional descriptive observational study was conducted on two universities' first team female soccer players (North-West University and Tshwane University of Technology) during preparations for the University Sports South Africa (USSA) 2016 tournament.

Chapter Two, entitled "Prevalence and incidence of soccer injuries among female players", provided a literature review of common soccer injuries. The prevalence and incidence of soccer injuries, vulnerable anatomical sites, intrinsic risk factors associated with lower limb injuries as well as the most vulnerable playing positions were discussed. The literature review that was presented encompassed the subject of female soccer players, the nature of their injuries, the predisposing intrinsic risk factors, and vulnerable playing positions. Overall, the literature indicated that a plethora of knee and ankle injuries were sustained by female soccer players and emphasised the need for a prevention strategy to curb these injuries.

The literature review first considered the prevalence and then the incidence of injury as reported in studies conducted. A high prevalence of injury was found on the lower extremity, and the ankle, knee and thigh are cited as the most vulnerable anatomical sites of injury. A high injury incidence was also reported during competition, as compared to training. The higher prevalence and incidence of these soccer injuries was attributed to the high physical demands and complex movement patterns of soccer. The most common type of soccer injuries among female players were also discussed and found to be muscle strains and ligament sprains. The most frequently reported ligament sprains occurred at the ankle and knee joints. The common mechanisms for both ankle and knee joint ligament injuries included poor landing from a jump and rotational movements or pivoting. With all the mentioned studies in previous literature, studies on female soccer players are still fewer than studies on male players. This indicates a gap in literature about the nature of female soccer injuries and further investigation is necessary.

The research questions posed were addressed in the third and fourth chapters: Firstly, what is the injury prevalence among university-level female soccer players? Secondly, what selected intrinsic risk factors are associated with lower limb injuries among university-level female soccer players?

Chapter Three comprised the first article, entitled "The prevalence of soccer injuries among trained female university students in their preparation for the USSA 2016 tournament" and was compiled in accordance with the guidelines of the *African Journal for Physical Activity and Health Sciences*. The purpose of this article was to determine the prevalence of soccer injuries that female players incurred in their preparation for the USSA 2016 tournament (October 2015 to March 2016). An injury history questionnaire was used to gather information about injuries incurred during the past six months. The most important findings of this study were analysed descriptively and inferentially, which indicated high lower limb injury prevalence compared to the upper extremity injuries, which was consistent with previous literature. The ankle (28,6%) and knee (22,2%) were the most injured anatomical sites of injury ($p<0,001$). An injury incidence of 328,1 injuries per 1000 playing hours was also reported in the study.

The variation regarding the most vulnerable position to injury was also deliberated and a high prevalence was found among defenders and goalkeepers, which differed from contemporary literature. The literature review and the scarcity of studies focusing on female soccer players suggests a need for further investigation pertaining to the intrinsic risk factors associated with lower limb injuries among this population, thus leading to the formulation of the research questions for the study.

Tackling or foul play by an opponent was the main contributor of injuries, which concurs with previous literature due to the nature of the sport. The majority of players were right dominant and sustained most of their injuries on the dominant site. This can be attributed to the volume of work that the dominant or preferred leg does during a game. The most severe injuries reported led to 186 days of time-loss among players. In conclusion it is recommended that coaches and players use the services of a complete medical team to effectively prevent and treat injuries.

Chapter Four was the second article entitled "Selected intrinsic risk factors associated with lower limb soccer injuries among female trained university soccer players in South Africa" and was compiled in accordance with the guidelines of the *African Journal for Physical Activity and Health Sciences*. The purpose of the article was to increase the present body of knowledge pertaining to the association between the selected intrinsic risk factors associated with injuries among female trained university players in South Africa. The selected intrinsic risk factors that were measured were hamstring and rectus femoris flexibility, ankle inversion, eversion, dorsiflexion and plantarflexion ROM, quadriceps-angles, as well as lower limb stability. The most important findings of the study were that reduced ankle inversion, ankle dorsiflexion and limited medial lateral lower limb stability were associated with lower limb injuries among university female soccer players.

An association between limited ankle inversion and dorsiflexion ROM and ankle injuries that was reported in the current study highlighted the importance of incorporating flexibility exercises in soccer programmes to address flexibility/ROM deficiencies that might predispose the players to risk of injury.

Poor postural control or inability to maintain balance or lower limb stability, as indicated by the deficiencies in the medial lateral lower limb stability measurements, can also contribute to ankle sprains, especially in a sport such as soccer where movement patterns such as pivoting and landing from a jump are prevalent. This finding concurred with previous literature.

In conclusion, it is recommended that pre-season measurements of the ROM of ankle invertors, evertors, plantarflexors and dorsiflexors as well as lower limb stability be addressed and incorporated in training programmes to benefit soccer players by preventing injuries. Failure to do so may lead to these restrictions hampering the players' performance and predisposing them to lower limb injuries.

5.2 CONCLUSIONS

The conclusions for the study were drawn in correspondence to the hypotheses described in Chapter One:

Hypothesis One: There will be a significantly high ($p<0,05$) prevalence of soccer injuries among university-level female soccer players.

Hypothesis is accepted based on the high number of injuries sustained among university-level female soccer players. Forty-three (81,1%) of the 53 players sustained 63 injuries ($p<0,0001$), which proved to be highly significant. Furthermore, there was a high prevalence of lower extremity injuries (79,3%) ($p<0,001$) in comparison to upper extremity injuries (20,6%). The ankle (28,6%) and knee (22,2%) were found to be the most vulnerable anatomical sites of injury ($p<0,001$). These findings concur with previous literature.

Hypothesis Two: A high body mass index, limited flexibility and lower limb instability ($p<0,05$; $r=0,05$) will be significantly be associated with lower limb injuries among university-level female soccer players.

Hypothesis is partially accepted based on the statistical significance for ankle inversion ($r=0,251$) and ankle dorsiflexion ($p=0,07$; $d=0,28$) ROM, as well as medial lateral lower limb stability ($p=0,001$; $d=0,75$) indicating their association with lower limb injuries among university-level female soccer players. Age, body mass index, stature, body mass, quadriceps angle, ankle dorsiflexion ROM, ankle plantarflexion ROM, hamstrings and rectus femoris flexibility as well as the overall and anterior posterior lower limb stability were not statistically significant ($p>0,05$).

5.3 LIMITATIONS AND RECOMMENDATIONS

Although this study will contribute greatly to the knowledge of players and coaches, the following limitations along with the relevant recommendations should be considered for future research:

1. A limitation encountered in the study was that some of the players did not complete all the testing components due to academic commitments and were therefore removed from the study. It is therefore recommended that data

be collected when the students are on a soccer camp and not when they are academically committed so that they can participate maximally without any dropouts.

2. A larger sample size of all the teams participating in the USSA tournament will increase the power of significance of the study. It is recommended that more teams from other universities be recruited for future research to increase the power of significance of the study.
3. A lack of pre-season measurements to determine if the players are at risk of injuries before the competitive season starts. It is recommended that pre-season flexibility/ROM and lower limb stability measurements be determined in order to address deficiencies that will aid in preventing injuries.

Despite the limitations mentioned, the study increases knowledge concerning soccer injuries, the nature of soccer injuries as well as the intrinsic risk factors associated with lower limb injuries among female soccer players. The uniqueness of the study is that it is the first to look at the association between ankle ROM, hamstrings and rectus femoris' flexibility and risk of injury among female soccer players. The study also highlights the importance of pre-season measurements of flexibility/ROM as well as limb stability/proprioception to address the deficiencies that might predispose the players to injuries and to incorporate them in training programmes for successful prevention of injuries. Injury recording is also vital for the teams throughout the season as this will reduce the subjectivity of reporting injuries by players as some could not recall properly, especially not the type of pain they experienced. It is also important that teams employ a multidisciplinary medical team that will work together in injury recording, rehabilitation/treatment as well as prevention, enhance full participation of players, and educate the coaches and players about the roles of each medical professional in terms of treating injuries. Further research is necessary to validate the findings of the study because of the small sample size that was used.

APPENDICES

APPENDIX A: RESEARCH METHOD AND PROCEDURES

1. RESEARCH METHOD

1.1 Literature review

To achieve an overview of injuries in soccer and to review the research done on risk factors associated with soccer players, the following electronic databases were used: SPORT Discus, Cochrane Library, Science Direct, Web of Science, EbscoHost, SabiNet and Google Scholar. The search words that were used are as follows: *soccer injuries, lower limb injuries in soccer, risk factors for injuries in soccer, female soccer injuries and intrinsic risk factors in female soccer.*

1.2 Empirical investigation

1.2.1 Study design

University level female soccer players (n=53) from selected soccer teams were recruited for voluntary participation in this cross-sectional once-off observational study – an injury prevention sub-study in a soccer skills and conditioning study within the Physical Activity, Sport and Recreation research focus area (NWU, Potchefstroom campus).

2. POPULATION

Initially 38 university level female soccer players from two teams namely North West University (NWU) and Tshwane University of Technology (TUT) soccer first teams preparing for the 2016 University Sports South Africa (USSA) National Football Championships were recruited for the study. However, on the testing days, the substitutes of the respective teams who complied with inclusion criteria also attended, and they were therefore tested and included in the study. The increased number of players increases the reliability of findings augmenting the limited research in this area. The substitutes came to the testing as per their coaches' request and their testing did not affect the cost of the study. All players completed the informed consent form. On the day of testing all players were required to submit their signed informed consent prior to testing (Appendix C). Players have been playing soccer for an average of nine years, playing for an average of three years for their respective Universities.

2.1 Inclusion and exclusion criteria

2.1.1 Inclusion criteria

The inclusion criteria for participation was:

i. Participants must be female soccer players aged 18 to 25 years.
ii. Participants must be registered students at North-West University or Tshwane University of Technology.
iii. Participant had to be selected to be in the university's senior team that participated at the USSA National Football Championships 2016.

iv. Participation was voluntary and an informed consent had to be signed.

2.1.2 Exclusion criteria

The exclusion criteria for participation was:

i. Female players who were not selected to be in the university's senior team that participated at the USSA National Football Championships 2016.
ii. Male soccer players.

3. MEASURING INSTRUMENTS AND EQUIPMENT

All measurements were conducted in a secluded room in the soccer facility where player's privacy was taken into consideration. The measurements commenced with completion of the injury history questionnaire by the players and the researcher, followed by flexibility/ROM measurements. The lower limb stability measurements were conducted at the North-West University and Tshwane University of Technology laboratories.

3.1 Demographic information and injury history questionnaire (Appendix D)

An injury history questionnaire was completed for each player prior to testing by means of an interview conducted by the researcher in a secluded room at NWU and TUT in order to collect information about injuries obtained in the past six months (one season). The demographic information included a player's name, university, age, home telephone number, cell phone number and race. The general information compiled included the player's body mass, stature, body mass index, and playing position. The injury history information included the player's training history such as the period of practice in a year, their training frequency per week, the duration of training sessions, and other activities involved in; it also included the injury prevalence history such as the type of injury, injury site, mechanism of injury, symptoms of injury, severity of injury and their previous treatment received. This questionnaire was adapted from Fuller *et al.,* (2006:85-86), Evans *et al.,* (2015:20), Ekstrand *et al.,* (2011:555) and Ellapen *et al*., (2009:418) according to the "consensus on definition and data collection" procedures in studies of football injuries outlined by the FIFA consensus injury statement. The questionnaire was printed in plain English language, as all players were proficient English speakers. Technical terms that were used were related to the sporting code to ensure clear understanding of questions and the researcher was available to answer any questions by players.

3.2 Anthropometric measurements

The following anthropometric measurements were taken two weeks prior to the USSA National Football championships according to the standard procedures of the International Society for the Advancement of Kinanthropometry (Stewart *et al*., 2011:52-54).

3.2.1 Stature

Maximum stature was measured to the nearest 0,1 cm with a Harpenden portable stadiometer (Holtain Limited, U.K.) with the player in standing position, heels together, buttocks and upper part of the back in contact with the scale. The head was in Frankfort plane and the player was instructed to take a deep breath and hold, while the tester gently lifted the mastoid processes upward. The researcher placed the head board firmly down on the vertex with the hair compressed as much as possible. The measurement was taken before the player exhaled (Stewart *et al*., 2011:53-54).

3.2.2 Body mass

Body mass was measured in kilograms to the nearest 0,1 kg on a portable electronic scale (Beuer Ps07 Electronic Scale, Ulm, Germany), with the player in minimal clothing and without shoes (Stewart *et al*., 2011). The researcher ensured that the scale was on zero. The player was instructed to stand on the center of the scale without support and the weight distributed evenly on both feet. Body mass index (BMI) was used to asses body weight relative to height and calculated according to the American College of Sports Medicine's guidelines by dividing body mass in kilograms (kg) by height in meters squared (kg/m^2) (Pescatello *et al*., 2014:63).

3.3 Flexibility

The following flexibility measurements were taken two weeks prior to the USSA National Football championships.

3.3.1 Hamstrings flexibility

The hamstring muscle group's flexibility was measured following the protocol by Schultz, Houglum and Perrin (2016), using a straight leg raise test. A Baseline goniometer (Fabrication Enterprises Inc., U.S.A) was used for taking the measurement. The player was instructed to lay supine on the plinth with their arms crossed over their chest, knees extended and pelvis parallel against the plinth. The axis of rotation of the goniometer was centralised on the greater trochanter, with the stationary arm positioned parallel to the midline of the trunk, whilst the movable arm positioned along the long axis of the femur. The player was requested to actively, flex the hip of the ipsilateral femur with their knee joint in extension and foot relaxed without flexing the contralateral hip. The player was furthermore requested to maintain their pelvis against the plinth for the duration of the test. The player was given two trials and the average of the two trials was recorded. The unit of measure was degrees.

3.3.2 Rectus femoris flexibility

The rectus femoris muscle's flexibility was measured using a Baseline goniometer (Fabrication Enterprises Inc., U.S.A) according to the protocol defined by Schultz *et al*., (2016). The player was instructed to lay supine on the plinth with their knees flexed over the edge of the plinth. The player was instructed to flex one knee, bringing the limb to the chest and holding it in that position, while maintaining the pelvis against the plinth. The axis of rotation of the goniometer was positioned over the lateral epicondyle of the ipsilateral knee, with the stationary arm in alignment with the long axis of the femur and the movable arm aligned with the lateral aspect of the tibia. The player was given two trials and the average of the two trials was recorded. The unit of measure was degrees.

3.3.3 Ankle eversion (flexibility) ROM

Ankle eversion was measured using a Baseline goniometer (Fabrication Enterprises Inc., U.S.A) according to the protocol defined by Menadue, Raymond, Kilbreath, Refshange and Adams (2006). The player was instructed to lay supine on the plinth, feet hanging off the plinth in a comfortable and relaxed position. The anterior aspect of the ankle between the medial and lateral malleoli, the midline on the anterior tibia using the crest of tibia as reference point, and the longitudinal midline on the anterior surface of the second metatarsal were marked. The axis of rotation of the goniometer was placed on the midpoint of the anterior aspect of the ankle; the stationary arm was placed on the midline of the anterior tibia, while the movable arm was aligned with the longitudinal midline of the anterior surface of the second metatarsal. The player was requested to maximally evert their ankle. The unit of measure was in degrees. Players were given two trials and the average of the two trials was recorded.

3.3.4 Ankle inversion (flexibility) ROM

Ankle inversion was recorded according to Menadue *et al.* (2006) protocol, where the player laid supine on the plinth with their feet hanging off the plinth in a relaxed position. A Baseline goniometer (Fabrication Enterprises Inc., U.S.A) was used for measurement. The anterior aspect of the ankle between the medial and lateral malleoli, the midline on the anterior tibia using the crest of tibia as reference point as well as the longitudinal midline on the anterior surface of the second metatarsal were marked. The player was requested to maximally invert their ankle (Menadue *et al*., 2006). The unit of measure was in degrees. Players were given two trials and the average of the two trials was recorded.

3.3.5 Ankle dorsiflexion (flexibility) ROM

Ankle dorsiflexion was measured following a protocol by Schultz *et al.,* (2016) using a Baseline goniometer (Fabrication Enterprises Inc., U.S.A) with the player in supine position on the plinth, knee flexed at 30° and gastrocnemius muscles in a relaxed position. The axis of rotation of the goniometer was centred over the lateral malleolus and the arms aligned with the fibula shaft and the head of the fifth metatarsal. The goniometer's neutral position reading was 90° and the player was requested to actively dorsiflex the ankle to the limit of motion. The measurement was recorded in degrees. Players were given two trials and the average of the two trials was recorded.

3.3.6 Ankle plantarflexion (flexibility) ROM

Ankle plantarflexion was measured with the player in supine position, knee flexed at 30° and gastrocnemius muscles in a relaxed position according to Schultz *et al*., (2016). A Baseline goniometer was used for the measurement. The goniometer's axis of rotation was centred over the lateral malleolus and the arms aligned with the fibula shaft and the head of the fifth metatarsal. The goniometer's neutral position reading was at 90° and the player was requested to actively plantarflex the ankle to the limit of motion. Two trials were given to the players and the average of trials was recorded in degrees.

3.3.7 Quadriceps angle (Q-angle)

Quadriceps-angle was measured using a Baseline goniometer (Fabrication Enterprises Inc., U.S.A) with the player in supine position, knee extended and the hip and foot in neutral position (Schultz *et al.*, 2016). A protocol by Schultz *et al.,* 2016 was followed. A line was drawn from the anterior superior iliac spine to the midpoint of the patella. Another line was drawn from the tibial tuberosity to the midpoint of the patella. The axis of rotation of the goniometer was on the midpoint of the patella, the stationary arm was in line with the ASIS and the movable arm in line with the tibial tuberosity. The angle between the two lines was measured twice and the average measurement was taken. The unit of measure was degrees.

3.4 Lower limb stability

Lower limb proprioception/stability was measured according to the protocol defined by Finn, Alvarez, Jett, Axtell and Kemler (1999). A Biodex Stability System static and dynamic (Biodex System 2) (Biodex Medical Systems, Inc.) was used and the ‘athlete single leg stability test’ protocol was administered. In this study, lower limb stability is synonymous with the concept of lower limb proprioception.

The player was requested to stand with her preferred leg on the Biodex Stability System, making sure that the supporting knee was flexed at 10° and maintained an upright position. The player was instructed to maintain a comfortable knee angle with the unsupported leg and keep their hands at their sides during testing (Finn *et al*., 1999). The stability platform was unlocked to allow movement while the player maintained the same position. The player adjusted the position of the supporting foot until a stable platform was established. The player was instructed to maintain the foot position for testing while the stability platform was locked.

The testing protocol consisted of a one-minute test using the eight resistances provided by the BSS. The effects of fatigue and leaning were reduced by using a single leg, and the player could touch down briefly with the toe of the opposite foot or held on the handrails to regain her balance once it was lost.

The values for anterior posterior index, medial lateral index and overall stability index were recorded on the left and right legs. The player had two trials and the better of the two trials was recorded.

4. PROCEDURE

The order of the test battery was as follows:

Ethical approval from the Health Research Ethical Committee of the Faculty of Health Sciences at the North-West University, Potchefstroom Campus was obtained prior to testing the players (NWU-00055-15-A1-02) (Appendix B). Information sheets were sent to the players and coaches of the selected soccer teams inviting them to participate in the research. It was made clear to the players that participation was voluntary and that they must not feel coerced to participate in the study irrespective of their inclusion in the team. Prior to the first day of testing an independent person was asked to explain the study to the participants. This person was a graduate student who was familiar with both the NWU research procedures as well as the study. The players received informed consent forms to read through and discuss with their families and complete privately. Players who were willing to participate in the research needed to submit the signed informed consent forms on the first day of testing, prior to testing.

On the first day of testing (two weeks before the start of the USSA National Football Championships) after submitting the signed informed consent forms, an injury history questionnaire (Appendix D) was completed by each player before anthropometric and flexibility measurements commenced in a private and enclosed designated testing area.

5. STATISTICAL ANALYSIS

Statistica 13, 2018 TIBCO STATISTICA version 13,3 software system was used for data analyses. The data was analysed descriptively (mean, mode, frequency and percentages), inferentially applying chi-square, a t-test and Spearman rank correlation tests. The chi-square statistical test was employed to determine the significance of injury prevalence ($p<0,05$). The chi-square test is a statistical test which can be used to indicate the association between categorical variables (Thomas, Nelson & Silverman, 2005). A t-test was used to determine if there is a difference between injured and non-injured players' body mass index, flexibility and lower-limb stability. Spearman rank correlation test is a non-parametric version of Pearson product-moment correlation test, which was used to measure the direction and strength of association between two ranked values or variables (Thomas *et al.,* 2005). The significance level for Spearman rank correlation was set at 10 % ($r=0,1$) and not 5% ($r=0,05$) because of the small sample size. The injury prevalence per 1000 playing hours was calculated as follows: the total number of injuries sustained/ the number of documented player hours multiplied by 1000 hours (Ekstrand *et al*., 2011; Nilstad *et al*., 2014). The Cohen's effect size was also used to determine practical significance (Cohen, 1988). The effect size was used to determine whether a relationship between two variables is significant (Steyn, 2002). The formula used was: d=difference between two means divided by estimate for standard deviation (Ellis & Steyn, 2003). The guidelines for interpretation of effect size are: small effect: $d=0, 2$; medium size: $d=0, 5$ and large size: $d=0,8$ (Ellis & Steyn, 2003).

6. ETHICAL CONSIDERATIONS

Ethical approval was obtained from the Health Research Ethical Committee of the Faculty of Health Sciences (NWU-00055-15-A1-02) (Appendix B) at the North-West University before commencing with the study.

The head of the soccer project was already in contact with the North West University and the Tshwane University of Technology Ladies Football teams' coaches discussing the proposed research project. The players were not currently involved in other research projects; thus this project was not an additional burden to them. After explaining all the procedures measuring equipment and instruments the coaches and managers gave permission for their teams to be included in the study. The research team made it clear to the coaches and managers that participation is voluntary, all information will be treated as confidential and that the names of participants will not be made public.

Upon confirmation of the teams' willingness to participate in the study, players were briefed by the research team on the nature and purpose of the study, testing procedures, equipment, and instruments the day before testing. Informed consent forms were given to the participants by a person trained for this purpose, and not by someone involved in the study. The risks involved and what was expected from the participants were thoroughly explained in the informed consent form. The participants were asked in the informed consent form if their data could be used for research purposes. The participants were allowed to go through the informed consent form privately in their homes and discuss it with their family members in order to make an informed choice. The research team ensured that the participants were aware of the anonymous and voluntary nature of their participation, and that all information would be handled with confidentiality – no individual participant data would be made available to any of the coaches or team managers. The research team explained to the participants that they may withdraw from the study without any explanation.

The informed consent form was in plain English, as all players are university level students and should be proficient in the language. The participants had an opportunity to ask questions during the briefing session and contact the researcher if further questions arose. Once participants understood the informed consent form, the testing procedures and after they have signed the consent form, only then were they were allowed to participate in the research.

Upon submission of the signed informed consent form the players completed the injury history questionnaire. After completing the necessary documentation, anthropometric measurements were done in a private and enclosed area. The participants were required to wear minimal clothing during measurements, which may have caused some discomfort. Some participants might have felt uncomfortable during the anthropometric measurements where body mass and stature were measured by a certified anthropometrist of the International Society for the Advancement of Kinanthropometry (ISAK) Level 2. Every participant was measured alone in a private area taking her privacy into consideration.

Participants were requested to wear shorts during flexibility/ROM measurements as landmarks were made on them with a temporary marker, which was wiped off after the measurements were taken. Participants were only required to be barefoot and wear shorts when conducting the flexibility/ROM and joint stability measurements and this should, therefore, not cause any discomfort for participants. No physical, social, psychological or other negative consequences beyond the risks encountered in normal life and everyday training were anticipated in the study.

The research was conducted during the team's training time; therefore, the players were not inconvenienced in any way. The teams were responsible for the player's usual transportation that they use to and from training on daily basis, so no extra expenses were incurred by players.

It was anticipated that the possible benefits for the participants outweighed the possible risks when taking part in the study. Research was conducted according to the Helsinki declaration. The basic ethics principles published by the Belmont Report (1979) and the NWU Manual for Masters and Doctoral Studies (2013:26) for scientific research involving human individuals were adhered to. The primary researcher ensured the participants of the following:

- Autonomy: Respect and fair treatment were promised to all participants and no bias with regard to race, background, values and beliefs was shown. Participants were informed about their rights, voluntary participation and that they were pressured into any situation which they were not comfortable with. All participants were allocated with a reference number for anonymity.
- Benefit: Maximizing potential benefits and minimizing possible risks might have had valuable impact on the participant either directly or indirectly. Direct benefits included accessibility to their results by means of a personal report provided four weeks post final testing period. Feedback will be given to the participants after all the data has been captured on a personal computer and analysed by the researchers. The data collected could assist the coaches together with the participants in compiling specific and effective conditioning programs for different player positions that could prepare them for the demands of the soccer matches, thus

improving their performance. Participants could benefit in terms of their own health by using the results provided to improve their physical conditioning and body composition. Indirect benefits could include understanding the different intrinsic risk factors that are associated with lower limb injuries and how to minimize such injuries in future.

- Non-harmfulness: The testing procedures were conducted in a safe environment at the North–West University and Tshwane University of Technology laboratories respectively. The language of correspondence during the procedures was English.
- Justice: The testing procedures were thoroughly explained to the participants prior to consent and honesty was requested. Partial anonymity was used to protect participants as individuals. Complete confidentiality could not be ensured, because research was conducted in a group setting and researchers could not ensure confidentiality by other group members who might disclose some information outside the research setting. Participants will not be identified in the final dataset. Anonymity and confidentiality will be ensured when reporting the findings by not using any individual identifiers resulting from the study. Only the researchers involved in this study will have access to the data obtained.

7. DATA STORAGE AND MAINTENANCE

Data entry was double checked thoroughly by the project leader upon entry to ensure that mistakes are eliminated. The student received the data from the project leader on an Excel spread sheet stored on a flash drive. A backup compact disc (CD) of the data was made and stored for a minimum period of seven years in a secure place in the project leader’s office, accessible only to primary researchers, after which it will be erased from the laptop and the CD will be destroyed. All electronic data sets are password protected.

APPENDIX A

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APPENDIX B

APPENDIX B: ETHICS APPROVAL CERTIFICATE

NORTH-WEST UNIVERSITY ®
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

Private Bag X6001, Potchefstroom,
South Africa, 2520

Tel: (018) 299-4900
Faks: (018) 299-4910
Web: http://www.nwu.ac.za

Institutional Research Ethics Regulatory Committee
Tel: +27 18 299 4849
Email : Ethics@nwu.ac.za

ETHICS APPROVAL CERTIFICATE OF STUDY

Based on approval by **Health Research Ethics Committee (HREC)** on **10/07/2017** after being reviewed at the meeting held on **16/03/2017**, the North-West University Institutional Research Ethics Regulatory Committee (NWU-IRERC) hereby **approves** your study as indicated below. This implies that the NWU-IRERC grants its permission that provided the special conditions specified below are met and pending any other authorisation that may be necessary, the study may be initiated, using the ethics number below.

Sub-study title: Intrinsic risk factors for lower limb injuries in university-level female soccer players

Study Leader/Supervisor: Dr C Pienaar
Student: TE Masenya

Ethics number: N W U - 0 0 0 5 5 - 1 5 - A 1 - 0 2

Institution	Study Number	Year	Status	Sub-study
NWU	00055	15	A1	02

Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation

Application Type: Sub-study
Commencement date: 2017-07-10 **Risk:** Minimal

Continuation of the study is dependent on receipt of the annual (or as otherwise stipulated) monitoring report and the concomitant issuing of a letter of continuation.

Special conditions of the approval (if applicable):

- Translation of the informed consent document to the languages applicable to the study participants should be submitted to the HREC (if applicable).
- Any research at governmental or private institutions, permission must still be obtained from relevant authorities and provided to the HREC. Ethics approval is required BEFORE approval can be obtained from these authorities.

General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, please note the following:

- *The study leader (principle investigator) must report in the prescribed format to the NWU-IRERC via HREC:*
  - *annually (or as otherwise requested) on the monitoring of the study, and upon completion of the study*
  - *without any delay in case of any adverse event or incident (or any matter that interrupts sound ethical principles) during the course of the study.*
- *Annually a number of studies may be randomly selected for an external audit.*
- *The approval applies strictly to the proposal as stipulated in the application form. Would any changes to the proposal be deemed necessary during the course of the study, the study leader must apply for approval of these amendments at the HREC, prior to implementation. Would there be deviated from the study proposal without the necessary approval of such amendments, the ethics approval is immediately and automatically forfeited.*
- *The date of approval indicates the first date that the study may be started.*
- *In the interest of ethical responsibility the NWU-IRERC and HREC retains the right to:*
  - *request access to any information or data at any time during the course or after completion of the study;*
  - *to ask further questions, seek additional information, require further modification or monitor the conduct of your research or the informed consent process.*
  - *withdraw or postpone approval if:*
    - *any unethical principles or practices of the study are revealed or suspected,*
    - *it becomes apparent that any relevant information was withheld from the HREC or that information has been false or misrepresented,*
    - *the required amendments, annual (or otherwise stipulated) report and reporting of adverse events or incidents was not done in a timely manner and accurately,*
    - *new institutional rules, national legislation or international conventions deem it necessary.*
- *HREC can be contacted for further information or any report templates via Ethics-HRECApply@nwu.ac.za or 018 299 1206.*

The IRERC would like to remain at your service as scientist and researcher, and wishes you well with your study. Please do not hesitate to contact the IRERC or HREC for any further enquiries or requests for assistance.

Yours sincerely

Linda du Plessis

Digitally signed by Linda du Plessis
DN: cn=Linda du Plessis, o=NWU, ou=Vaal Triangle Campus, email=linda.duplessis@nwu.ac.za, c=ZA
Date: 2017.07.31 13:05:20 +02'00'

Prof Linda du Plessis
Chair NWU Institutional Research Ethics Regulatory Committee (IRERC)

APPENDIX C: PARTICIPATION INFORMATION LEAFLET AND INFORMED CONSENT

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

Health Research Ethics Committee
Faculty of Health Sciences
NORTH-WEST University
(Potchefstroom Campus)
2015 -10- 02
HREC Stamp

PARTICIPANT INFORMATION LEAFLET AND CONSENT FORM FOR UNIVERSITY-LEVEL FEMALE SOCCER PLAYERS

TITLE OF THE RESEARCH PROJECT: INVESTIGATING PERFORMANCE INDICATORS AND INJURY RISK FACTORS FOR THE DEVELOPMENT AND PERFORMANCE OF FEMALE SOCCER PLAYERS

REFERENCE NUMBER: NWU-00055-15-A1-02

PRINCIPAL INVESTIGATOR: DR. MARTINIQUE SPARKS

ADDRESS: BUILDING K3, CNR OF THABO MBEKI & MEYER STR, POTCHEFSTROOM

CONTACT NUMBER: 018 299 1770

You are being invited to take part in a research project. Please take some time to read the information presented here, which will explain the details of this project. Please ask the researcher any questions about any part of this project that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research entails and how you could be involved. Also, your participation is **entirely voluntary** and you are free to decline to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part.

This study has been approved by the **Health Research Ethics Committee of the Faculty of Health Sciences of the North-West University (NWU-00055-15-A1-02)** and will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki and the ethical guidelines of the National Health Research Ethics Council. It might be necessary for the research ethics committee members or relevant authorities to inspect the research records.

APPENDIX C

What is this research study all about?

- *This study will be conducted at your home training field at the university and at the annual University Sports South Africa (USSA) tournament and will involve us measuring your body composition (e.g. Mass, skinfolds etc.), flexibility as well as requiring you to perform two fitness tests, a speed test, a stability test and a skills test with experienced health researchers trained in Sport science. You will also be asked to complete two psychological questionnaires and an injury questionnaire. We will also monitor and analyse all of your matches during the USSA tournament. Thirty-eight participants will be included in this study.*
- *The objectives of this research are:*

  - *to determine the anthropometric profile according to player position of university-level female soccer players, thus developing a player profile for each position describing body mass, height, stature, and fat percentage;*
  - *to determine the relationship between technical skills and the aerobic- and anaerobic fitness characteristics of university-level female soccer players, thus determining whether your technical skill performance will be influenced by your level of aerobic- and anaerobic fitness;*
  - *to determine the position specific internal and external match demands of university-level female soccer players by making use of global positioning system (GPS) analyses, thus using GPS technology to provide information such as your heart rate and the amount of time you spend at different intensity efforts performing activities such as standing, walking, jogging and running.*
  - *to determine the effect of an aerobic fatiguing test on the salivary cortisol levels and the psychological state of amateur female soccer players;*
  - *to determine the effect of an anaerobic fatiguing test on salivary cortisol levels and the psychological state of amateur female soccer players;*
  - *to determine the effects of the match-outcome (win/lose) and fatigue as a result of a soccer match on salivary cortisol levels and the psychological state of amateur female soccer players*
  - *to determine the injury prevalence among university level female soccer players.*
  - *to determine the intrinsic risk factors associated with lower limb injuries among university level female soccer players.*

Why have you been invited to participate?

- *You have been invited to participate because you are female and represent your university in soccer*
- *You have also complied with the following inclusion criteria: you are currently injury free and you are part of the USSA squad.*
- *You will be excluded if: you become injured or ill at any time during the project or if we are not able to test you 2 weeks before the USSA championship starts.*

APPENDIX C

What will your responsibilities be?

- *You will be expected to:*

- *Complete the informed consent form before the first day of testing. Informed consent will be obtained by an independent person not directly involved in the study.*
- *Complete a questionnaire that pertains to your demographic information, playing and injury history on the first day of testing.*
- *You will be instructed not to engage in strenuous exercise for at least 48 hours before the fitness testing session. The research team will guide the coaches towards which activities will be allowed to engage in before testing. The research team will also consult with coaches beforehand to inform them of the intended dates of testing, so that they can plan their training program in such a way to accommodate the testing and necessary rest before testing commences.*
- *Conduct assessments for body composition. Various measurements will be taken using a skinfold calliper by Level 2 International Society for the Advancement of Kinanthropometry (ISAK) certified anthropometrists at a private designated testing area. This will include measurements of body mass, stature, skinfolds, breadths, girths and lengths and will require you to wear minimal clothing. You are allowed to strip down to as much clothing as is comfortable for you. These measurements will be taken at a private enclosed location. The flexibility in your legs and ankles will also be tested in this area.*
- *While you wait to be measured an injury history questionnaire will be completed for you by a Biokineticist. You will also be asked to complete two psychological questionnaires and provide a saliva sample before the onset of the physical testing*
- *Conduct tests for speed (40 m sprint test) and stability. The tests will be explained to you after which you will engage in a general warm-up of 10-15 min consisting of low-intensity jogging followed by static and dynamic stretching. You will then conduct the tests for speed and stability. You will be allowed to wear you soccer boots to complete these tests.*
- *You will then perform the technical skills test (consisting of dribbling, passing and control), followed by the aerobic fitness test (Yo-Yo Intermittent recovery test level 1 (Yo-Yo IR1)). During the execution of the aerobic fitness test you will be asked to run while being fitted with a portable gas analyser apparatus to measure you expired air as you run. This will require a harness to be fitted to your chest as well as a mask over your head and face. The mask will not hinder your breathing and you will be able to breathe normally. There will also be a heart rate belt fitted across your chest to monitor your heart rate during the test. After the completion of the aerobic fitness test, you will rate how tired you are and a blood lactate concentration [LA] will be taken from the fingertip of the left hand by means of a finger prick test. After blood sampling, you will again complete the skills test. You will not be allowed to recover between the technical skills test and the aerobic test, because we want to examine the effect of exhaustion on soccer skill performance. After the final test you will complete two psychological questionnaires for a second time and thirty minutes after the last test another saliva sample will be taken.*

- *Engage in explosive power (Vertical jump) test, technical skills and anaerobic fitness tests on the second day of testing. The tests will be explained to you after which you will perform general warm-up of 10–15 min consisting of low-intensity jogging followed by static and dynamic stretching. You will also be asked to complete two psychological questionnaires and provide a saliva sample before the onset of the physical testing. You will then conduct the explosive power test, technical skills test (consisting of dribbling, passing and control) and the anaerobic fitness test (repeated sprint ability test (RSA). During the execution of the repeated sprint ability test, you will be required to sprint shuttles of 5 meters over a distance of 20 meters. After the completion of the anaerobic fitness test, you will rate how tired you are and a blood lactate concentration [LA] will be taken from the fingertip of the left hand by means of a finger prick test. After blood sampling, you will again complete the skills test. You will not be allowed to recover between the technical skills test and the anaerobic test, because we want to examine the effect of exhaustion on soccer skill performance. After the final test you will complete two psychological questionnaires for a second time and thirty minutes after the last test another saliva sample will be taken.*
- *Be assessed at the USSA championship during the matches. You will be asked to wear a GPS sampling unit. This is a vest that is worn underneath your playing shirt, it is lightweight and will not obstruct your play in any way. Again a heart rate belt will be fitted across your chest to monitor your heart rate during the match. Before commencement of the tournament, you will be allowed to wear the GPS harness with the unit and heart rate (HR) transmitter belts during a practice session to familiarize yourself with units, to ensure you do not feel uncomfortable on the first day of the tournament.*
- *During the tournament saliva samples will be collected and the STAI and POMS questionnaire completed 1 hour before- and 30 minutes after the match, independent of the time of day that the match will take place. Following the soccer match, players will be instructed to indicate their RPE and complete the two questionnaires. Thirty minutes after the match the saliva samples will be collected.*

Will you benefit from taking part in this research?

- ➢ *The direct benefits for you as a participant will be that you will have access to your results by means of a personal report provided to you within 4 weeks after the final testing period. In the case of any immediate or unanticipated incidental findings occurring during the time of testing, you will be informed. The data gathered could enable you as player and your coach to compile specific and effective conditioning programs for the different player positions (attackers, midfielders and defenders) that will prepare you for the demands of soccer matches, consequently resulting in an improvement of performance. You could also benefit in terms of your own health by using results provided to you to improve your body composition and physical condition.*
- ➢ *The indirect benefit will be a broadening of specialist sport science knowledge with regards to female soccer, which can be transferred to the larger soccer community. This includes knowledge in the field of physical and physiological profiles and match demands of university level female soccer players. Workshops will be held after the completion of the project to empower not only university-level coaches, but also developing coaches to construct effective training programs for their female soccer teams.*

- *Scientists will gain understanding into the different intrinsic risk factors that are associated with lower limb injuries and how to minimize such injuries in future.*
- *Two Biokineticists will also travel with your team during the tournament to assist with strapping and massaging before and after matches.*

Are there risks involved in your taking part in this research?

- *The risks in this study are:*

- *Physical discomfort: No severe physical stress beyond the risk encountered in normal life and everyday training are anticipated. All the skills and fitness tests are movements that you regularly do in your training program. You will be thoroughly warmed up before taking part in any of these tests. Should you experience pain or injury at any point you can stop the test and the physiotherapist or team doctor will first be allowed to examine you and assess your injury or discomfort.*
- *Physical exhaustion: The Yo-Yo IR1 test and RSA test are maximal performance tests that need to be done until complete exhaustion. However, you are free to stop the test if you experience any light headedness, shortness of breath or headaches. An Automated External defibrillator (AED) with a qualified operator will also be at all testing opportunities if the need to use the apparatus arises.*
- *Social stress: No negative influence due to the presence of other players and the coaching staff are anticipated, due to you being accustomed to participate in a group and in front of the coaching staff and spectators. A clinical psychological consultant will be available for debriefing in case of any emotional reactions.*
- *Blood sample collection: Some discomfort might be experienced when the finger prick is performed for blood sample collection. The procedure will be thoroughly explained to you and you will be free to withdraw if you are not comfortable with continuing. It will be a single prick on your finger taken by qualified scientists. Extreme pain is not expected. The finger prick test will be done on both the first and second day of testing. The needle of the finger prick apparatus as well as the disposable gloves will immediately be dispelled into an anatomical waste bin after each measurement taken. After a lactate reading is given by the lactate analyser the used blood lactate strips will also be dispelled into the portable biodegradable waist container. All the material will be disposed immediately after the collection of the data. The disposable waist container will be collected by the manufacturer, as per instructions.*
- *Salivary sample collection: No severe physical stress beyond the risk encountered in normal life and everyday training are anticipated. Saliva will be collected through a plastic straw into a 20 ml collection vial. The saliva sample will only be used to do hormonal analysis; no other analyses will be done.*
- *Psychological stress: A Sport Psychological Consultant will be available for debriefing in case of any emotional reactions experienced.*
- *Injury at the championship: You will not be exposed to additional risk due to the research conducted, in addition to that related to playing the game. Trained paramedics arranged by the tournament directors will be present at the tournament in case of any injuries.*

- *The benefits outweighs the risk*

What will happen in the unlikely event of some form of discomfort occurring as a direct result of your taking part in this research study?

- *You might feel uncomfortable during the anthropometric measurements where body mass, stature, skinfolds, breadths, girths and lengths will be measured as you will be required to wear minimal clothing and the measurements might result in discomfort. The measurements will be taken by two experienced ISAK Level 2 certified anthropometrists. You will be measured alone in a private designated and enclosed area and will be allowed to strip down to as much clothing as is comfortable for you. Testing will be done taking your privacy into consideration*
- *Should you have the need for further discussions following the physical or psychological discomfort which might be experienced during the testing procedures, an opportunity will be arranged for you to consult with the team doctor, physiotherapist, or clinical psychologist.*

Who will have access to the data?

- *Anonymity will be partial to protect you as individual. Confidentiality will be ensured by assigning a code to you only known by the researchers. Complete confidentiality cannot be ensured, as the research will be conducted in a group setting and the researchers cannot ensure confidentiality by other group members who might disclose information outside the research setting. In the final dataset it will not be possible to identify you. The reporting of findings will be anonymous and confidential by not using any individual identifiers in any publications resulting from this study. Only the researchers involved in this study will have access to the data obtained.*

What will happen with the data/samples?

- *This is a once off collection that will only take place during 2015 and the data will be fully analysed here in South Africa by the Statistical Consultation Services of the NWU.*
- *The hard copies of the data recorded on the first three testing procedures will be stored for a minimum of 7 years in a secure safe in the project leader's office, accessible only by the primary researchers, after which it will be destroyed by means of a paper shredder. The electronic data recorded by the GPS units and heart rate monitors will be downloaded to a password protected personal laptop immediately after each match and a back-up will be made on a compact disc (CD) and stored for a minimum of 7 years in a secure safe in the project leader's office, accessible only by the primary researchers, after which it will be erased from the laptop and the CD destroyed.*
- *The salivary samples will only be used for stress hormone analysis and no other analyses will be conducted on those samples. These analyses will be done at a professional laboratory (Ampath), guaranteeing confidentiality.*

Will you be paid to take part in this study and are there any costs involved?

No, you will/will not be paid to take part in the study but refreshments will be provided during and after the testing. You will not have any additional travel expenses during the times that this procedure will be conducted, as the first 3 days of testing will be conducted during normal practice times when you will be at the training field. The final testing to be conducted at the USSA tournament will also not lead to any additional travel expenses for you, as these expenses for travel, accommodation and meals will already have been paid for by the respective universities. There will thus be no costs involved for you, if you do take part.

Is there anything else that you should know or do?

- You can contact Dr Martinique Sparks at 018 299 1770 if you have any further queries or encounter any problems.
- You can contact the Health Research Ethics Committee via Mrs Carolien van Zyl at 018 299 2089; carolien.vanzyl@nwu.ac.za if you have any concerns or complaints that have not been adequately addressed by the researcher.
- You will receive a copy of this information and consent form for your own records

How will you be notified of the findings?

- The findings of the research will be shared with you 4 weeks after the final testing period. We will be sharing the findings with you by providing you with a personal report regarding your performance scores. You are welcome to contact us regarding the findings of the research. Findings with regards to the game analyses and playing position profiles will be shared with the coaching staff, however these results will be given as group statistics with no individual players identified.

Declaration by participant

By signing below, I …………………………………..…………. agree to take part in a research study titled: Investigating performance indicators and injury risk factors for the development and performance of female soccer players

I declare that:

- I have read this information and consent form and it is written in a language with which I am fluent and comfortable.
- I have had a chance to ask questions to both the person obtaining consent, as well as the researcher and all my questions have been adequately answered.
- I understand that taking part in this study is **voluntary** and I have not been pressurised to take part.

- I may choose to leave the study at any time and will not be penalised or prejudiced in any way.
- I may be asked to leave the study before it has finished, if the researcher feels it is in my best interests, or if I do not follow the study plan, as agreed to.

Signed at (*place*) ....……......…………….. on (*date*) …………...……….. 20....

....

Signature of participant **Signature of witness**

Declaration by person obtaining consent

I *(name)* ……………………………………………..……… declare that:

- I explained the information in this document to …………………………………..
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter.

Signed at (*place*) ....……......…………….. on (*date*) …………...……….. 20....

....

Signature of person obtaining consent **Signature of witness**

Declaration by researcher

I *(name)* ……………………………………………..……… declare that:

- I explained the information in this document to …………………………………..

- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter.

Signed at (*place*) ....…........…………….. on (*date*) …………....……….. 20....

....

Signature of researcher **Signature of witness**

APPENDIX D: THE PREVALENCE OF SOCCER INJURIES AMONG UNIVERSITY LEVEL FEMALE SOCCER PLAYERS

PERSONAL INFORMATION:

Name: ______________________________________**University:** ________________________

Age: ____________ **Telephone No: (H)** _________________ Cell**:** __________________________

Race: African ☐ White ☐ Indian ☐ Colored ☐ Asian ☐

Body Mass: __________ Stature: __________ BMI: __________

What position do you play? ____________________

How long have you been playing soccer for the university? ____________________

How long have you been playing soccer?____________________

Which is your dominant leg? ______________

Angles	Right	Left
Hamstrings		
Rectus femoris		
Ankle inversion		
Ankle eversion		
Ankle dorsi-flexion		
Ankle plantar flexion		
Quadriceps angle		

APPENDIX D

PROPRIOCEPTION/LIMB STABILITY

Proprioception	**Right**	**Left**
Overall Index		
Anterior Posterior Index		
Medial Lateral Index		

TRAINING HISTORY

1. How many months in a year do you practice soccer?

1	2	3	4	5	6
7	8	9	10	11	12

2. How many times a week do you have soccer practice?

1	2	3	4	5
6	7	8	9	10

3. What is the average duration of training per session?

1 hr	2 hrs	3 hrs	4 hrs	5 hrs
Other				

4. Do you practice / participate in any additional activities beside soccer?

Gym	Swimming	Cricket	Touch Rugby
Others			

5. If so, how many times a week:

1	2	3	4	5
6	7	8	9	10

APPENDIX D

6. What type of training do you perform?

Strength Training	Aerobic	Flexibility	Agility	Core Stability
Skills	Co-ordination	Other:		

INJURY PREVALENCE

1. Have you sustained a muscle or bone or nerve or ligament ***pain*** in the last 6 months while playing soccer?

Yes ☐ No ☐

Any physical complaint, which exceeded the structural and functional integrity that was sustained by a player during a soccer match or training, irrespective of the need for medical attention or time-loss from soccer activities (adapted from Fuller et al., 2006, Evans et al., 2015 and Ekstrand et al., 2011)

2. If yes, explain how the injury/pain occurred:

Tackled by an opponent	Tripped by an opponent	Rapid Rotational Movement	Fall or poor landing	Re-occurring injury
Over-use	Lost balance	Others		

3. Mark the area where you experience the symptoms of the pain/injury

☐ a) Neck
☐ b) Shoulder
☐ c) Elbow
☐ d) Forearm
☐ e) Hand
☐ f) Middle back
☐ g) Lower back
☐ h) Buttock
☐ i) Thigh
☐ j) Knee
☐ k) Lower limb
☐ l) Ankle
☐ m) Foot
☐ n) Other:____________________

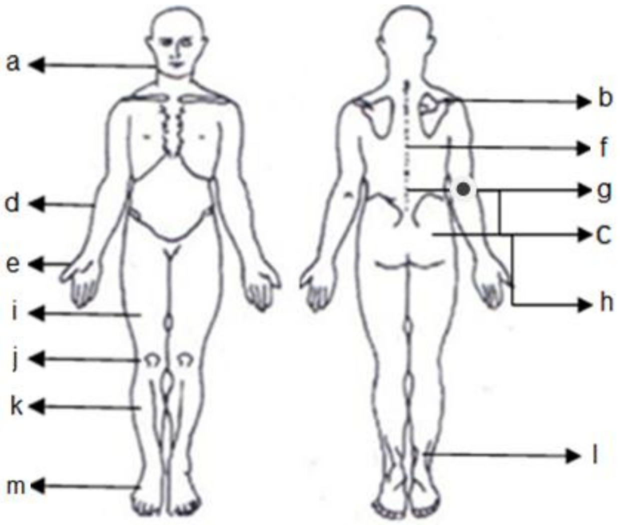

Figure 1 Adapted from Ellapen et al, 2009)

4. What type of injury who sustained?

APPENDIX D

Muscle/tendon	ligament	Nerve	Bone

5. What type symptom and/or sign have you experienced?

Dull Ache ☐ Numbness ☐ Burning ☐ Sharp ☐ Spasms ☐
Radiating ☐ Pins and Needles ☐ Swelling ☐ Discomfort ☐

6. How often did you experience the above mentioned pain symptoms in the past 6 months?

☐ a) Once or a few times in the day
☐ b) Every few days
☐ c) Once a month
☐ d) Other: ____

7. How long did the musculoskeletal pain/injury prevent you from participating in soccer practice?

1 day	2 days	3 days	4 days	5 days	Others

8. How would you rate the intensity of the symptom you experienced?

1	2	3	4	5
Uncomfortable	Low	Moderate	High	Severe

9. How long did your pain/injury persist for?

☐ a) A few hours
☐ b) A few days
☐ c) It is continuous
☐ d) It is unpredictable

10. Have you obtained the services of any of the following healthcare professionals for your musculoskeletal symptoms?

- ☐ a) Orthopaedic Surgeon
- ☐ b) General Practitioner
- ☐ c) Physiotherapist
- ☐ d) Chiropractor
- ☐ e) Biokineticist
- ☐ f) Massage Therapist
- ☐ g) Other: ____

11. Did you play through the pain/injury? Yes ☐ No ☐

12. As a result of this, did the musculoskeletal pain increase? Yes ☐ No ☐

Adapted from: Fuller *et al.*, (2006:85-86), Evans *et al.*, (2015:20), Ekstrand *et al.*, (2011:555) and Ellapen *et al*., (2009:418).

APPENDIX E: INSTRUCTIONS FOR AUTHORS: AFRICAN JOURNAL FOR PHYSICAL ACTIVITY AND HEALTH SCIENCES

AFRICAN JOURNAL FOR PHYSICAL ACTIVITY AND HEALTH SCIENCES (AJPHES)

Introduction

AJPHES is a peer-reviewed journal which considers publication in manuscripts of the following disciplines; physical activity, human movement studies as well as sport-related professions in Africa. The journal gives an opportunity to the above-mentioned disciplines to report their research findings based on experiences and African settings and share ideas with others. Manuscripts from other continents are also considered. Publication for manuscripts will only be considered based on the understanding that they were not published in any other journal and corresponding authors need to make such declarations. Parts of the manuscripts that have been published or presented at congresses, seminars or symposia need to be referenced in the acknowledgement section of the manuscript.

PREPARATION OF MANUSCRIPTS

The following should be noted when preparing a manuscript for publication at AJPHES:

- Manuscripts should be typed in fluent English using 12-point Times New Roman font and 1.5 line-spacing on a white A4-sized paper, justified fully with 3cm margin on all sides.
- Microsoft Word, Office 2007 for Windows should be used.
- Manuscripts should not exceed 12 typed pages (including tables, figures, references etc.)
- US$ 10.0 will be charged extra per page for articles exceeding 12 typed pages.
- Authors are responsible for paying the publication fee to cover the high cost of publication.
- Pages must be numbered sequentially starting with title page.
- Presentation format for the manuscript should be in line with the publication format guidelines of the American Psychological Association (APA) (6th edition).

Structure of manuscript

Title page

Title page of the manuscript should contain the following information:

- It must be a concise and informative title.
- Author(s') name(s) with first and middle initials. Authors' highest qualification and main area of research specialisation to be provided.
- Institutional addresses for author(s') including telephone and fax numbers.
- Contact details of corresponding author, including e-mail address.
- A short title of not more than 6 words.

APPENDIX E

Abstract

- An abstract of 200-250 words with a maximum of 5 keywords below the abstract.
- It must be typed on a separate page using single line spacing, with the purpose of the study, methods, major results and conclusions presented correctly.
- Abbreviations must be excluded or defined.

Text

Text should include the following headings using single line spacing:

- Introduction
- Materials and methods
- Results
- Discussion
- Acknowledgement
- References
- Appendices (if appropriate)

Introduction

- Introduction should start on a new page, giving a background of the study and state the problem and purpose of the study.
- Relevant references should be cited by authors to support the basis of the study.
- A concise but informative and critical literature review is required.

Methodology

- Section should provide relevant and enough information regarding the study participants, ethics/informed consent, instrumentation, research designs, validity and reliability estimates, data collection procedures, statistical methods and data analysis techniques used.
- Qualitative research techniques are also accepted.

Results

- Results should be presented clearly and precisely.
- Figures and tables must be separately presented or at the end of the manuscript with appropriate location indicated in the text.
- Materials that are appropriate to be presented in the discussion section should not be included in the results.
- *Systeme internationale (SI)* units should be used to express the formulas, units and quantities.
- Colour printing of tables and figures can be done on authors' request and expense.

Discussion

- Important aspects and the study's major conclusions should be included in the discussion section.
- No repetition of information that was presented in the results section.
- Relevant references should be cited to justify the findings of the study.
- Discussion should be critical and written tactfully.

References

- The referencing style to be used is APA.
- References cited in the text should be listed alphabetically in the reference section at the end of the article.
- No reference numbering in the text or in the reference list.

SUBMISSION OF MANUSCRIPT

- Articles should be submitted electronically, via email attachment; however, it is important that the corresponding author ensures that the articles are free of viruses.
- The reviewing process for AJPHES takes 4-6 weeks and authors will be advised about the decision taken on their manuscripts within 60 days.
- Authors are advised to avoid self-referencing or do it minimally to ensure anonymity during reviewing process.
- Original manuscripts and all correspondence should be addressed to the Editor-In –Chief on the following contact details provided on the AJPHES website.

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- Accepted manuscripts for publication may be returned to the author(s) for final proof reading and corrections.
- All corrected proofs should be returned to the Editor-In-Chief electronically within a period of one week.

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APPENDIX F: PROOF OF LANGUAGE EDITING

WORDPLAY EDITING
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Email: karien.hurter@gmail.com
Tel: 071 104 9484
Website: http://wordplayediting.net/

Dear Professor,

This letter is to confirm that this master's thesis by Tsholofelo Masenya was proofread by a professional language practitioner.

Regards,

Karien Hurter

APPENDIX G: PROOF OF STATISTICIAN CONSULTATION

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20 April 2018

Re: Dissertation, Ms T Masenya, student number: 25835505

We hereby confirm that the Statistical Consultation Services of the North-West University analysed the data involved in the study of the above-mentioned student and assisted with the interpretation of the results. However, any opinion, findings or recommendations contained in this document are those of the author, and the Statistical Consultation Services of the NWU (Potchefstroom Campus) do not accept responsibility for the statistical correctness of the data reported.

Kind regards

Prof SM Ellis (Pr. Sci. Nat)

Associate Professor: Statistical Consultation Services