FUNCTIONAL MOVEMENT SCREENING AND INJURY PROFILING IN PROFESSIONAL SOCCER PLAYERS

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DECLARATION

I, Karel Christiaan du Toit, certify that the mini-dissertation hereby submitted for the degree M.Sc. Clinical Sports Physiotherapy at the University of the Free State (UFS) is my independent effort and had not previously been submitted for a degree at another university/ faculty. I furthermore waive copyright of the mini-dissertation in favour of the UFS.

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Karel Christiaan du Toit

Researcher **Date**

I, Mrs. A van der Merwe, approve submission of this mini-dissertation for the M.Sc. Clinical Sports Physiotherapy degree at the UFS. I further declare that this mini-dissertation has not been submitted as a whole or partially for examination before.

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Anke van der Merwe

Study leader **Date**

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LIST OF ABBREVIATIONS

BMI	Body mass index
F.C.	Football Club
FIFA	Federation Internationale de Football Association
F-MARC	FIFA Medical assessment and research Centre
FMS	Functional Movement Screen
GPS	Global Positioning Systems
PCMA	Pre-Competition Medical Assessment
PSL	Premier Soccer League
UEFA	The Union of European Football Associations
UFS	University of the Free State
WAFU	West Africa Football Union
ZPSL	Zimbabwean Premier Soccer League

INTERCHANGEABLE TERMS

Football – Soccer

Forwards - Strikers

Recurrent injury - Re-injury

OPERATIONAL DEFINITIONS

The term **injury** is defined as *"any physical complaint (contact or noncontact) sustained by a player during a football match or training session that prevented the player from taking a full part in training or match play activities for one or more days following the day of injury*" (Fuller *et al.,* 2006:193).

An **index injury** will be used to describe a re-injury. It will refer to the initial injury sustained and documented during the study (Fuller *et al.,* 2006).

A **re-injury (recurrent injury)** is defined as an injury, with a similar diagnosis to that of the index injury, which occurs in the same anatomical location after the participant has returned to full participation during the same recorded season (Fuller *et al.,* 2006).

Injury severity is defined by the number of days elapsed between the date of injury and the full return to football participation and the participant is eligible for team selection (Fuller *et al.,* 2006). Injury severity will be classified as follows; minimal (1 – 3 days), mild (4 – 7 days), moderate (8 – 28 days) and severe (> 28 days).

Injury surveillance refers to the description of injury data regarding the classifications and incidence. Injury surveillance consists of, but is not limited to, numerous aspects pertaining to injury, namely injury incidence, injury location, diagnosis, injury causes, injury severity and risk factors for injury (Roos, 2018).

Injury reporting or classification also needs to follow specific criteria in order to ensure correct information and appropriate data is collected. Injury classification, for use in this study, will include anatomical location of injury, type of injury, mechanism of injury and whether it was a recurrent injury during the recorded season. Injury reporting will be part of injury surveillance. A report form as well as the code form adapted from Dvorak, Junge and Grimm (2009) can be viewed in appendix C and appendix D of this study.

ABSTRACT

FUNCTIONAL MOVEMENT SCREENING AND INJURY PROFILING IN PROFESSIONAL SOCCER PLAYERS

Introduction and aim: The Functional Movement Screen (FMS) is the most regularly used musculoskeletal screening tool in professional football but despite its popular use, research related to the FMS and injury in football is limited to youth and amateur players. Recent research suggestions of an "optimal range" for the FMS score may improve its clinical use and relevance, however baseline composite FMS scores in professional football are lacking. African football injury rates have been found to be elevated and this is a cause for concern. Therefore, the main aim of this study was to establish baseline FMS composite scores in a professional football team (Amazulu F.C.) participating in the South African Premier Soccer League (PSL) and to determine any association between the 2017/2018 pre-season FMS composite scores and injury incidence. The secondary aim of the study was to establish the injury incidence and severity of Amazulu F.C.

Methodology: The study design implemented was a prospective cohort study. The participants included 27 professional footballers from Amazulu F.C. participating in the PSL. Participants' FMS scores were recorded during the pre-season period and injury surveillance was conducted throughout the season. Injury surveillance data was recorded with the use of FIFA's Medical assessment and research Centre (F-MARC) injury report forms. Data analysis was done to determine the 2017/2018 pre-season FMS composite scores as well as injury incidence for the Amazulu F.C. Wilcoxon-signed ranked tests were utilised to determine any association between 2017/2018 pre-season FMS composite scores and injury incidence.

Results: This study found no statistical significant ($p=0.34$) association between injury and FMS scores for one PSL team over one season. The median FMS composite score obtained by a professional football team in the PSL was 15 and ranged between 11 and 18. The injury incidence of the PSL team for the season was 57 injuries, seven of which were classified as severe, with the knee the most frequently injured anatomical location. Participants in this study who scored 16 on the FMS demonstrated the lowest injury median in comparison to all other participants.

Conclusion(s): The baseline FMS score in the Amazulu F.C. professional football players was 15 and may serve as the foundation for future research. This study found no statistical significant association between the pre-season FMS score and injury incidence. This supports the recent literature which states that the FMS is not an injury prediction tool but should rather be seen as a screening tool. The Amazulu F.C. injury surveillance was found to be in-line with recent world football research but, given the small sample size in this study, the results should be interpreted with caution.

CHAPTER 1: INTRODUCTION

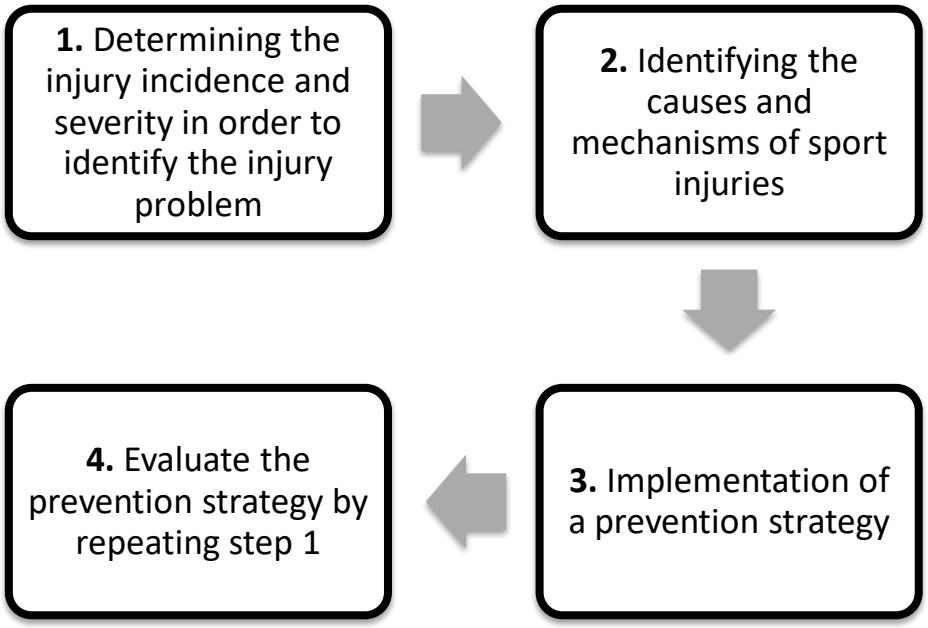
1.1 Background

Football is the most participated sport worldwide and continues to advance globally (Conley, 2015). In Africa, football provides an opportunity for many to improve their current social status (Grimm, 2014). Football is a physically demanding sport related to high injury rates (Ani *et al.,* 2015). In professional football, severe injuries remain high with no noted decline in injury rate (Ekstrand *et al.,* 2013). Since 2001, in a 13 year study period Ekstrand *et al.* (2016) noted an increase of 4% in training related hamstring injuries. Despite a decline in football related ligament injuries, high injury rates remain a burden in professional football (Ekstrand *et al*., 2013).

Injury prevention protocols in football, especially at a professional level appear insufficient with regards to the prevention of muscle injuries. This is an alarming finding in modern day football and suggests a need for improved sport specific screening to identify individuals at risk in order to improve prevention strategies.

The model of injury prevention in sports was presented by Van Mechelen *et al.* (1992) and is demonstrated in Figure 1. Step one relates to the identification of a sport and region specific injury incidence and severity.

Figure 1 Prevention of sport injuries progression (Van Mechelen *et al*. 1992).



The second step in the injury prevention sequence, is understanding the mechanism of injury and identifying risk factors associated with a specific sporting code and region. This allows for appropriate injury prevention protocols to be developed and implemented in step three (Bakken, 2018). The final step is to repeat the injury surveillance to determine whether the prevention protocols were effective.

The negative effects of injury on both the player and team, resulted in the introduction of various screening tools in professional sports (Rusling *et al*., 2015). Targett and Geertsema (2013:138) described screening as "*a process used in a population to identify unrecognised diseases in individuals without signs and symptoms*".

Federation Internationale de Football Association (FIFA) advocates all football teams to conduct an appropriate medical screening assessment for all players prior to competitive participation (Dvorak, Junge and Grimm, 2009). The Functional Movement Screen (FMS) has been found to be one of the most popular screening tools used in international football premier leagues (McCall *et al*., 2015).

1.2 Functional Movement Screen (FMS)

Musculoskeletal screening is one approach towards injury prevention used in sport. For screening tools to be used successfully, it is essential to be modified to suit the specific physical requirements of the professional athlete involved (Bakken, 2018). Injuries in football are unlikely to occur as a result of a single cause but rather from multifactorial causes (Bakken, 2018). Therefore the musculoskeletal screening tools used in professional football should be designed to assess functional movement patterns in order to identify biomechanical dysfunctions and pain which may potentially compromise performance or contribute towards injury development (Cook *et al.,* 2006a). This led to the development of the Functional Movement Screen (FMS) by Gary Cook (Cook *et al.,* 2006a).

The FMS is an assessment tool used to link pre-participation physical examinations and physical performance testing and consists of seven fundamental functional movements. These movements require adequate joint range of movement, muscle strength, flexibility, coordination, balance and proprioception in order to be completed successfully (Dorrel *et al.,* 2015, Schneiders *et al.,* 2011). The FMS is scored out of 21, with each movement scored between zero and three (Cook *et al.,* 2006a). Although screening tools are widely used in professional sport, there is limited research pertaining to injury prediction and its use in football (Van Dyk *et al.,* 2017).

Since the influential findings of Kiesel *et al.* (2007) demonstrating that a FMS score of 14 or less may indicate high risk of injury in professional American footballers, numerous research studies have investigated the FMS ability to predict injury. The cut-off FMS score of 14 or less has been further supported by the systemic review of Bonazza *et al.* (2016) and in a critically appraised topic by Krumrei *et al.* (2014).

In a more recent systematic review, contradictory evidence was found by Moran *et al.* (2017) suggesting that the correlation between FMS composite score and injury is insufficient. This finding is supported by a systematic review and meta-analysis by Dorrel *et al.* (2015) demonstrating the diagnostic accuracy of the FMS to predict injury as low.

As previously mentioned, McCall *et al*. (2015) found the FMS to be the most commonly used screening tool in professional football leagues, but no research including FMS and professional football players were found. Although no research was available on professional footballers, youth and amateur football research studies related to FMS were found. Four studies included youth football players and the remaining two studies included adult amateur football players, with all study participants varying in degrees of experience. The FMS composite scores varied between the different age groups and level of participation (Rusling *et al*., 2015, Conley, 2015, Marques *et al.,* 2017, Silva *et al.,* 2017, Sprague *et al.,* 2014, Schroeder *et al.,* 2016).

Thus, it is deemed necessary by the researcher to first establish the baseline FMS composite scores in a specific specialised population, namely professional footballers, in order to better understand and evaluate the use of the FMS for a specific population. This will help establish a foundation for future research regarding FMS in professional football. Although the FMS is intended as a screening tool, due to growing research related to the FMS and its association to injury risk and injury prediction, it was deemed necessary to further investigate this notion (Orser, 2018).

As the Head of Medical of Amazulu F.C. and a physiotherapist by profession, the occupation of the author of this research study is provided to give insight into the reasons for the inclusion of the specific study population and the interest to explore the use of the FMS in the South African professional football environment and establish whether the injury statistics of Amazulu F.C. are in-line with modern trends and research.

As previously mentioned, injury rates in football remain high with professional football players at risk of sustaining up to two injuries per season resulting in time-loss from play (Eirale and Ekstand, 2013). Playing styles and geographical regions have shown to impact injury incidence in various European football leagues (Stubbe *et al*., 2015). Thus, injury incidence in African football is expected to differ from European counterparts.

Research on various African football leagues concluded injury incidence to be higher than European football leagues (Calligeris *et al.,* 2015, Ani *et al.,* 2015 and Chagonda, 2015). Chagonda (2015) found match injury rate of 81.7 injuries per 1000 player-hours in Zimbabwean Premier soccer league (ZPSL) and Calligeris *et al.* (2015) found match injury rates as high as 88.9 injuries per 1000 player-hours in the PSL. These findings were substantially higher than the European match injury rates of 12 to 35 injuries per 1000 player-hours found by Constantinou (2010). It is considered that poverty, poor surface quality, lack of equipment and level of education could play a role in higher injury incidence in Africa (Nyagetuba *et al.,* 2015).

The high injury incidence in African football is concerning and requires further investigation. The need to establish the true injury problem in Africa is essential to protect our players and implement urgent action if required. It is therefore important to establish injury statistics pertaining to the incidence, risks and mechanisms of injury to a specific league and region in order to minimise and prevent football injuries (Dvorak, Junge and Grimm, 2009, Stubbe *et al*., 2015).

1.3 Problem statement

The high injury rates in professional football, specifically pertaining to severe injuries and the proposed increase in specific muscle injuries, highlights the need for intervention (Ekstrand *et al.,* 2016). Injury prevention protocols in football, especially at a professional level appear insufficient with regards to the prevention of muscle injuries. Thus, the use of appropriate screening in professional sport is imperative to aid in injury prevention. In professional football leagues the FMS is the screening tool most frequently used (McCall *et al*., 2015).

Despite the popular use of the FMS, no studies have been found by the researcher pertaining to the FMS and professional senior footballers. The FMS composite score have been found to differ greatly between varying populations and levels of participation. Therefore the researcher deemed it necessary to first establish the baseline FMS composite scores in the professional footballers partaking in the PSL. This will assist in establishing the use of the FMS in the PSL and form the foundation for future research related to this matter.

Although injury research related to African football injuries displayed increased injury rates, published literature was limited, with only one study found on the Premier Soccer League (PSL) in South Africa regarding injury incidence (Calligers *et al.* 2015).

The need for injury research and the benchmarking of FMS composite scores in South African professional football is highlighted by the lack of research in this field within the South African Premier Soccer League. Therefore, the injury surveillance will be conducted on South African professional footballers participating in the Premier Soccer League (PSL) for one full season on one team and the relevant associations between the FMS findings and the injury incidence will be assessed.

1.4 Research question

What are the FMS composite scores for a KwaZulu-Natal based professional soccer team (Amazulu F.C.) and is there an association between FMS scores and injury incidence?

1.5 Aim of study

The aim of the study was to determine the pre-season FMS composite scores for a KwaZulu-Natal based professional soccer team (Amazulu F.C.); and to determine the association between FMS scores and injury incidence.

1.6 Study objectives

The following primary objectives were set in order to achieve the aims of the study:

- Determine the 2017/2018 pre-season FMS composite scores for Amazulu F.C.
- Determine the injury incidence of the Amazulu F.C. at the end of the 2017/2018 football season.
- Determine any association between 2017/2018 pre-season FMS composite scores and injury incidence.

A secondary objective was also set, namely to:

- Describe the injury profile for Amazulu F.C. for the 2017/2018 football season.

1.7 Significance of study

No available research including FMS and professional football players was found. This study thus poses a great significance in professional football as it will provide a baseline score for the FMS in professional football and allow for a source of reference. It will improve clinical reasoning when using the FMS on professional football players and help physiotherapists interpret the meaning of the individuals' FMS score related to asymmetries and dysfunctions.

Furthermore, it will assist medical professionals working in the PSL to better understand the players' FMS results regarding possible injury risk factors and help implement a more individualised and specific injury prevention protocol.

Injury surveillance on the PSL will indicate whether the injury incidence in the PSL is an urgent problem, requiring immediate attention. The knowledge of injury characteristics in the PSL will enhance the development of appropriate and individual driven prevention program to help tackle the injury burden present in professional football.

Therefore, this research study could assist PSL teams in implementing appropriate prevention strategies specified to the league and region, also creating a better understanding of the FMS's uses and potential as an injury prevention and prediction tool in the PSL.

1.8 Outline of dissertation

This research study will be narrated and explained as described in the following outline:

Chapter 2: Literature review – this section will include a review of literature relating to the FMS and football injuries. The most relevant and recent research will be explored and related to the aims of this study in order to provide knowledge regarding the research topic.

Chapter 3: Research methodology – the study methodology will be explained and presented as required.

Chapter 4: Results - this section will describe the FMS data and the PSL injury surveillance data obtained and displayed in tables and figures.

Chapter 5: Discussion - The results will be discussed and evaluated in relation to the most recent and relevant research and its clinical relevance considered.

Chapter 6: Conclusion and Recommendations – the study's findings will be concluded and its clinical relevance considered. The limitations of the study will also be explained and the recommendations for future research suggested.

In the following chapter a thorough review of the available literature will be presented and discussed.

CHAPTER 2: LITERATURE REVIEW

2.1 Overview

This chapter will review the relevant literature pertaining to the research aims. A brief introduction into the sport of football will be provided and relevant aspects discussed. Football injuries in professional players remain a burden with no decline noted. Screening and prevention protocols in professional football appear insufficient. Thus, the screening process in professional football and its purposes is reviewed.

Concerningly, a possible increase in muscle injuries in professional football is suggested. Therefore, football injuries will be explored and important aspects such as incidence, risks and causes of injury will be discussed.

The FMS will be discussed in regards to its development, baseline scores, injury predictive values as well as the application of thereof. Conflicting research regarding FMS will also be explored.

The growing research relating to football injuries resulted in FIFA emphasising the importance of defining the causes, incidence and nature of injuries (Dvorak, Junge and Grimm, 2009). Therefore, establishing set terminology and definitions in injury research is imperative to ensure high quality studies and allow for comparative research data (Fuller *et al.,* 2006).

Variations in terminology and definitions used in sports injury research have been noted to significantly alter the results and outcomes of these studies (Fuller *et al.,* 2006). To avoid any misunderstandings and confusions which the reader might incur with regards varying concept definitions, the researcher included the operational definitions section, which will be utilised during the course of the study.

The term injury for the use in this study is defined as "*any physical complaint (contact or noncontact) sustained by a player during a football match or training session that prevented the player from taking a full part in training or match play activities for one or more days following the day of injury*" (Fuller *et al.,* 2006:193).

2.2 Football

As noted by d'Hooghe (2013), the progression from using an animal bladder as a ball in the Middle Ages to the use of global positioning systems (GPS) to monitor player movements in the modern day game indicates the advancements of football over the centuries. Football has always been a game of eleven players versus eleven, with both teams aiming to score a goal by getting the ball in the opponents goals. Football is participated by men, women and children around the world with FIFA determining that approximately two hundred and sixty-five million individuals participate in football regularly (Akodu *et al.,* 2012). Although football has many health benefits there is always an inherent risk of injury due to the physical demands of the sport (Pilis *et al.,* 2017).

The physical demands of football include running, pivoting, turning and kicking. Other physical demands of the game, such as jumping, acceleration, deceleration and player contact, can contribute to a greater risk of injury (Conley, 2015). It was determined by Bloomfield *et al*. (2007) that specific playing positions namely, defenders, midfielders and strikers are exposed to different physical demands and require different physical traits.

The total distance covered by a professional footballer in a match is shown to be between nine and twelve kilometres, which includes between 1000 and 1500 distinct movement changes per player (Owen, 2016a). Midfielders spent the most time running and sprinting in comparison to all other positions during a competitive match. Midfielders along with full-backs are found to cover significantly greater distances than centre-backs (Owen, 2016a). Bloomfield *et al.* (2007) demonstrated a significant difference in the three playing positions with regards to specific purposeful movements. It was found that defenders performed the least amount of time sprinting but performed most skipping and shuffling movements in comparison to all other positions (Bloomfield *et al.,* 2007). The quantity of high intensity loads varied between each different playing position, therefore each position requires different physical adaptation to manage the varied load (Owen, 2016a).

These findings provide valuable knowledge in the planning and implementing of player conditioning, football specific training and injury prevention protocols throughout the season. As discussed above it is clear that specific playing positions in football require varying physical demands and attributes. However, Owen (2016a) also noted different playing styles, team formation and tactics can alter the physical demands placed on professional footballers. This has contributed to the continuous evolution of fitness and conditioning in modern football.

Owen (2016b) describes the key components of football conditioning as tactical, technical, physical and psychological, which can all be influenced by the specific playing system and playing style of each team, coach and club. For example, it was demonstrated that a forward can do up to 30% more high intensity running in a playing system of four – three – three when compared to playing systems of four - four – two and four – five – one (Owen, 2016a). Although the in-depth analysis of football specific conditioning and style of play falls out of the scope of this study it is important to mention due to the direct influence and contribution to injury development.

It was found that midfielders sustained the most injuries in the Italian premier league and the PSL followed by defenders (Falese *et al.,* 2016, Calligers *et al.*, 2015). Hagglund *et al.* (2012) demonstrated that goalkeepers had decreased risk of injury in all 4 muscle groups (Adductors, Hamstrings, Quadriceps and Calf) but no difference in muscle injury rates of outfield players. Hawkins *et al.* (2001) found defenders to sustain more injuries in the English football league over two consecutive seasons. However, it has to be mentioned that this study was conducted in 2001 and the evolution of football in the past 15 years with regards to playing styles, conditioning and general professional conduct has to be considered.

These findings illustrates the development and advancements in modern day football, highlighting the importance of continued research in football injury surveillance and conditioning. Similarly, injury prevention strategies should be aimed at the specific injury information of a specific league. Screening in sport is one tool to help prevent injury and should be specific to the tested population and sport.

2.3 Screening in Sport (Football)

Professional sports and various occupations carry inherent risk of injury, illness and other possible factors leading to detrimental outcomes (Bakken *et al.,* 2016). Injury and decreased performance have substantial negative impacts on both individual and institution with regards to financial, biopsychosocial and possible long-term health implications (Dallinga *et al.,* 2012).

Therefore, the prevention of sport and occupation related injury and illness is apparent. In professional football it is of great importance to protect the players health and wellbeing to ensure that optimal performance levels are achieved. Periodic health evaluation or pre-participation examinations is the screening of individuals in an attempt to identify risk factors, in order to ensure safe participation and forms part of a prevention strategy (Bakken, 2018). The identified risks, symptoms and/or deficiencies will ensure individuals are managed appropriately and examined further to prevent potential injury, illness and/or defected performance.

In order to ensure the most accurate and adequate outcomes are achieved during the screening process, it is required to be specific to the target population and the potential physical demands which an individual may incur. Screening in football consists of three main components including general medical screening, musculoskeletal screening and performance screening, which will be discussed in more detail below.

2.3.1 Medical screening

Medical screening in football focuses on the general medical health of the individual and the history and physical assessment of the cardiovascular system. Some cardiovascular assessments may include echocardiography, if deemed necessary (Brukner and Khan, 2012).

The FIFA Pre-Competition Medical Assessment (PCMA) consists of a comprehensive examination including medical history, clinical examination, orthopaedic examination, 12 lead-resting electrocardiography, echocardiography and blood results (Dvorak, Junge and Grimm, 2009).

In a study done by Bakken *et al.* (2016), periodic health evaluations were conducted on 558 professional footballers. It was detected that 95.5% of the participants had at least one condition which required further investigation, treatment or follow-up. The most common general medical conditions detected included vitamin D deficiency or insufficiency, Hepatitis B, dyslipidaemia and iron deficiency (Bakken *et al.,* 2016). This allows for prompt action where required, protection of the football player and enhances performance.

Sudden cardiac death and acute myocardial infarctions may be triggered by strenuous exercise in susceptible individuals. Football was found to cause 44.9% of all sport related deaths in Italy and 33.3% of all sport related deaths in Spain of athletes under 35 years (Özdemir *et al.,* 2008). These findings clearly indicates the necessity of medical screening in sport especially professional football. Although most injuries in football are related to musculoskeletal conditions, the prevention of potentially fatal conditions are essential.

In the above-mentioned study by Bakken *et al.* (2016) on 558 professional footballers, musculoskeletal conditions were detected in 32.3% of the participants. This highlights the benefits of screening in professional football and illustrates the possible use of screening to help prevent injury.

2.3.2 Musculoskeletal screening

The knowledge that musculoskeletal injuries in professional football remains high, encourages periodic screening in order to identify risk factors and introduce targeted intervention programs (Bakken, 2018). It is essential that the musculoskeletal screening tool used, is specifically directed at the targeted sport code and can accurately identify individuals at risk within the targeted population (Van Dyk *et al.,* 2017). It is therefore important to establish which screening tool is best suited for professional footballers.

The FIFA PCMA consist mainly of traditional musculoskeletal evaluation tools including general posture observations, general muscle strength testing, muscle flexibility and range of movement testing of the spine, hip, knee, ankle and foot (Dvorak, Junge and Grimm, 2009). General orthopaedic integrity tests are included mainly for the knee and ankle joints (Dvorak, Junge and Grimm, 2009). A musculoskeletal medical history is also obtained which includes a history of previous severe injuries, previous musculoskeletal surgery and the presence of any current injury or complaint, which will identify areas requiring further examination (Dvorak, Junge and Grimm, 2009). Although the FIFA PCMA is thorough, it mainly consists of general and traditional musculoskeletal examinations rather than functional and sport specific screening.

Research pertaining to the above-mentioned screening tools is discussed in order to identify the most appropriate tests. In a systematic review by Dallinga *et al.* (2012) numerous screening tools were analysed to determine the ability to predict injury in team sports. The review included numerous sporting codes, namely soccer, basketball, American football, volleyball, ice hockey and Australian football league with all study participants varying in age, gender and sport experience. Dallinga *et al.* (2012) found literature to support general joint laxity to predict injury in the lower extremities. Further screening tools identified to predict musculoskeletal injury was increased age, decreased hip abduction range of movement and a lower hamstring to quadriceps ratio (Dallinga *et al.,* 2012). Hamstring injuries were associated to an increase in age, but inconclusive findings were demonstrated for hamstring injuries and hamstring flexibility. Groin injury have been associated to the Hip-adduction-to-abduction strength test in ice hockey players and ankle injuries associated with age and body mass index (BMI) (Dallinga *et al.,* 2012).

Although some tools displayed encouraging findings, limitations related to the above-findings by Dallinga *et al.* (2012) are the inclusion of the high variety of tasks and the need to establish which tool to use. Further, the varying sporting populations included in the review, as well as level of experience, age and gender of all participants make it difficult to establish sport specific use of certain screening tools. Thus, these findings should be interpreted with appropriate clinical reasoning and care.

Numerous musculoskeletal screening tools are available but determining the best possible tests can be difficult. There is no uniformity in screening protocols with most screening tools at jeopardy of being subjective and unreliable (Brukner and Khan, 2012). Further problems noted with the screening process are the strenuous workloads and time consuming efforts often leading to low compliance (Brukner and Khan, 2012). Therefore, screening tools should be modified to suit the specific physical requirements of the professional athlete involved. In order for screening tools to be effective, it is imperative for these tools to be valid, reliable and have acceptable measurement errors (Bakken, 2018).

In consideration of the discussed research on musculoskeletal screening, it is evident that the need to establish the most accurate and appropriate screening tool for a specific sport is required.

2.4 Functional Movement Screen (FMS)

2.4.1 Introduction

There are a wide variety of physical and performance tests used in the screening of football players. The main purposes of screening in football is to prevent injury, prevent re-injury, enhance performance and predict future injury (Cook *et al.,* 2006a). The numerous individual tasks and time-consuming tests identified by Dallinga *et al*. (2012) in sport screening encouraged sports medicine teams to develop an all-encompassing functional screening tool such as the Functional Movement Screen (FMS) (Cook *et al.,* 2006a). The FMS is a screening tool that attempts to combine sport specific functional movements in conjunction with the individual tests identified to predict injuries (Dorrel *et al.,* 2015). This will possibly decrease the time and workloads related to musculoskeletal screening and hopefully improve the accuracy and compliance of musculoskeletal screening.

Movement screening enhances the view on the individual's biomechanical chains during movement in order to assess functional capabilities and identify possible injury risk factors during performance (Gadziński *et al.,* 2016).

2.4.2 Test Components and scoring

The FMS consists of seven fundamental functional movements. These movements require adequate joint range of movement, muscle strength, flexibility, coordination, balance and proprioception in order to be completed successfully (Schneiders *et al.,* 2011). The seven movements identify movement dysfunctions and/or asymmetries in individuals that might predispose them to injury. These movements aim to identify the presence of muscle imbalance and weakness by exposing an individual to end-range positions that require adequate stability and mobility (Cook *et al.,* 2006a).

Each of the seven movements are scored between zero and three, with three being the best possible score and the total score adding up to twenty-one. A participant is scored three points when a movement is achieved successfully with no use of compensatory movements. A participant is scored two points if movement is performed with compensation and one point if the movement is not achieved adequately. A score of zero is given if pain was present during the movement test (Gadziński *et al.,* 2016). The FMS score sheet adapted from Cook *et al.* (2006a) can be found in appendix I.

The seven FMS movements include the Deep Squat, Hurdle Step, In-line Lunge, Shoulder Mobility Test, Active Straight Leg Raise, Trunk Stability Push-up and Rotary Stability Test (Cook *et al.,* 2006a). The FMS score rubric as prescribed by Cook *et al.* (2006a) is available in appendix H.

2.4.3 Movement Descriptions

The above-mentioned tests are discussed below to provide information regarding the movement purpose and functional association.

The Deep Squat - is a common action in all sport, as it requires sufficient range of movement of the ankles, knees, hips, shoulder and spine. It also assesses symmetry and the ability to functionally control the movement with sufficient core control. Power movements (jumping, football heading) are often generated from a deep squat position and the presence of decreased range of movement, asymmetry and muscle imbalance may increase injury risk (Cook *et al.,* 2006a).

The Hurdle step - assesses the stride biomechanics and requires stability and coordination. This movement imitates a stepping action over a hurdle level to the participants' tibial tuberosity. It requires single leg stance stability and dissociation of movement of bilateral hips and the torso (Cook *et al.,* 2006a). Again, any asymmetries, decreased flexibility and minimised joint range of movement will be exposed and may possibly lead to the development of injury.

The In-line Lunge - focuses on narrowing the base of support and attempts to expose the participant to stresses of deceleration, rotational movements and lateral movements. This action requires full hip and ankle mobility and overall stability. Trunk control during the instable action is assessed along with quadriceps flexibility and knee control (Cook *et al.,* 2006a).

The Shoulder Mobility test - combines maximal shoulder range of movement of both shoulders in opposite directions, namely internal rotation with adduction and external rotation with abduction on the opposite side. This assesses range of movement and normal function of the scapula along with adequate thoracic spine mobility (Cook *et al.,* 2006b).

Active Straight Leg Raise - will assess muscle flexibility, dissociation of lower extremity movement and core stability (Cook *et al.,* 2006b).

The Trunk Stability Push-Up - assesses upper body strength and movement in conjunction with core stability. Spinal control and the presence of any asymmetries are tested in this closed chain movement (Cook *et al.,* 2006b).

Rotary Stability test - requires adequate dissociation of movement between the upper and lower limbs with subsequent trunk stability. It's a complex movement assessing neuromuscular control and co-ordination (Cook *et al.,* 2006b).

These movements are accompanied by clearing exams which are performed to expose the presence of pain. If pain is present during any of the clearing exams, a score of zero is given to the associated movement test. The following clearing exams are included (Cook *et al.,* 2006b).

The Shoulder clearing test - is performed to detect any impingement or deficits that require a more complex shoulder girdle evaluation (Cook *et al.,* 2006b).

Spinal extension clearing test - in this test the spine will be placed at the end-range of spinal extension in a prone position with the arms in an extended position with the upper torso of the floor. The presences of pain or movement blockage may indicate the existence of pathologies and warrant further investigation (Cook *et al.,* 2006b).

Spinal flexion clearing test - in this assessment the spine will be placed at the end-range of spinal flexion, with the hips and knees in full flexion. The participant, in a prone position, attempts to sit on their heels with their upper limbs extended above their heads. The presences of pain or movement blockage may indicate the existence of pathologies and warrant further investigation (Cook *et al.,* 2006b).

In order for screening tools to be effective, it is imperative for these tools to be reliable, valid and have acceptable measurement errors (Bakken, 2018).

2.4.4 Interrater and Intra-rater Reliability of the FMS

The interrater reliability of composite FMS scores and the individual movement tests have been reviewed between novice and expert examiners (Schneiders *et al.,* 2011). The interrater reliability was found to be excellent for FMS composite scores with intraclass correlation coefficient of 0.971 and good to excellent for individual tests with Kappa values ranging from 0.7 to 1.0 (Schneiders *et al.,* 2011).

A systemic review and meta-analysis by Bonazza *et al.* (2016) also found good to excellent intra-rater and interrater reliability with regards to composite FMS scores, as well as individual movement tests. Bonazza *et al.* (2016) determined intraclass correlation coefficient for interrater reliability to be 0.81 (95% CI, 0.70-0.92) and intra-rater reliability to be 0.81 (95% CI, 0.69-0.92).

A systemic review by Kraus *et al.* (2014) demonstrated that numerous studies described the FMS scoring system as reliable and found good to excellent reliability of different examiners using the FMS system. Further, Kraus *et al*. (2014) confirmed that the FMS is a reliable screen when conducted by an educated and experienced examiner.

2.4.5 FMS Composite Scores

The FMS individual movement tests, as described in 2.4.3, identify dysfunctions or asymmetries in individuals which might predispose them to injury. Football injuries are likely to occur due to multifactorial causes, possibly making the FMS a more sport specific screening tool (Bakken, 2018).

The FMS has been widely used in professional football, but no research regarding the baseline composite scores are available in literature. In order for any screening tool or test to be used successfully, baseline data is of importance to allow physiotherapists, coaches and sport scientists to accurately interpret raw data (Schneiders *et al.,* 2011).

Research, although very limited, on baseline FMS values found an average FMS composite score of 15.7 in physically active individuals with no history of musculoskeletal injury, with no difference between male and female participants (Schneiders *et al.,* 2011). This study by Schneiders *et al.* (2011) included both male and female participants, aged between 18 and 40 years, from varying populations consisting of tertiary students, sport clubs and the general public.

Therefore the above-mentioned study by Schneiders *et al.* (2011) should be interpreted with caution when related to a specific population, namely professional football players. As the FMS composite scores can be influenced by numerous factors, namely age, sex, body composition, sporting participation and specific sporting codes (Letafatkar *et al.,* 2014, Moran *et al.,* 2017, Nicolozakes *et al.,* 2018).

For this reason, football specific research was reviewed in order to determine the availability of baseline composite FMS scores in professional football. The literature found on FMS composite scores in football players are displayed in table 1. Four studies included youth football players and the remaining two studies included adult amateur football players with all study participants varying in degrees of experience (c.f. Table 1). The FMS composite scores appear to vary between the different age groups and the level of participation with improvement noted from youth development to young adults and further improvement with higher level of participation (c.f. Table 1).

Table 1 Composite FMS scores in Football research (compiled by the researcher Du Toit, K.C. 2018)

SD – standard deviation *age range is provided where no SD was available

Author	**Mean FMS scores (SD)**	**Study Population**	**Mean Age years (SD) or (age range)**
Rusling *et al*. (2015)	12.1 (+/-2.3)	125 professional academy players	13.6 *(range 8 to 20)
Conley (2015)	12.9 (+/-1.56)	119 youth male footballers (South Africa)	15.29 *(range 13 to 19)
Marques *et al.*(2017)	13.00 (+/-1.61)	103 youth male footballers (Brazilian)	*(range 14 to 20)
Silva *et al.* (2017)	13.87 (+/-2.93)	23 youth national footballers	15.78 (+/-0.53)
Silva *et al.* (2017)	14.96 (+/-2.07)	25 youth national footballers	17.32 (+/-0.48)
Sprague *et al.* (2014)	16.16 (+/-1.54)	20 male soccer players National collegiate athletic Association Division 2 athlete	20.1 (+/-1.1)
Schroeder *et al.* (2016)	13.6 (+/-2.1)	96 amateur footballers (German)	23.7 (+/-3.5)

None of the mentioned research or otherwise found research related to FMS scores or its association with injury, included senior professional football players. This is concerning when considering the FMS is a frequently used screening tool in professional football premier leagues (McCall *et al*., 2015).

Thus, it is deemed necessary to establish baseline FMS composite scores in professional footballers in order to interpret the raw data with greater accuracy and purpose. The baseline FMS composite scores for a specific population may better help the understanding and association, if any, between FMS and injury.

2.4.6 FMS and injury association

The FMS was originally designed as a screening tool to identify movement dysfunction but since the influential findings of Kiesel *et al.* (2007) demonstrating that the FMS score of 14 or less is associated to high risk of injury in professional American footballers, numerous research studies have investigated the FMS ability to predict injury.

Keisel *et al.* (2007) identified that professional American footballers scoring 14 or less were at higher risk of sustaining a serious injury. Further, a FMS score of 14 or less in female college athletes identified participants to be at a significant increase of risk of injury (Chorba *et al.,* 2010). The systemic review by Bonazza *et al.* (2016) further supported the finding by Keisel *et al.* (2007), indicating that participants scoring 14 or less in the FMS are more susceptible to sustaining an injury. The above-mentioned findings suggested that the FMS could be more than just a musculoskeletal screening tool, but could possibly predict injury.

However, a recent systematic review done by Moran *et al.* (2017) found insufficient correlation between the FMS and injury. Further, Dorrel *et al.* (2015) demonstrated low diagnostic accuracy of the FMS to predict injury. The contradictory findings suggested further investigation and research is required in this field in order to establish the true use of FMS in sports. Research related to FMS and injury will be analysed and discussed below.

Warren *et al.* (2015) found no association between FMS composite score and non-contact injuries, in a wide variety of sporting codes. Sorensen's (2009) study on high school basketball players failed to find evidence that the FMS can predict injury. It was found that 22% of the participants scoring below the composition score of 14, as recommended by Kiesel *et al.* (2007), sustained injuries and 24% of the participants scoring above 14 sustained injuries.

Mokha *et al.* (2016) demonstrated that individuals who score one out of the possible three for any of the FMS tests, or who present with asymmetries, have a higher probability of sustaining an injury. Rusling *et al.* (2015) found two out of the seven movements had significant association between non-contact injuries in youth footballers, namely the Deep Squat and the Trunk Stability Push-up.

Letafatkar *et al. (*2014) predicted that a university athlete could be 4.7 times at greater risk of suffering a lower limb injury when scoring less than 17 on the FMS, which stands in contrast to a score of lower than 14 as advocated by Kiesel *et al.* (2007). In the study by O'Connor *et al.* (2011) on 874 male marine officers it was determined that a score of 14 or less was associated to injury risk, but demonstrated low sensitivity. The possibility of a bimodal distribution was described by O'Connor *et al.* (2011), demonstrating that participants scoring 18 on the FMS had significantly higher injury rates than those who scored 17.

In a recent literature review by Orser (2018) it was determined that risk of injury was associated with FMS scores of 14 or less as well as with scores of 18 or more. Therefore, Orser (2018) suggested the possibility of a “optimal range” for FMS scores. This is based on the suggestion that participants scoring 18 or more on the FMS may lack movement variability in training routine, leading to increased risk of injury (Orser, 2018). Given that this is hypothetical further investigation is suggested.

Orser (2018) suggests athletes scoring between 15 and 17 on the FMS may continue with performance testing, where athletes with a score of 14 or less or 18 or more require further assessment. This possibly suggests categorisation of participants into the scores specific categories to establish associations between injury risk.

The above findings of the FMS and its association to injury demonstrates the need for further research, particularly in a specific sport code and population. The need to establish baseline FMS composite scores is deemed essential in order to form normative data in a specific population to accurately investigate the association of FMS and injury.

This research study aims to determine a pre-season composite FMS score in a PSL team, in order to form the baseline for further research and allow for a source of reference.

Referring back to the sequence of injury prevention model introduced by Van Mechelen *et al.* (1992) the initial step of prevention involves the identification of a sport and region specific injury incidence and severity. Thus, related to the study aim, a review of football injuries including African football injuries will be conducted in the next section in order to establish the most appropriate screening tool related to injury incidence, risks and mechanisms.

2.5 Injury profiling in Football

The pressures to perform at the highest professional level, along with the physical requirement of sport, including running, pivoting, turning and kicking lead to high injury rates in football (Bloomfield *et al*., 2007, Ekstrand *et al.,* 2013). In 2005 an Injury Consensus Group was formed with the guidance of FIFA’s Medical assessment and research Centre (F-MARC) to design a consensus statement with regards to football injury research (Fuller *et al.,* 2006). The consensus statement aims to improve uniform outcomes on football injury research. Despite the introduction of the Injury Consensus Group, it is still reported that many problems occur in football injury research as a result of methodological inconsistencies (Stubbe *et al.,* 2015).

Therefore the operational definition section is included to improve the understanding of the terms and definitions used. Football injuries will be reviewed regarding injury incidence, site and diagnoses of injury, injury severity and injury risk factors associated to football.

2.5.1 Injury Incidence

The Union of European Football Associations (UEFA) injury study conducted by Ekstrand *et al.* (2009) provides guidance on the incidence of football injuries and the natural pattern of seasonal injury variations. The UEFA injury study was performed on the elite European leagues over seven seasons and aimed to identify injury characteristics and variations. This study included 23 elite European teams from England, Italy, Spain, Netherlands, France, Portugal, Germany, Belgium, Scotland and Ukraine. This information is beneficial, as most studies conducted on injury surveillance in football are usually conducted over only one season. The extended research period will provide more accurate and plausible information.

The UEFA injury study by Ekstrand *et al.* (2009) concluded that each football player could expect to sustain on average, two injuries every season. Ekstrand *et al.* (2009:556) stated that "*an elite team with 25 players can expect about 50 injuries each season"*. This will directly influence team performance as approximately 12% of the squad will be unavailable for selection at any time of the season (Eirale and Ekstrand, 2013).

In the Dutch Premier Soccer League 62.7% of the players were affected by injury and one in four players will be affected by injury in the Italian Serie A league (Stubbe *et al.,* 2015, Falese *et al.,* 2016).

Contrastingly, in the only study found on the PSL, it was determined that a PSL team reported a total of 130 injuries during one football season (Calligeris *et al.,* 2015). This Indicates that a player would average 4 injuries per season in the South African PSL. This finding is concerning as the incidence is much higher in comparison to the previous research results. Although this is only obtained from one team and should be interpreted with caution.

The only other studies found on African injury incidence included two studies on injury occurrence during a specific cup tournament and one study on the Zimbabwean Premier Soccer League (ZPSL).

Akodu *et al.* (2012) determined that injury incidence was higher during the West Africa Football Union (WAFU) Nations' cup than that of other tournaments conducted in Europe and World cup tournaments. However, mention needs to be made of the definition of injury used in Akodu *et al.'s* (2012) study, as it did not consider the consequences of the injury with regards to further participation or not. Therefore the study results needs to be interpreted with caution and true extent of injuries in the study questioned.

Further in African injury research, Chagonda (2015) found a match injury rate of 81.7 injuries per 1000 player-hours in Zimbabwean Premier soccer league (ZPSL) to be higher than the European match injury rates of 12 to 35 injuries per 1000 player-hours found by Constantinou (2010). Even higher match injury rates of 88.9 injuries per 1000 player-hours in the PSL was described by Calligeris *et al.* (2015).

These varying results between Ekstrand *et al.* (2009), Calligeris *et al.* (2015), Hawkins *et al*. (2001), Stubbe *et al.* (2015) and Falese *et al.* (2016) on injury incidence across different leagues and regions suggest that all professional leagues should have injury surveillance done in order to establish the injury information specific to the league and region.

These variations in findings should be interpreted with caution as it was determined that there are possible flaws in football epidemiology analysis, as research methodologies are inconsistent. This was a result of considerable differences in injury definitions, data collection methods and injury recording used between the various injury research studies (Stubbe *et al.,* 2015).

Thus, appropriate and on-going injury incidence surveillance in the African football leagues, specifically in South Africa, is required to establish accurate results.

2.5.2 Injury Location

The UEFA injury study by Ekstrand *et al.* (2009) revealed that 87% off all football injuries are sustained in the lower extremities. Identically, Hawkins *et al.* (2001) found that 87% of football injuries occurred in the lower extremities in the English Premier League. Stubbe *et al.* (2015) found 83% of all injuries in the Dutch Premier League occurred in the lower limbs. Thus, it is safe to conclude that the majority of football injuries occur in the lower extremities.

Ekstrand *et al.* (2009) identified the anatomical locations most commonly affected in football injuries was the thigh (23%), knee (18%), ankle (14%) and the hip/groin (14%), respectively. Similar findings regarding injury locations and prevalence were demonstrated in the Dutch Premier soccer league, Italian Serie A and English Premier League (Stubbe *et al.,* 2015, Falese *et al.,* 2016, Hawkins *et al.,* 2001).

In the available research on African football, similar results were found in the ZPSL by Chagonda (2015) and the PSL by Calligeris *et al.* (2015) in one season, although the order of prevalence differed. The most notable difference was lower knee injuries (8%) in the PSL reported by Calligeris *et al.* (2015). Another exception was higher head/face injuries in the ZPSL with 13% and 8% of all injuries in the PSL a result of head/face injuries. This was higher than the 2% determined by Ekstrand *et al.* (2009) in the UEFA injury study and 1% by Hawkins *et al.* (2001) in the English Premier League. This possibly highlights the different playing styles and skill level between the varying leagues.

The knowledge that the majority of football injuries occur in the lower extremities, specifically the thigh, knee and ankle allows for improved prevention programs as well as identifies focus points in football specific conditioning programs.

2.5.3 Injury Diagnosis, Type and Mechanism

Insight into the diagnosis, type and mechanisms of injury in football allows for a more accurate prevention approach. This knowledge enables medical staff and coaches to expose an athlete to specific events that may result in injury in order to acquire specific adaptation to the imposed demands (Brukner and Khan, 2012).

The UEFA injury study by Ekstrand *et al.* (2009) demonstrated muscle strains (35%), ligament sprains (18%) and contusions (17%) as the most common diagnosis in football. Hawkins *et al*. (2001) found similar results in the English Premier League. This finding highlights the increased risk of muscle injuries in professional football.

Mechanism of injury is defined as the process of how a physical injury occurs. Mechanism of injury can often be used to help diagnose and determine the severity of an injury (The Free Dictionary, 2018).

Hawkins *et al.* (2001) monitored four English Premier League football teams for two seasons, determined that running (19%), tackled (15%), tackling (9%) and twisting/turning (8%) were the most frequent mechanisms of injury. The literature review on soccer injury in the lower extremities by Wong and Hong (2005) supported these findings as running and tackling being the most prevalent mechanisms.

Football injuries can be identified as contact or non-contact injuries. Hawkins *et al.* (2001) determined that non-contact injuries accounted for 58% of all injuries and the remaining 38% as contact. The literature review by Wong and Hong (2005) supported that non-contact injuries were the primary type of injury, accounting for 59% of all football injuries.

Available research on football injuries in Africa offered limited insight into the diagnosis and mechanism of injury. The study on the PSL by Calligeris *et al.* (2015) demonstrated contusions as the most common diagnosis, accounting for 33% of all injuries followed by muscle strains (29%) and Sprains (23%), respectively.

This finding suggest that African footballers are at a higher risk of contusion injuries than European footballers. This knowledge could allow for the evaluation of the playing style in Africa, as it may be more physical than European style and adapt injury prevention protocols to accommodate the specific league.

Based on the above findings, muscle strains are the most common injuring in football. Secondly, running has been identified as the most common mechanism of injury with most football injuries occurring in a non-contact situation. Considering these findings, it should be priority to identify modifiable risk factors in individuals in order to design and implement adequate running and muscle conditioning programs to minimise the risk of injury.

It is important to establish whether contusions are always the most prevalent injury diagnosis in African football, as causes need to be identified and addressed. If it is as a result of law violations or poor pitch quality, prompt action is required to minimise these injuries.

2.5.4 Injury Severity

It is important to determine the severity of injury as it could provide insight into the availability of adequate treatment and rehabilitation, which return to play protocols are implemented and determine the extent of the injury problem present in a specific league.

As mentioned in the operational definitions, injury severity is classified as follows minimal (1 – 3 days), mild (4 – 7 days), moderate (8 – 28 days) and severe (> 28 days).

The UEFA injury study demonstrated that 16% of all injuries in football are classified as severe, which was on average eight severe injuries per team in one football season (Ekstrand *et al.,* 2009). Similarly, Stubbe *et al.* (2015) demonstrated 15% of all injuries in the Dutch Premier Soccer League were considered as severe.

Falese *et al.* (2016) demonstrated that 48.5% of all injuries in the Italian Serie A league were recorded as severe. These findings should be interpreted with caution as it was found that minimal injuries (< 4 days) were not recorded in this study, hence a possible misrepresentation of severe injuries as a higher percentage.

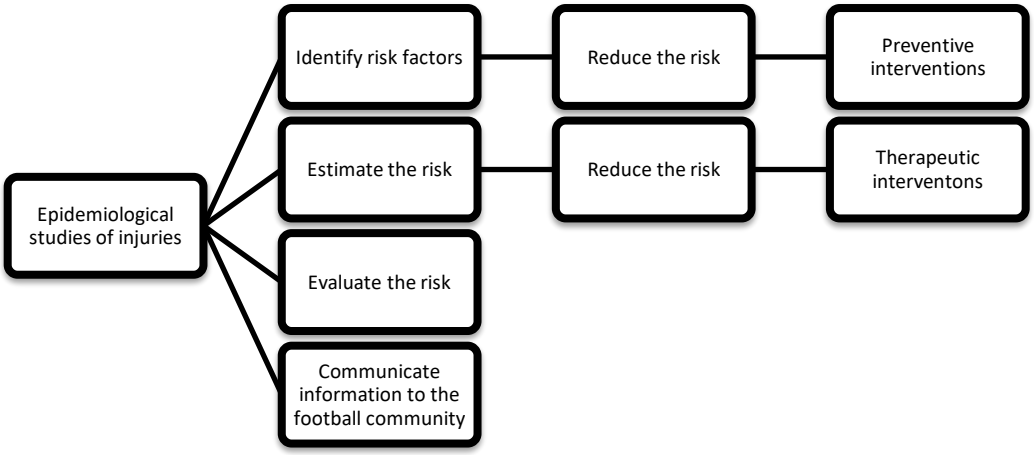
Concerningly, the study on the PSL by Calligeris *et al.* (2015) demonstrated that 56% of all injuries were classified as severe (>28 days). This is more than half of all injuries sustained and would have directly impacted squad availability.

The high injury severity in South African football is a great concern considering the relatively low severe injury rate in European football (Ekstrand *et al.,* 2009). It is essential to determine whether the injuries in the PSL are consistently of a severe nature and assess whether it is an on-going complication. The above finding emphasises the need for injury research in African football leagues.

2.6 Risk factors for injury

The F-MARC's concept of injury prevention demonstrates risk analysis to follow injury epidemiological studies in football (c.f. Figure 2). All sports are predisposed to injury but participant susceptibility is affected by interactions between (intrinsic factors) and the environment (extrinsic factors) (Roe *et al.,* 2017). Therefore injury risk management supplements injury prevention.

Figure 2 F-MARC's concept of prevention (Dvorak, Junge and Grimm, 2009).



Injuries often occur as a result of multiple factors during an inciting event, which involves predisposed individual athlete characteristics known as intrinsic factors interacting with extrinsic risk factors (Roe *et al.,* 2017).

2.6.1 Intrinsic risk factors

F-MARC's Football Medicine Manual describes intrinsic factors as player-based factors that might predispose a player to an injury (Dvorak, Junge and Grimm, 2009). The footballer's age, gender, previous medical history, muscle strength, flexibility and joint range of movement are all intrinsic risk factors that have been identified as risk of injury (Dvorak, Junge and Grimm, 2009).

Intrinsic risk factors are classified as modifiable or non-modifiable factors. Specific interventions can be aimed at the modifiable intrinsic risk factors in order to reduce the injury risk (Brukner and Khan, 2012). McCall *et al.* (2015) identified previous injuries, fatigue and muscle imbalance as being the most prevalent intrinsic risk factors predisposing a football player to injury. These intrinsic risk factors will be discussed in greater detail below.

Previous injury has been well established as a significant intrinsic risk factor, as previous injury may lead to neural inhibitions, muscle atrophy, fascicle length changes, strength deficits and increased fatigue (Roe *et al.,* 2017). This could result in a player unable to withstand the demands of the sport and therefore be more susceptible to injury. Although previous injury may not be modifiable, the adaptations to an athlete's body following injury can be assessed and managed. Appropriate return to play protocols should be in place to minimise re-injuries associated with early return to play.

Fatigue can be associated with number of aspects including mental and physical fatigue. Fatigue may alter the biomechanics of an individual and influence the central nervous system. The change in biomechanics can increase the demands on certain structures leading to increased tissue damage and ultimately injury (Brukner and Khan, 2012). Muscle fatigue associated with accumulative bouts of exercise may be a potential risk of injury, more so than a single bout of exercise (Tosovic *et al.,* 2016). Brisk and uncontrolled training loads are thought to be more likely responsible for non-contact injuries (Gabbett, 2016).

Muscle imbalances may also result in a potential increase in injury risk. Hägglund *et al.* (2013) suggests that imbalances may develop from specific kicking leg preference and/or dominant side compensation in football players. The imbalances will result in overuse of specific muscles or failure of other muscle groups to withstand the specific demands (Hägglund *et al.,* 2013). Muscle imbalance correction during the football preseason was found to decrease hamstring injury rates (Croisier *et al.,* 2008).

Hägglund *et al.* (2013) indicated that older players are more susceptible to muscle injuries, especially increased risk of calf injuries. The reasons for the increased risk of muscle injuries in older players are unclear but it has been proposed to be due to age-related changes, such as decreased range of movement and flexibility (Hägglund *et al.,* 2013).

Other possible risks such as the role of specific playing position has yielded contrasting evidence regarding specific increased injury risks (Falese *et al.,* 2016). Higher injury rates have been found in midfielders by Calligeris *et al.* (2015) and Falese *et al.* (2016). Hägglund *et al.* (2013) demonstrated that risk of muscle injuries were lower in goalkeepers but no noted difference in muscle injury rates of outfield players.

Sports medical professionals should aim to expose prevalent intrinsic risks factors, specifically modifiable factors and in doing so minimise risk of injury.

2.6.2 Extrinsic risk factors

Extrinsic risk factors are external factors which footballers are exposed to, such as specific situations or event-based circumstances (Dvorak, Junge and Grimm, 2009). Extrinsic factors can be categorised as human, equipment and environmental factors (Brukner and Khan, 2012).

Human factors consists of opponents, referees and teammates that may contribute to an inciting event resulting in injury (Brukner and Khan, 2012). In African football this has shown to be a concern, as Calligeris *et al.* (2015) demonstrated that 24% of all injuries sustained during a PSL season was a direct result of unfair play.

Equipment used in football is predominantly the type of footwear to ensure adequate grip on surfaces and protection from external contact situations. Different types of football studs are designed for different climate conditions (dry/rain) and pitch conditions (soft/hard). Inappropriate footwear can lead to a player slipping or getting their foot stuck causing twisting and turning, possibly resulting in injury (Wong & Hong, 2005). Shin guards are used for protection from external trauma and should be of standard quality and appropriate size.

Pitch quality could be a significant extrinsic risk factor in African communities. Nyagetuba *et al.* (2015) found that sub-optimal pitch conditions were associated with injury and that injury severity was likely to be higher on poor quality pitches. This study found that injury incidence were two times more on poor quality pitches than on good quality ones. Chomiak *et al.* (2000) found that 21% of severe injuries in football players could be related to bad quality pitches. Therefore, pitch quality is at times a modifiable risk factor and should be considered when possible. This could possibly explain the high injury severity demonstrated by Calligeris *et al.* (2015) in the PSL.

The extrinsic factors described by Hägglund *et al.* (2013) are match type (league or cup), match venue (home or away), part of season (preseason, first half/second half of season) and climate conditions (rain/heat).

Hagguld *et al.* (2012) found that the specific period of the football season was associated with injury, for example during the preseason there were up to 40% more quadriceps muscle injuries compared to any other time during the football season. This is possibly due to different type of football sessions during this period of the season, including more passing, crossing and shooting drills placing higher demands on the quadriceps muscle.

Hamstring and adductor muscle injury rates increased during the competitive season and were more prevalent during matches (Hagguld *et al.,* 2012). Competitive match play possibly require higher physical demands than training sessions, this could result in the higher rate of hamstring injuries during matches.

Hawkins *et al.* (2001) determined that training injuries peaked during preseason and match injuries peaked during the first month of the competitive season, injuries then declined during the remainder of the season. Higher injury rates during the preseason and early part of the season could be due to the lack of conditioning and adaptation during this time of the season (Hawkins *et al.,* 2001).

During the UEFA injury study it was demonstrated that 57% of all injuries were sustained during matches, with the remaining 43% of the injuries occurring during training (Ekstrand *et al.,* 2009).

Sound knowledge and understanding of the risk factors for injury occurrence could allow for more accurate preventative measures being implemented during the football season. Determining geographic specific risk factors pertaining to Africa such as pitch quality, poor referees and/or climate conditions may assist in a more specific injury prevention strategy.

2.7 Conclusion

Screening is widely used in professional football, with FIFA requiring most professional leagues to perform pre-participation medical assessment to ensure safe participation. Although the wide use of musculoskeletal screening tools, uniformity is lacking and choosing the most appropriate tool can prove to be challenging.

The FMS could possibly introduce a more uniform and objective approach in musculoskeletal screening. The FMS is commonly used in professional football leagues, but no research was found on professional football players and the FMS. Therefore, establishing baseline FMS composite scores in professional footballers will form the foundation for future research and assists in establishing its ability to predict injury.

Knowledge of the FMS baseline score and the values associated with injury will enable medical staff involved with professional football to better understand FMS score results and the use thereof clinical setting.

The F-MARC has done a lot to promote and develop injury prevention programs in the European setting. African, and specifically South African research pertaining to injury surveillance (incidence and prevalence) is however still grossly limited (Calligeris *et al.,* 2015). The implementation of adequate prevention strategies is hampered by the sparse knowledge regarding injuries in African football, possibly compromising the health and safety of all African players.

This research study will aim to supplement the identified gaps in the literature by determining a baseline FMS score in a KwaZulu-Natal based PSL team and the injury incidence of one PSL season. The researcher envisions that the study results could aid in the development of a specified injury prevention strategy for South Africa that would address specific intrinsic and extrinsic injury risk factors to the PSL.

In the next chapter the research methodology will be described and discussed in detail.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

In this chapter the relevant study methodology and procedures will be provided and discussed.

3.2 Study design

The study design implemented was a prospective cohort study. This specific design was used as it follows a group of similar individuals that form part of a larger group, namely professional footballers, but differ in specific factors, namely the FMS scores.

3.3 Study population and sample

The study participants included all available participants from the KwaZulu-Natal based PSL team Amazulu F.C. The squad consisted of 34 male professional players.

Amazulu F.C. were the specific study population used in this study as researcher is the Head of Medical of Amazulu F.C. and a physiotherapist by profession, thus explains the interest and availability of the specific population in this research field.

All players who provided the researcher with informed consent and met the below mentioned inclusion criteria were included in the study.

3.3.1 Inclusion criteria:

- Consent to participate.
- Players currently contracted with Amazulu F.C. as a professional football player.
- Male players aged between 18 and 40 years.
- Players participating in full football training and eligible for match selection, without complaint or musculoskeletal pathology.

3.3.2 Exclusion criteria:

- Participants with any recent musculoskeletal injury (<6 weeks).
- Participants who had any surgery, including musculoskeletal surgical intervention, in the past 12 months which resulted in a time-off period of 6 weeks or longer.
- Any injury resulting in the participant being unable to compete (symptom free) for a minimum of 6 weeks.
- Players who were released from Amazulu F.C. or only joined Amazulu F.C. after commencement of the study.

3.4 Ethical aspects

3.4.1 Avoidance of harm

Protection of all participants is essential in all research. As this research study involved human participants, the researcher was responsible in assuring that no physical and/or emotional harm came to any participant. The research was executed in such a manner as to continuously respect participant rights and welfare. All participants were managed and treated throughout the season by the medical staff of Amazulu F.C. All participants who were injured during the course of the season, regardless of the circumstances, were treated by the medical staff of Amazulu F.C. as per usual. If an adverse event occurred during the testing procedure, the participant would receive the required medical care and the data would be excluded from the study. No adverse events occurred during the course of the entire study.

3.4.2 Voluntary study participation

Participation in the study was voluntary. Participants were aware of their right to refuse and withdraw consent for their information to be used for the research study at any time.

3.4.3 Privacy and confidentiality

Data regarding the privacy of results and personal information of the participants was managed confidentially. This was accomplished by issuing a random code assigned to each participant. The code was linked to their questionnaire, FMS test sheet and injury recording document. The FMS testing and questionnaires were done in a high performance setting with complete privacy and in a private evaluation room. The data was recorded and stored on a secure computer in the private office of the researcher. The data will be stored and kept private for a period of five years before being destroyed. All staff of Amazulu F.C. involved with the squad was blinded to the study data.

3.4.4 Ethics committee

The Research commenced once it was reviewed and approved by the Health Sciences Research Ethics Committee of the University of the Free State (UFS). (HSREC 75/2017) (Appendix B)

3.4.5 Informed consent

Each participant was given an information document (Appendix G) and given time to read through it, after which informed consent was obtained from all parties involved. The information document gave a short brief on the study and explained all the risks, benefits, confidentiality measures and general study details. Participants were given opportunity to ask the researcher questions for clarification. All willing parties then returned a signed consent form (Appendix F) indicating that they grant permission to participate in the study. Permission was obtained from the Amazulu F.C. general manager (Appendix A) for the study to take place at their facilities and for the use of all necessary resources.

3.4.6 Remuneration

There were no incentives for the players as this screening was part of the routine pre-season testing and conditioning procedures of Amazulu F.C.

The participants may benefit from the study in the future, as the intervention will assist in possible injury prevention screening and injury management. All test results were made available for the participants.

No additional funding was required.

3.4.7 Publication

The researcher will, following study completion, aim to publish the study findings in an accredited peer reviewed journal. All participants were made aware of this and were informed that their identities will not be compromised. The research results will be made available to each participant upon request. The researcher used the program Turnitin to demonstrate no plagiarism was committed and submit the report (Appendix J).

3.5 Measurements

The following measurement instruments were used to collect the required data in order to answer the posed research questions:

- Medical history questionnaire (Appendix E)
- FMS Scoring Sheet (Appendix I)
- Injury and coding report form (Appendix C and Appendix D)

3.5.1 Medical history questionnaire

All participants were required to complete a medical history questionnaire prior to the FMS testing. The questionnaires included demographical information as well as past and present medical history (Appendix E). The questionnaire was constructed by the researcher, in accordance to the FIFA PCMA with additional demographical information included (Dvorak, Junge and Grimm, 2009).

Demographic information pertaining to the participants' physical stature, age, level of participation, dominance and past participation history was obtained. This information helped to identify the characteristics of the specific population, professional football players, and to determine whether the participants of the study can represent the target population for generalisation.

The medical section of the questionnaire aimed to ensure the safety of all participants, identify the presence of any medical conditions requiring prompt management and gain knowledge on the musculoskeletal condition of the participant. These questionnaires were reviewed for information that possibly resulted in a participant not being eligible to participate and identify any relevant contraindications to study participation. Immediate medical care would have been granted if needed. The musculoskeletal history could identify whether a participant required further assessment or referral whereas players with numerous or relevant current complaints could be managed to ensure safe participation.

3.5.2 Functional movement screens (FMS)

All participants were required to complete the FMS test, conducted by the researcher, during the 2017/2018 preseason testing period. The researcher of this study is the Head of Medical of Amazulu F.C. and a qualified physiotherapist, as previously mentioned.

All tests are described in detail in section 2.4.3, along with the clearing exams. The three clearing tests are performed to identify whether pain is present prior to the performance of the movement patterns. If pain is present in any of the clearing tests, a zero is scored for that associated movement test.

The FMS Grading criteria is provided in Appendix H (Cook *et al.,* 2006a). The FMS scoring sheet is presented in appendix I, which further demonstrates the grading criteria and indicates the clearing tests (Cook *et al.,* 2006a).

3.5.3 Injury reporting

All injuries were recorded according to the injury report form provided in Appendix C, with the use of the codes provided in the injury coding form in Appendix D. All injuries were recorded as per the operational definitions section. The Injury report and injury code forms where constructed according to the F-MARC's football medicine manual (Dvorak, Junge and Grimm, 2009).

All football related injuries, of all study participants, were recorded from the first day of pre-season training, throughout the 2017/2018 season, until the last day of the season. All injuries and information pertaining to the injury was recorded by the researcher.

The injury diagnosis, anatomical locations and injury severity was recorded, as per the operational definitions and in accordance to the injury code form on the injury report form. A team physician was on-call at all times for medical injury management.

Injuries occurring from non-football related situations, for example motor vehicle accidents, accidental falls or other miscellaneous causes not related to football, were not recorded for this study. Participants sustaining such injuries were treated as per usual but no data pertaining to such situations was used for this study. However, it should be noted that no such event occurred during this study.

The researcher was present in all the activities of the club including all training sessions, home and away matches as well as all other relevant sessions and was thus responsible for the recording of all injuries sustained during the season. The presence of the researcher allows for accurate injury recording and prevents under or over reporting of injuries. It further assists with accurate injury severity reporting and avoid injuries being overlooked.

3.6 Pilot study

The pilot study was conducted prior to the start of preseason for the senior professional players. Five participants from the Amazulu F.C. reserve team were included, with the same procedures used in the main study implemented during the pilot study. The participants met with the researcher at the Amazulu gym facility, where they were welcomed and given an information sheet, questionnaire and consent form.

A brief overview and explanation regarding the FMS and the research study was conducted by the researcher. Participants were then given time to ask questions and requested to sign the consent forms. Once consent was obtained, participants completed the questionnaire, with assistance provided as required.

The FMS testing was then conducted, on the same day, in a private assessment room. All participants were tested individually and dressed in the adequate attire, namely training shoes and football uniform.

The FMS individual movements were explained, with each participant given three opportunities to complete each movement. Each movement was strictly graded by the researcher, according to the specific criteria provided in Appendix H. After the testing of all participants, injury surveillance was commenced. The pilot study's injury surveillance was conducted for 4 weeks with no participants sustaining an injury during this period.

Due to the fact that these participants did not have professional contracts with Amazulu F.C. and participated in a different league, their results were not included in the main study.

The pilot study was completed successfully and no changes were made to the study procedure or documentation. The pilot study provided insight into the time duration required for each questionnaire and FMS testing session. This aided in the planning of the execution of the main study.

The pilot study helped to identify important information that should be emphasised to participants on the day of testing. This information included individual participant test time required, wearing adequate training shoes and no warm-up to be allowed prior the FMS testing. Due to the short duration of injury monitoring, no player sustained an injury and the injury report form remained unchanged.

3.7 Data Collection procedure

The study was conducted in accordance to the requirements of, and approval by, the Health Sciences Research Ethics Committee of the University of the Free State (UFS) (HSREC 75/2017) (Appendix B).

The researcher contacted the general manager of Amazulu F.C., requesting permission to conduct a research study on the first team members. Permission was granted and the study procedures were planned. After obtaining permission and ethical clearance, a meeting was arranged with all professional players contracted to Amazulu F.C. registered to participate in the upcoming 2017/2018 PSL season.

All members of the Amazulu F.C. squad met before the commence of the 2017/2018 preseason at the Amazulu F.C. gym facilities' auditorium. The researcher, who is also the Head of Medical at Amazulu F.C., provided all players with an information sheet and consent form. The researcher welcomed all players and thoroughly explained the research aims and procedures involved, namely the medical questionnaire, FMS testing and injury recording throughout the preseason and season. Thereafter players were allowed to ask the researcher any questions to clear up confusions or concerns they may have.

All participants willing to participate in the study then handed-in their signed consent and were given the medical questionnaire consisting of demographical information, match play time and medical history (Appendix E). All medical questionnaires were completed on the same day at the first meeting. The researcher was available to provide assistance where needed and to answer any questions pertaining to the research study. All included participants completed the medical questionnaires and were given a time slot for the following day during which the FMS test was conducted. All participants were advised regarding attire and no prior warm-up.

The FMS screening for all participants was conducted on the following day at the Amazulu F.C. gym facilities. On arrival participants were placed in a waiting area, to ensure no warm-up was conducted and adequate attire was available. The researcher, with more than four years` experience with the FMS, conducted all the screening tests. The FMS tests were conducted as prescribed in literature, in an adequate private area with participants in full training attire and in proper running shoes. No warm-up prior to the FMS tests was performed as this could alter the performances and minimise imbalances, resulting in a false score.

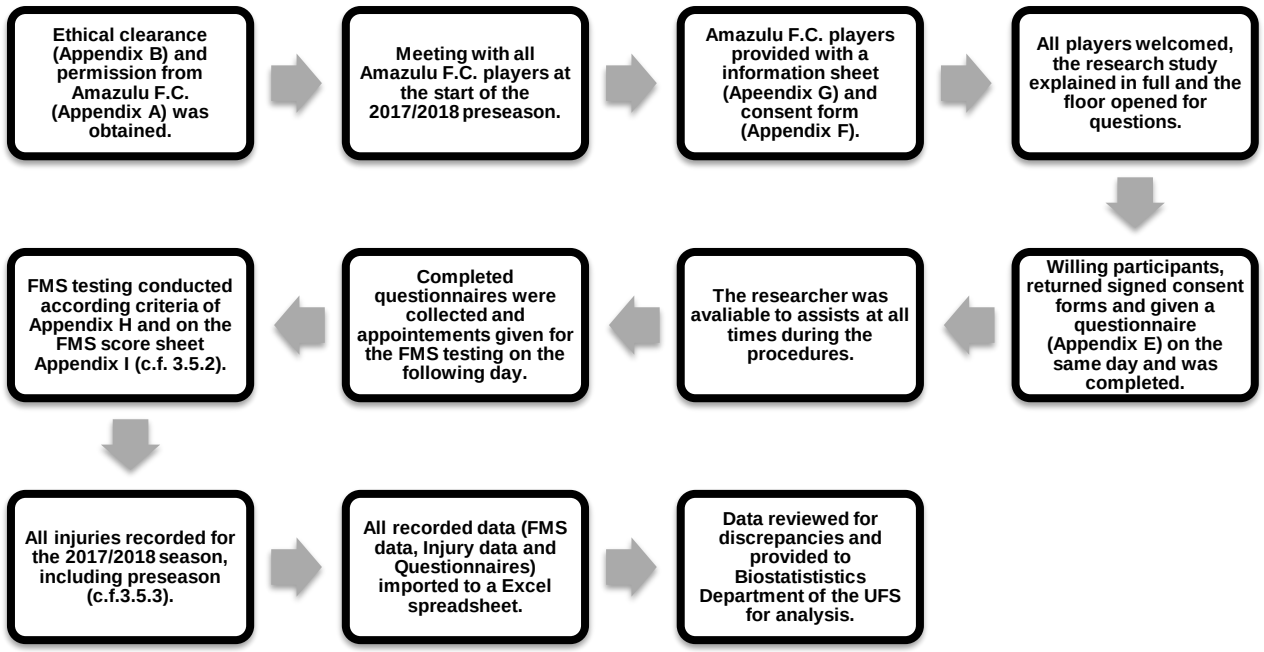
The individual movements were explained and participants were given three opportunities to complete the movement. Each movement was then graded according to the grading criteria as shown in Appendix H. All FMS scores were documented on the FMS score sheet provided in Appendix I.

Once all FMS tests were concluded the scores were recorded in duplicate form and stored as a hardcopy and softcopy in the researcher's office at Amazulu F.C. The FMS scores of all participants were documented by means of a coded list of the players' identity, with the reference key available to the researcher. The coding was utilised to protect the identity of the participant and to minimise any possible bias and maintain confidentiality. All staff of Amazulu F.C. involved with the squad was blinded to the FMS scores.

All injuries sustained during any part of the season, including preseason, was recorded by the researcher as per the study definition of "injury". Injuries were recorded as per section 3.5.3. Injury severity was recorded, by the researcher, as per the operational definitions.

At the end of the 2017/2018 PSL season all recorded data, which included all medical questionnaires, preseason FMS score sheets and all recorded injuries of all participants were imported into an Excel spreadsheet, checked for discrepancies by the researcher and provided for analysis done by the Biostatistics Department of the UFS. The data collection procedures are summarised in Figure 3.

Figure 3 Data collection procedures



3.8 Measurement and methodology errors

An area of concern in this study was the misleading definition and classification of the term “injury”. In order to prevent confusion and ensure no errors in this regard, a study specific definition of the term injury and an injury reporting system was used during this study.

The definition of injury used in this study was in accordance to previous research and in-line with the Injury Consensus Group established under the guidance of FIFA’s F-MARC. All terms and definitions used in this study is provided in the operational definitions section.

Other possible errors were with regards to variations in the FMS testing procedure. All participants were therefore tested in similar conditions regarding attire and environment on the same day, according to the standardised testing procedures.

All FMS testing was conducted by the main researcher of the study to ensure consistency and fair scoring. All FMS testing was conducted according to section 3.5.2 in order to avoid errors.

Misdiagnosis or non-documentation of some injuries were avoided as a result of the presence of the researcher at all times and the assistance of an highly experienced sport physician on call at any time. Further, no accurate diagnosis was needed for the injury report form.

3.9 Data Analysis

The data analysis was done by the Department of Biostatistics, University of Free State, Bloemfontein. Descriptive statistics, namely frequencies and percentages for categorical data and medians and percentiles for continuous data were calculated. The Wilcoxon signed-rank test was utilised to determine any association between FMS composite scores, injury statistics and match minutes played. This test was chosen as it allows for the paired t-test to be utilised when the outcome data is not normally distributed and outcome data are ranked (McDonald, 2014). As two nominal variables and one measurement variable is use this proved to be the most appropriate test to use. The researcher further analysed data in order to obtain any relevant information pertaining to the study objectives and aims.

3.10 Conclusion

This chapter described the detailed methodology used during the execution of this research study. The next chapter will present the research results in form of figure and tables.

CHAPTER 4: RESULTS

4. 1 Introduction

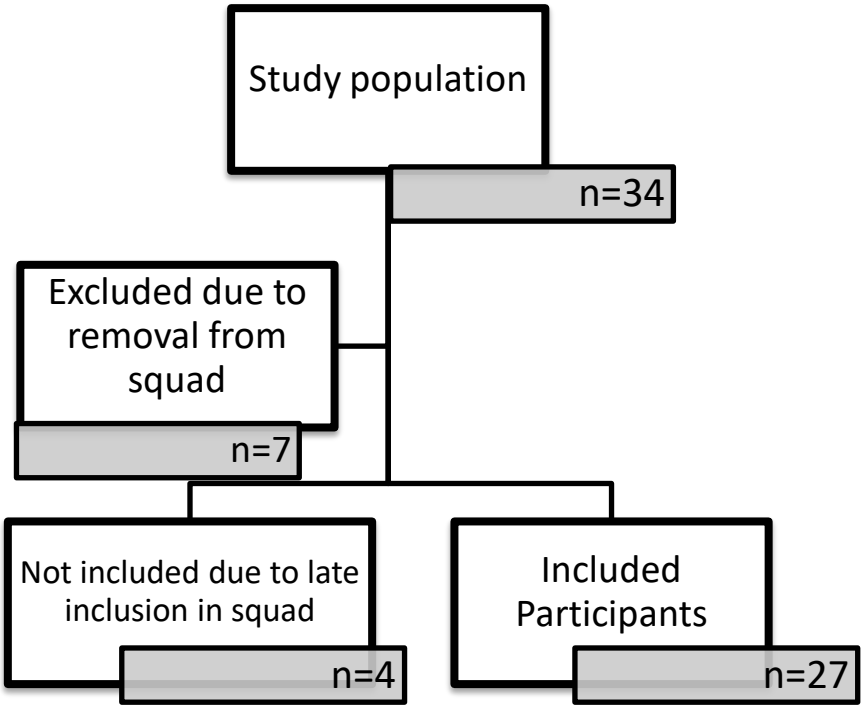
The purpose of this chapter is to analyse and present the results of the study. The participants' FMS scores were documented and associations made accordingly. The injury statistics for Amazulu F.C. is presented and displayed in the form of tables and figures. Due to the data being skewed, median values were calculated where deemed appropriate.

4.2 Demographics of participants

4.2.1 Study population

The participants comprised of professional male football players from a KwaZulu-Natal based PSL team, Amazulu F.C. At the start of the season 34 participants were included in the study. Through the course of the season seven participants were excluded from the study as a result of contract termination or were sent on loan to other divisions. Four players joined the club during the midseason and were ineligible to partake in the study. The total participants following the exclusion and inclusion criteria was 27 (c.f. Figure 4). No other members were excluded due to illness, injury or surgery detected from the pre-participation medical questionnaire. No further participants were excluded during the course of the study.

Figure 4 Study population



4.2.2 Participant anthropometry

The participants' median age was 25 years old with the oldest participant being 39 years old and the youngest 19 years old (c.f. Table 2).The median height and weight of the participants was 74kg and 179cm, respectively. The median body mass index (BMI) of the participants was 23,72 kg/m2. The minimum and maximum values pertaining to the study demographics can be seen in Table 2. Further, it was also noted that 96% (n=26) of the participants were right side dominant.

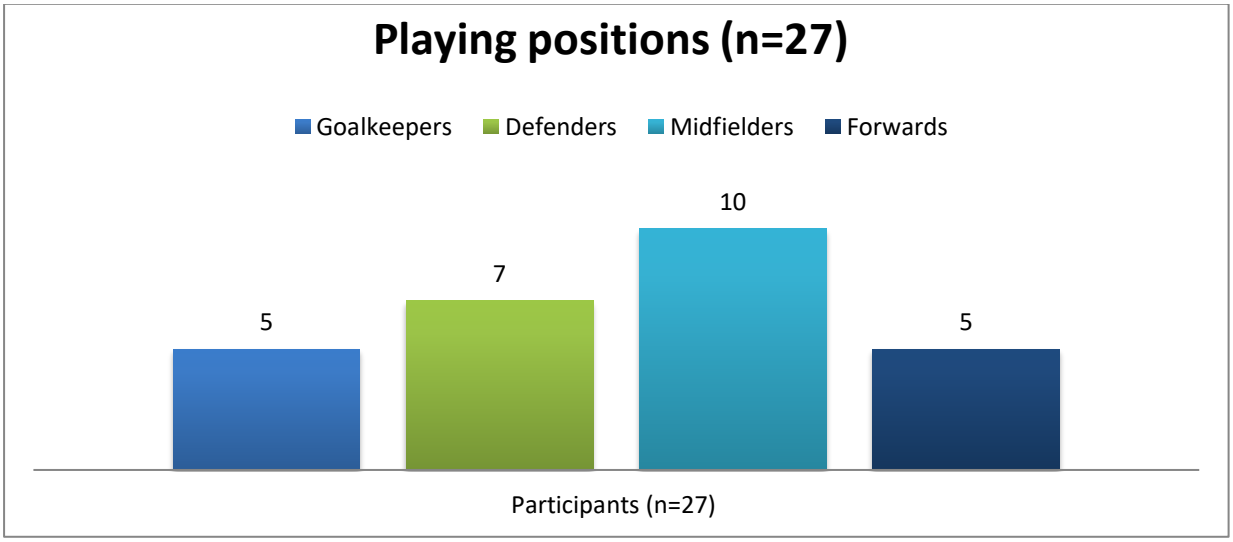
Table 2 Participant anthropometry (n=27)

	Minimum	Median	Maximum
Age (years)	19	25	39
Weight (Kg)	65	74	103
Height (m)	1,69	1,79	1,88
BMI (kg/m2)	20,75	23,72	29,45

4.2.3 Participant playing positions

The study participants were categorised according to their playing positions. It was determined that more than a third of participants were midfielders and represented 37% (n=10) of all participants. The remaining participants' playing positions are displayed in Figure 5.

Figure 5 Participants playing positions (n=27)



4.2.4 Seasonal Exposure

Throughout the season the participants were exposed to field based training, official matches, recovery sessions, gym sessions and friendly matches. Field based training included all football field sessions whether it was technical or tactical sessions and/or included football conditioning. Recovery sessions included active recovery (stationary bike/light jogging), foam rolling, band stretches, mobility work and cold water immersion. Gym sessions consisted mainly of weight lifting and core work.

The team played 33 official matches during the season, which consisted of 30 league games and 3 Cup matches (2 Nedbank cup matches and 1 Telkom Knockout match). This amounted to 3000 official match minutes, with one of the cup matches going into extra-time lasting 120 minutes. Therefore, the team spent 13% of the PSL season playing official matches.

The remainder of the season was spent at field training (68%), gym sessions (5%), recovery sessions (8%) and playing friendly matches (6%) (c.f. Table 3).

Table 3 Seasonal exposure time(n=22010)

Exposure	Time minutes (%) (n=22010)
Field Based Training	14900 (68%)
Official Matches	3000 (13%)
Recovery Sessions	1710 (8%)
Friendly Matches	1260 (6%)
Gym Sessions	1140 (5%)
Total Season Exposure Time	22010 (100%)

The median official match minutes of the participants was 1279 minutes throughout the season. The participant that played the most official match minutes, managed 2328 minutes for the season (c.f. Table 4).

Table 4 Match Exposure time (n=3000)

Official Match Exposure	Median Time in Minutes
Minimum Exposure	0
Median Exposure	1279
Maximum Exposure	2328

4.3 Functional Movement Screen

4.3.1 FMS composite score

In this study it was determined that the median FMS composite score of Amazulu F.C. was 15 with a minimum of 11 and a maximum of 18. It was found that 41% (11) of all participants scored ≤ 14 on the FMS and the remaining 59% (16) scored ≥ 15.

4.3.2 Injury incidence

In this study a total of 57 injuries were sustained by Amazulu F.C. during the recorded PSL season. A total of 81% (n=22) of all participants were injured during the course of the season (c.f. Table 5). The median injury per participant was two.

Table 5 Number of participants injured vs. non-injured participants

	Number of players (n=27) (%)
Injured participants	22 (81%)
Non-injured participants	5 (19%)

4.3.3 Association between FMS score and injury incidence

Participants who sustained injuries were grouped in Group A, with the participants who did not sustain any injuries grouped in Group B (c.f. Table 6).

Table 6 Association between FMS scores and two groups of injured and non-injured participants (n=27)

	Median FMS	Minimum FMS	Maximum FMS
Group A (n=22) Injured participants	15	11	18
Group B (n=5) Non-injured participants	16	14	16

No statistical significance (p=0.34) between median pre-season FMS scores and injury incidence was found.

Further investigations into the study participant's individual FMS scores with regards to individual injury incidence was done. In Table 7 the individual FMS scores are displayed relating to the number of participants as well as the median injury per participant pertaining to each specific FMS score. The FMS composite score of 11 was omitted as only one participants achieved this score.

Table 7 Individual FMS scores related to score specific injury incidence

Individual FMS composite score	Number of participants (n=26)	Median injury per participant
12	3	3
13	2	3.5
14	5	2
15	6	2
16	6	1
17	2	3
18	2	3

It was determined that most participants scored either 15 or 16 on the FMS. Participants who scored 13 on the FMS had the highest median injury per participant and participants who scored 16 had the lowest median injury per participant (c.f. Table 7).

4.3.4 FMS Categories

Following the data collection and result analyses yielding no significant findings further investigation was conducted. An oversight on the part of the researcher was identified regarding the FMS scores not being categorised into sub-categories indicating high-, medium- and low- risk for injury.

As discussed in section 2.4.6, numerous authors indicated a score of ≤ 14 on the FMS to be associated with high injury risk (Kiesel *et al.,* 2007, O'Connor *et al.,* 2011, Chorba *et al.,* 2010, Bonazza *et al.,* 2016).

In the current study it was found that from the five non-injured participants, four participants obtained a score above the advocated score of ≤ 14 on the FMS. For this reason the pre-season FMS composite and injury data collected for this study was analysed according to score specific groups.

In addition, O'Connor *et al.* (2011) demonstrated that participants scoring 18 on the FMS had significantly higher injury rates than those who scored 17. Further, Orser (2018) suggested participants with FMS scores of ≤ 14 or ≥ 18, required further assessment and may indicate greater risk of injury. The participants scoring in the so-called "optimal range" of between 15 and 17 may continue with performance testing and may indicate less risk of injury.

Even though participant categorisation with regards to FMS scores was not an aim or objective of this study, the researcher opted to expand the data by further categorising participants according to their FMS scores.

The categories, as guided by Orser (2018), were formed as follows:

- Category A: FMS score ≤ 14
- Category B: FMS score 15-17
- Category C: FMS score ≥ 18

The FMS score categories are displayed in Table 8 and relevant comparisons made as indicated (c.f. Table 8). Participants in Category A sustained 47% (n=27) of all injuries and accounted for the category that sustained the most injuries during the season. In Category A, 91% of the participants were injured and 100% of the participants in Category C were injured. Thus, Category B had the lowest percentage of participants injured, with 71% of all participants in the so-called "optimal range" injured (c.f. Table 8).

Category A had the lowest median match minutes out of the three categories, with Category C participants obtaining the highest median match minutes. The remaining results pertaining to the Categories are displayed in Table 8.

Table 8 Participants categorisation in FMS score categories as indicated

	Category A (≤ 14)	**Category B (15 – 17)**	**Category C (≥ 18)**
Number of Participants (%) (n=27)	11 (41%)	14 (52%)	2 (7%)
Number of injuries sustained (%) (n=57)	27 (47%)	24 (42%)	6 (11%)
Percentage of participants injured	91%	71%	100%
Median match minutes of participants	963	1303	1773
Median injury per participant	2	2	3

4.4 Injury Results

4.4.1 Injury Characteristics

In this study, it was demonstrated that 84% (n=48) of all injuries sustained by Amazulu F.C. during the recorded PSL season occurred in the lower extremities (c.f. Table 9).

Table 9 Injured anatomical segment

Injured anatomical segment	Number of injuries (n=57)
Lower extremities	84% (48)
Upper extremities	9% (5)
Other (Head and Spinal injuries)	7% (4)

In the recorded PSL season, 37% (n=21) of all injuries sustained by Amazulu F.C. were related to previous injuries (c.f. Table 10). Five injuries which occurred during the 2017/2018 PSL season, were re-injuries of index injuries and accounted for 9% of all injuries sustained by Amazulu F.C.

Table 10 Injury related to previous injury

Injuries related to previous injury	Number of injuries (n=57)
Yes	37% (21)
No	63% (36)

Injuries predominantly occurred on the non-dominant side and accounted for 65% (n=37) of all injuries. The remaining injuries occurred on the dominant side or in a central region and is represented in Table 11.

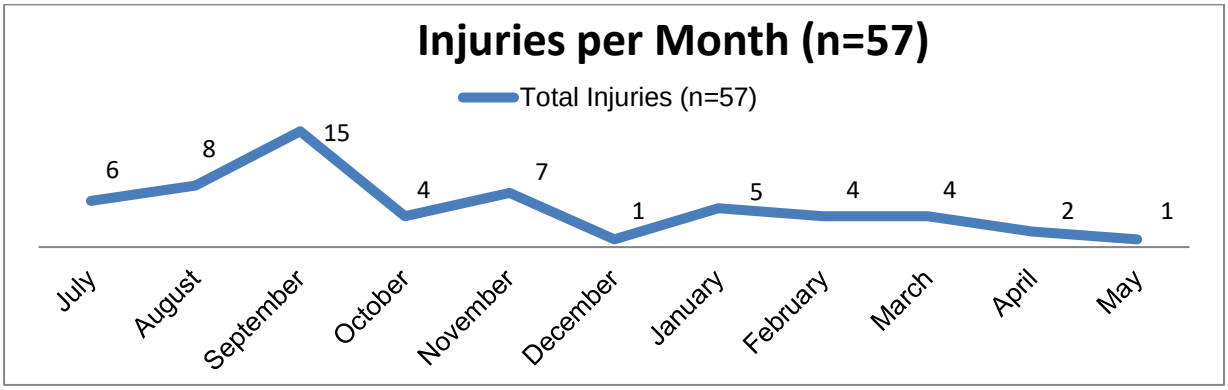
Table 11 Site of injury * head/spine injuries

Site of Injury	Percentage (n=57)
Dominant side	30% (n=17)
Non-dominant side	65% (n=37)
Central(*)	5% (n=3)

In this PSL study it was found that 18% (n=10) of all injuries occurred during the preseason, with the remaining 82% (n=47) of injuries occurring during the competitive season.

However, the first half of the Amazulu F.C. season (June - December) was responsible for 72% (n=41) of all injuries, while the remaining 28% (n=16) occurred in the second half of the season (January – May). Further, the injuries displayed a steady decline throughout the course of Amazulu F.C.'s PSL season (c.f. Figure 6).

Figure 6 Monthly injury report



Injury settings throughout the season were categorised as training injuries or match injuries. During the season 51% (n=29) of all injuries occurred during training and 49% (n=28) occurred during matches (c.f. Table 12).

Further, the type of injury in this study was classified as either contact or non-contact injuries. Contact injuries accounted for 39% (n=22) of all injuries and 61% (n=35) of injuries were reported as non-contact injuries, as presented in Table 13.

Table 12 Injury settings

Injury Setting	Percentage (n=57)
Match	49% (n=28)
Training	51% (n=29)

Table 13 Type of injury

Type of Injury	Percentage (n=57)
Contact	39% (n=22)
Non-contact	61% (n=35)

The anatomical location that accounted for the most injuries in the recorded PSL season sustained by Amazulu F.C., was determined as the knee, responsible for 33% (n=19) of all injuries. Further, the thigh 16% (n=9) and ankle 11% (n=6) were the second and third most injured anatomical locations, respectively. The remaining anatomical regions injured during the PSL season are represented in Table 14.

In the recorded PSL season, 26% (n=15) of all Amazulu F.C. injuries were diagnosed as sprains followed by contusions as 16% (n=9) and strains as 14% (n=8), respectively. The remaining diagnoses sustained during the season are represented in Table 14.

Table 14 Anatomical locations injured (left) and Injury Diagnoses (right)

Anatomical region Injured	**Number of injuries (%) (n=57)**	**Injury Diagnosis**	**Number of injuries (%) (n=57)**
Knee	19 (33%)	Sprains	15 (26%)
Thigh	9 (16%)	Contusions	9 (16%)
Ankle	6 (11%)	Strains	8 (14%)
Foot	5 (9%)	Muscle Fibre Rupture	5 (9%)
Lower Leg	4 (7%)	Tendinopathy	5 (9%)
Shoulder	4 (7%)	Ligament Rupture with instability	4 (7%)
Groin	3 (5%)	Lesion of the meniscus	4 (7%)
Lower Back	2 (4%)	Other	4 (7%)
Toe	2 (4%)	Ligament Rupture without instability	1 (2%)
Head	2 (4%)	Concussion without the loss of consciousness	1 (2%)
Finger	1 (2%)	Dislocation	1 (2%)

This study determined that most of the injuries sustained in the PSL season by Amazulu F.C. are of a moderate nature, accounting for 35% of all injuries. Seven injuries sustained by Amazulu F.C. during the PSL season were categorised as severe injuries, accounting for 12% of all injuries. The remaining injury severity classifications can be seen in Table 15.

Table 15 Injury severity

Injury Severity	Percentage (n=57)
Minimal (1 – 3 days)	25% (n=14)
Mild (4 – 7 days),	28% (n=16)
Moderate (8 – 28 days)	35% (n=20)
Severe (> 28 days)	12% (n=7)

Further, a review of the seven severe injuries indicated that all were sustained in the first half of the season and four (57%) involved the knee. Official match play was responsible for five (71%) of the seven severe injuries. Direct contact was found to be the main cause, responsible for five (71%) of the severe injuries. Midfielders sustained four (57%) of the severe injuries (c.f. Table 14). A summary of the information obtained regarding severe injuries sustained is displayed in Table 16.

Table 16 Severe injury summary (n=7)

Location of injury	Knee	4 (57%)
Diagnosis	Lesion of the Meniscus	3 (43%)
Setting	Match	5 (71%)
Type	Contact	5 (71%)
Playing position	Midfielder	4 (57%)

This concludes the results of the current study on the FMS and the injuries sustained by Amazulu F.C. during the recorded season. The results will be discussed in detail in the following section.

CHAPTER 5: DISCUSSION

5.1 Introduction

This chapter provides an in depth discussion of the results with the aim of interpreting the findings in relation to similar research. All findings are discussed in practical context and the clinical relevance thereof considered. The study limitations are also discussed and suggestions for future research made.

5.2 Functional Movement Screen (FMS)

5.2.1 Composite Score

The median FMS composite score for Amazulu F.C. in this current study was 15 and ranged between 11 and 18. As previously mentioned, research on FMS composite scores in professional football is limited. Therefore, the FMS scores found in this study could serve as the foundation for future research in professional football and the FMS.

The only other study found on South African football players regarding the FMS determined a mean FMS composite score of 12.9 and ranged between 10 and 16 for youth development players (Conley, 2015). Thus, professional football players in the PSL performed better FMS scores than the South African youth development players. This finding was supported by Gadziński *et al.* (2016) who demonstrated that amateur senior football players scored higher on the FMS than junior players.

The low FMS scores obtained by youth football players (c.f. Table 1) could be as a result of incomplete development of the musculoskeletal system and, in contrary, senior football players may be better conditioned to perform the FMS. Due to the vast age difference between the youth participants in the FMS studies (c.f. Table 1) and the professional football players in this study, it is not advised to compare these two populations.

However, Gadziński *et al.* (2016) demonstrated a much higher mean FMS score of 17.53 in senior amateur football players compared to this current study. Sprague *et al.* (2014) also demonstrated a higher mean score of 16.16 in a study done on adult amateur footballers. Conflictingly, an FMS composite score of 13.6 was determined in adult amateur football players by Schoeder *et al.* (2016). However, these finding should be interpreted with caution, as the population in the above-mentioned studies consisted of amateur football players and the study of Gadziński *et al.* (2016) included only 15 senior Silesia-Opole 3rd league players and Sprague *et al.* (2014) included 20 football players.

It is also important to bear in mind that professional football players may differ greatly from amateur players given that the former have higher physical demands and higher training loads (Owen, 2016a), which may necessitate a different FMS composite score.

The lack of research pertaining to baseline FMS scores in professional football players makes interpretation and appropriate use of the FMS results difficult and requires further research. This study's baseline FMS score of 15 could serve as a foundation for future research investigating the use of FMS with the aim to identify individuals at risk of injury in South African professional football players.

5.2.2 Injury Incidence

This study also aimed to determine the injury statistics, namely the injury incidence of the Amazulu F.C. over the course of one PSL season in order to establish a better understanding of the football injury aetiology in South Africa.

In the UEFA injury study by Ekstrand *et al.* (2009) it was found that each football player could expect to sustain, on average, two injuries every season. Ekstrand *et al.* (2009:p556) stated "*an elite team with 25 players can expect about 50 injuries each season"*. In this current study the total injuries sustained by Amazulu F.C. during the 2017/2018 PSL season was 57, with a median injury of two per player.

Therefore, the findings of this study was in-line with the UEFA injury study. This was encouraging as the UEFA injury study was well founded and comprehensive, including 23 elite clubs from all over European's premier leagues, namely England, Italy, Spain, Netherlands, France, Portugal, Germany, Belgium, Scotland and Ukraine, which was conducted over seven consecutive seasons.

Contrastingly, Calligeris *et al.* (2015) found that a Western Cape-based PSL team reported a total of 130 injuries during one football season. In Calligeris ***et al.'s*** (2015) study, 32 participants were included and, according to the findings of Ekstrand *et al.* (2009), the total number of injuries should on average accumulate to 64 injuries per season. However, Calligeris *et al.* (2015) reported double the amount of total injuries per season. The vast difference in results may be due to various definitions used for the term "injury".

Calligeris *et al.* (2015:17) defined an injury as any "*physical complaint sustained by a player that resulted from a football match or football training, irrespective of the need for medical attention or time loss from football activities"*.

In this current research study and in the UEFA injury study an injury was defined as *"any physical complaint (contact or noncontact) sustained by a player during a football match or training session that prevented the player from taking a full part in training or match play activities for one or more days following the day of injury"* (Fuller *et al.,* 2006:193).

Even though the definition used by Calligeris *et al.* (2015) was dissimilar to the definition of injury used in this research study, Calligeris *et al.* (2015) had noted that only four injuries did not result in a player not participating in football activities. In effect a total of 126 injuries, according to the injury definition used in this current research study, were recorded. This does not correlate with the lower number of injuries reported during the execution of this research study.

Calligeris *et al.'s* (2015) injury statistics may have included injuries with no time off period and the true extend of recorded injuries may be contentious and should thus be interpreted with caution. Even though methodological errors are considered, other causes for the high injury rate and substantial difference between the two studies require further investigation.

As previously discussed, football injury is unlikely to occur as a result of a single cause but rather from multifactorial causes (Bakken, 2018). This makes it improbable to conclusively state reasons for the difference in injury incidence. A few considerations may include the quality of pitch conditions, possible difference in weather conditions, coaching and conditioning methods implemented and general athletic care and management. Further, the level of competition and skill could also have contributed to higher injury incidence found by Calligeris *et al.* (2015).

This current study's findings regarding injury incidence in one PSL team are in-line with world football. However, the concerning difference between the two PSL studies warrants continued injury surveillance in the South African PSL.

5.2.3 Association between FMS composite scores and injury incidence

This study found that 81% of the participants were injured. Although it was found that the non-injured participants had a higher median FMS score of 16 in comparison to the injured participants' score of 15, there was no statistical significant association between injury and FMS scores.

This suggests that low FMS scores might not be able to predict future injury. Recent research found on the FMS and its association to injury, does not support the use of the FMS as an injury prediction tool (Moran *et al.,* 2017, Bakken *et al.,* 2016, Schroeder *et al.,* 2015, Rusling *et al.,* 2015). This supported the findings of the current study on professional football players.

Since the influential findings of Kiesel *et al.* (2007) demonstrating that a FMS score of ≤ 14 may indicate a possible predisposition to injury, numerous research studies have investigated the FMS value of ≤ 14 to predict injury, yielding conflicting findings (Kiesel *et al.,* 2007, O'Connor *et al.,* 2011, Chorba *et al.,* 2010 Mokha *et al*., 2016, Sorensen, 2009).

However, some research demonstrated that a score of ≤ 14 in the FMS could indicate a participant's predisposition to injury (Krumrei *et al.,* 2014, Kraus *et al.,* 2014, Bonazza *et al.,* 2016). Although this finding was under scrutiny recently, there is some moderate scientific evidence supporting this in team sports.

In this current study it was found that 25% of the participants who scored above the score of ≤ 14 were not injured, which was higher than the 9% of participants not injured who scored ≤ 14. It should however be stated that identifying risk for injury was not within the scope of this research study.

In a recent literature review by Orser (2018), it was suggested that a possible "optimal range" in the FMS scoring system exists. Further supported in a study by O'Connor *et al.* (2011), on 874 male marine officers, a FMS score of ≤ 14 was associated with increased risk injury and a FMS score of 18 sustained significantly higher injury rates than a score of 17. This suggest the possibility of bimodal distribution.

This current study's categorisation was done according to the FMS values identified in literature published by Orser (2018), Kiesel *et al.* (2007), Chorba *et al.* (2010) and O'Connor *et al.* (2011). This allowed the researcher to expand the data and aim to link the obtained results to published literature with regards to FMS scoring and possible injury incidence.

The categories were formed, as guided by above-mentioned literature, as follows:

- Category A: FMS score ≤ 14
- Category B: FMS score 15-17
- Category C: FMS score ≥ 18

Most participants were categorised in Category B, accounting for 52% of all study participants (c.f. Table 5). Even though more participants were in Category B, Category A participants sustained the most injuries, responsible for 47% of all injuries. Further, 71% of participants in Category B were injured, which is relatively lower than the 91% and 100% of participants injured in Category A and Category C, respectively.

This finding could be in support of the “optimal range” proposed by Orser (2018), as participants scoring between 15 and 17 on the FMS demonstrated less injured participants than those scoring ≤ 14 or ≥ 18 on the FMS. This should be interpreted with mindfulness and caution as the study sample was small, with only two participants grouped in Category C.

The idea of an “optimal range” and possible bimodal distribution was further supported by the findings of this study on the participants’ individual FMS score and its link to the median injury per participant (c.f. Table 7). Participants scoring ≤ 14 or ≥ 18 on the FMS had a median of 3 for injuries recorded, whereas participants scoring between 15 and 17 on the FMS had a median of 2. A score of 16 on the FMS had the lowest median injury per participant of one.

It is considered that an athlete with hypermobility or general joint laxity, although purely presumptive, may obtain a higher score in the individual FMS movement tests, such as the Shoulder Mobility test, the Active Straight Leg Raise, the Deep Squat and the In-line Lunge. The stability aspect of the movement is definitely considered as well as all proprioceptive and neuromuscular factors, but hypothetically a professional athlete should be able to perform one to three repetitions of a stability test with relative ease. An athlete with hypermobility or general joint laxity athlete may achieve a higher FMS score as the endurance aspect of stability is not tested. Fatigue has been found to alter biomechanics and function, thus it is expected that an athletes’ FMS score could differ under fatigue.

As noted by Hägglund *et al.* (2013) and Ekstrand *et al.* (2009) football injury risk increases with the increase in time of each half, time of the season and type of setting. Further, Gabbett (2016) suggested inappropriate, brisk and uncontrolled training loads are more likely to increase risk of injury. These findings suggests fatigue to be associated with injury in professional football. This may provide some insight for athletes with higher FMS scores to sustain higher injury rates.

Although the limitations of this current study are evident, future research related to FMS categorisation, the exploration of the “optimal range” as well as the suggestion of bimodal distribution, is recommended. Further, as noted by Orser (2018), the FMS is intended to be used as a screening tool rather than a diagnostic tool. Therefore, for screening purposes, it is suggested to establish sport specific composite scores in order to identify individuals that may require further assessment before continuing sport specific participation.

This study’s findings suggest that professional footballers from one PSL team scoring ≤ 14 or ≥ 18 on the FMS, may sustain more football related injuries during one season. Further, the results supported the “optimal range” theory with participants scoring between 15 – 17 having the lowest median injury per participant.

5.3 Injury Profile

Establishing key injury characteristics, specifically related to a football league and region, allows for better season planning regarding conditioning, injury prevention and management of training loads (Owen, 2016a). This could in turn result in optimal competition adaptation and minimising of injury.

This study found that 84% of all injuries sustained by a PSL team occurred in the lower extremities. This finding was supported by all football research found, including a study on the PSL, which found 78% of all injuries occurred in the lower extremities (Calligeris *et al.,* 2015). Both Hawkins *et al.* (2001) and Ekstrand ***et al.'s*** (2009) European studies found that 87% football injuries occurred in the lower extremities. This safely concludes that the majority of football injuries occur in the lower extremities.

This finding is plausible given that majority of actions and physical demands in the sport of football is reliant on the optimal function of the lower limbs and core muscles.

In this current study, the knee, which accounted for 33% of all injuries, was found to be the most injured anatomical location. This was followed by thigh (16%) and ankle (11%) injuries, respectively. However, in the UEFA injury study the thigh was the most injured anatomical location, accounting for 23% of all injuries, followed by knee (18%) and ankle (14%) injuries, respectively (Ekstrand *et al.* 2009).

The study by Calligeris *et al.* (2015), also conducted on a South African PSL team, determined that the thigh and ankle were the most commonly injured body parts, both contributing 21% to all injuries. Interestingly, Calligeris *et al.* (2015) demonstrated knee injuries only accounted for 8% of all injuries in the PSL team they have investigated, which is contradictory to the findings of this study.

One reason for differing results could be the geographical differences in study locations. Calligeris *et al.* (2015) conducted their study on a Western Cape based team, whereas this current study was conducted on a KwaZulu-Natal based PSL team. The two teams were likely exposed to different pitch quality, training methods, participant skill levels and climate conditions. Other aspects to consider is that both studies only included one team and the injury data was only collected over one football season.

The conflicting finding, in both PSL studies, again suggests the need for extended injury data collection to more accurately evaluate the PSL injury trends and patterns including regional variations.

In this current study sprains (26%) were the most diagnosed injury followed by contusions (16%) and strains (14%).

In the UEFA injury study muscle strains (35%) was the most common diagnosis in football (Ekstrand *et al.,* 2009). In the PSL study by Calligeris *et al.* (2015) 29% of all injuries were strains. Surprisingly, an increase in hamstring injury in competitive match play has been reported in literature (Ekstrand *et al.,* 2016).

Muscle strains in this current study appeared lower than what was reported in relevant football injury research, possibly due to injury surveillance only conducted on one team during one season. Long-term surveillance is required to conclude whether this is due to a seasonal variation or a different reason such as adequate periodisation, muscle conditioning, prevention strategies or decreased skill level with less demands.

Contusions were found to be the most common diagnosis in the PSL by Calligeris *et al.* (2015) and in this current research study contusions were the second most prevalent diagnosis. In two other European studies by Hawkins *et al*. (2001) in England and Falese *et al.* (2016) in Italy, both demonstrated low contusion rates of 7% and 4% respectively, which is much lower than the reported contusion incidence in the two South African PSL football teams.

Contusions are usually caused by a direct blow, either from an opponent or an object. Therefore, the higher contusion rates in the PSL could be as a result of a more physical South African playing style, foul play or decreased technical abilities when considered to the lower contusion rates in European leagues (Calligeris *et al.,* 2015, Wong and Hong, 2005).

Both studies on South African football teams were conducted over one season only and may stabilise over several seasons which could illustrate a more accurate representation of injury types in the PSL. Again, as mentioned above, the PSL teams differed in region, pitch condition and likely training methods and results should be interpreted with caution.

5.3.1 Injury period

In this study the majority of injuries occurred during the competitive season (82%) with the remaining 18% of all injuries occurring during the preseason. Further, 72% of all injuries occurred in the first half of the season and the remaining 28% in the remainder of the season.

The vast difference between the timing of injuries during the football season is of interest and importance. Ekstrand *et al.* (2009) found a consistent injury occurrence throughout the season but reported traumatic injuries to be more prevalent in competitive season and overuse injuries to spike during preseason. Hägglund *et al.* (2013) reported lower limb muscle injury rates to be lower during the football preseason when compared to the competitive season.

Hawkins *et al.* (2001) reported that match injuries peaked during the first month of the competitive season then declined during the remainder of the season, which is similar to the results of this study. In this study it was determined that 40% of all injuries occurred in the first two months of the competitive season.

Hawkins *et al.* (2001) expressed concern over the periods of injuries and considered players possibly not yet reaching adequate conditioning and adaptation, making them unable to withstand the demands of full competition. Hawkins *et al.* (2001) further emphasised the need to evaluate preseason programs and the progression of training load, as these aspects could be responsible for the peak in injury training.

Falese *et al.* (2016) also reported similar injury peaks early in the season, again citing the high workloads and adaptation demands placed on the players as possible factors resulting in injury.

It is also worth mentioning that the team included in this study experienced some set-backs during the 2017/2018 preseason, which could have impacted the results obtained. At the start of the 2017/2018 preseason the team was newly promoted from the second division to the PSL. Thus, the competitive level and performance demands were enhanced which could have altered the physicality of the game.

Given that the researcher had access to the team throughout the season, the following insight can be given regarding external factors which may have contributed to the injury incidence. During the preseason the team was exposed to extreme high volumes of training durations of approximately 180 minutes, 6 days a week, with minimal recovery periods. For a large duration of the preseason the team was exposed to extremely poor pitch quality which may also have contributed to the development of injuries. The accumulative fatigue from the strenuous preseason possibly led to the high injury rate in the first two months of the competitive season, as the competitive demands may have been too high for the players to withstand.

Also, differing coaching styles can have an impact on injury incidence in a sports team (Mallo, 2014, Owen, 2016a). The team included in this study underwent a technical and head coach change just one week prior to the first competitive match of the season. It was hypothesised by Owen (2016b) that players may be more susceptible to injuries when changing from a purely aerobic training regime to a more sport specific and conditioning based training schedule. The varying intensities and physical requirements from these two different training approaches could be the reason for increased injury risk.

Considering the above-mentioned findings indicating a higher volume of injuries during the first half of the football season, future long-term and continuous injury surveillance is required which will allow for the identification of injury trends and patterns over time. This could result in the identification of modifiable risk factors and provide insight and knowledge to the coaching staff, medical personnel and players involved in the PSL.

5.3.2 Injury Setting and Type

This current research study found that the injury incidence during training was higher than the number of injuries sustained during match play. It was established that 51% of all injuries occurred during training which was relatively higher than the training injury incidence of 33% found in a other PSL team by Calligeris *et al.* (2015).

Ekstrand *et al.* (2009) reported that match injuries sustained during competitive play were significantly higher than training injuries, with Hawkins *et al.* (2001) reporting similar findings in an injury audit on professional footballers, with 63% of all injuries occurring in competitive matches. Similarly, in the PSL, Calligeris *et al.* (2015) determined that 67% of all injuries occurred during competitive match play.

The above-mentioned external factors and set-backs possibly faced by the team, in this current study, during the preseason should be considered as possible reasons for the high training injury rate.

In this current study 61% of all injuries occurred from non-contact situations. Wong and Hong (2005) also found that non-contact injuries were more prevalent in football injuries. Hawkins *et al.* (2001) found similar findings in the English Premier League with 58% of all injuries as a result of non-contact mechanisms.

In contrast, Calligeris *et al.* (2015) found that contact injuries accounted for 67% of all injuries in the PSL. This varied greatly to the results of this study on the PSL which found 39% of all injuries occurring due to contact.

The differences in results could be due to numerous reasons; the higher rate of non-contact injuries found in this study may possibly be due to the excessive training volumes and poor pitch quality leading to mental and physical fatigue with increased tissue damage making participants vulnerable to injury. As mentioned by Gabbett (2016) brisk and uncontrolled training loads are more likely responsible for non-contact injuries.

The high number of contact injuries found by Calligeris *et al.* (2016) in their included PSL team may be due to specific playing style, or various other reasons undisclosed by the author. However, mention was made that 24% of all injuries recorded was a direct result of unfair play and violations of the football laws (Calligeris *et al.,* 2015).

These findings regarding the prevalence of non-contact vs. contact injuries are very different from those reported in European leagues, and highlights the need for injury surveillance to determine specific type of injury trends and causes of injury in the South African professional football population.

5.3.3 Injury Severity

This study found that most injuries sustained in the PSL were classified as moderate (8 – 28 days) which correlates with the findings of Ekstrand *et al.'s* (2009) study on the 23 UEFA teams in the 10 different European leagues along with Hawkins *et al*. (2001) in England, Stubbe *et al.* (2015) in Netherlands and Falese *et al.* (2016) in the Serie A in Italy. This South African study's findings is therefore in-line with its international football counterparts, indicating that moderate injuries are the most common.

Severe injuries accounted for 12% of the reported injuries in this study, which are in line with other football related injury studies of Ekstrand *et al.* (2009) and Stubbe *et al.* (2015). In contrast to this study's low number of reported severe injuries, Calligeris *et al.* (2015) found that 56 % of all injuries sustained by one team in the PSL season were severe. This finding is particularly concerning as severe injuries would result in a substantial time-off period and prove to be a substantial burden to both player and club.

Falese *et al.* (2016) demonstrated the most immediate severe injury percentage of 48.5%. However, it is important to bear in mind that the study of Falese *et al.* (2016) differed in injury severity categories from this current study which was described as follows; minor injuries (4-7 days), moderate (8-28 days) and severe (> 28 days). Falese *et al.* (2016) also mentioned that no minimal injuries (less than 4 days) were documented and may have resulted in underestimation of injury incidence and overestimation of injury duration percentage.

Hawkins *et al.* (2001) found that approximately 23% of all injuries sustained the English Premier League were severe. This is comparable with the results of previous studies as the definition of a “severe injury” was similar (Calligeris *et al.,* 2015; Ekstrand *et al.,* 2009).

This highlights the major difference in the severe injury rate in a South African PSL team, as the 56% of severe injuries were substantially higher than reported in the other injury related football studies, including the findings of this current research study (Calligeris *et al.,* 2015; Ekstrand *et al.,* 2009). However, mention must be made of research methodology inconsistencies in football research which could possibly explain the vast difference in findings of severe injuries between the two PSL studies but further investigation is still suggested.

The difference in the findings between this research study and the study conducted by Calligeris *et al.* (2015), both South African based studies, regarding the incidence of injury severity suggest an urgent need for extended injury surveillance in the PSL.

5.3.4 Previous injury and Re-injury

This study found that 37% of all injuries were related to previous injury. Previous injury has been well established as a significant injury risk factor, as it may lead to neural inhibitions, muscle atrophy, fascicle length changes, strength deficits and increased fatigue (Roe *et al.,* 2017). A previously conducted systematic review reported high level of evidence, indicating that previous injury increases the risk of re-injury in professional football players (McCall *et al.,* 2015).

Ekstrand *et al.* (2009) stated that re-injury resulted in a longer time off period and are often a result of inadequate rehabilitation and early return to play. In this study 9% of all injuries sustained were re-injuries of index injuries sustained during the 2017/2018 PSL season of Amazulu F.C. This finding is in-line with the 12% of re-injury found in the UEFA injury study by Ekstrand *et al.* (2009). Calligeris *et al.* (2015) demonstrated a re-injury rate of 12% on a South African PSL team based in the Western Cape.

The findings of this study regarding re-injury rates are similar when compared to other studies conducted on similar populations, suggesting that adequate rehabilitation and return to play protocols may be in place. However, it remains imperative that rehabilitation protocols be continuously revised, benchmarked and adjusted to allow for an even lower percentage of re-injury.

5.4 Additional findings

5.4.1 Individual FMS Movements

Although this study did not aim to evaluate individual movement tests of the FMS, the researcher decided to investigate individual subtest scoring. This decision was made due to the fact that the FMS scores both lower limb and upper body function and strength. Data may be skewed, especially when testing a sport code where focus is on lower limb function and strength, due to participants scoring significantly higher on the upper body function tests.

It was demonstrated by Rusling *et al.* (2015) that the individual movement tests, Deep Squat and Trunk Stability Push-up associated significantly with football injuries. This finding was further demonstrated by Mokha *et al.* (2016), who noted that participants scoring one in any of the individual movement tests were 2.73 times at greater risk of injury.

In this study the Trunk Stability Push-Up test was performed the best with all but one participant scoring the highest possible score of 3. As previously discussed, The Trunk Stability Push-Up assesses upper body strength and movement in conjunction with core stability (Cook *et al.,* 2006b).

The following two best scoring movements were the Active Straight Leg Raise and Shoulder Mobility. The Active Straight Leg Raise assesses muscle flexibility, dissociation of lower extremity movement and core stability (Cook *et al.,* 2006b). Further, Shoulder Mobility test assesses range of movement and normal function of the scapula along with adequate thoracic spine mobility (Cook *et al.,* 2006b).

In contrast, the Hurdle step and Rotary stability test, which mainly includes lower extremity and core stability assessment, displayed the worst performance scores. Considering the highest scoring movements included mostly upper extremity strength and mobility, an adaptation to the FMS to be more specific to football with regards to lower extremity examination could yield more sport specific results.

The results of this study, along with published football injury research, conclude that the majority of football injuries occur in the lower extremities. Considering this finding, a possible adaptation to the FMS could exclude upper extremity tests, namely Shoulder Mobility test, to improve its accuracy and specificity to football. This was supported by Kraus *et al.* (2014) who found a strong correlation between FMS and lower extremity injuries, if the shoulder mobility test was eliminated.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

In this final chapter the conclusions, recommendations, as well as the limitations of the study will be discussed.

6.2 Functional Movement Screen

The aim of this research study was to determine the pre-season FMS composite score for a KwaZulu-Natal based football team (Amazulu F.C.); and to determine the association between FMS scores and injury incidence.

It was determined that the median FMS composite score of Amazulu F.C. was 15 and ranged between 11 and 18. The score of 15 was found to be higher than South African youth players, but mixed results for amateur adult football players. The lack of FMS composite score data in professional football allows for this finding to serve as a foundation for future FMS research in the PSL as the baseline score of 15 can be used as a reference.

In this study 81% of all participants were injured, with a median injury of two per participant. The PSL team sustained 57 injuries during the season which was in-line with world football injury research.

Although non-injured participants had a higher median FMS score of 16 in comparison to the median FMS score of 15 in injured participants, no statistical significant association between injury incidence and FMS scores were found. This suggests that low FMS scores are not necessarily able to predict future injury.

Recent research suggests a possible “optimal range” that exists in the FMS scores, indicating that athletes who score in the “optimal range” might not be as likely to incur an injury and may be allowed to continue with performance testing. The participants who score outside of the “optimal range” would require further assessment and possible intervention prior to the commencement of performance testing.

The inconclusive findings of the study resulted in further investigation. Although, not an aim this study, participants were categorised in accordance to recent literature. Firstly, it was found that the participants who scored above the score of ≤ 14 on the FMS, were less likely to sustain an injury than participants who scored > 14 on the FMS.

Further, participants who scored in the “optimal range” of 15 – 17 suggested by Orser (2018), reported the lowest median injury. This yielded surprising results, indicating that a possible “optimal range” for the FMS score exists.

Further, the individual participant FMS scores were compared to the median injury per participant in each score. In this current study participants who scored 12 and 13 on the FMS as well as 17 and 18 on the FMS had a higher injury median per participants than participants who scored between 14 and 16. This may indicate the “optimal range” for the South African professional football team to be between 14 – 16, this is purely anecdotal and requires further research to be supported.

Lastly, participants who scored 16 on the FMS had the lowest injury median, further supporting the possibility of a bimodal distribution and an “optimal range” associated with FMS testing.

The use of the FMS as its originally intended purpose, a screening tool, is recommended in the PSL to identify individuals that require further assessment. The use of the FMS to predict injury is questionable. The researcher hopes this current study’s findings will provide some insight into the use of the FMS in the PSL and the composite FMS scores associated with the professional footballers playing in the PSL. Further investigation, especially in a larger sample size, is required to successfully conclude these findings.

6.3 Injury profiling

The secondary study aim was to describe the injury profile for Amazulu F.C. for the 2017/ 2018 football season. This current study determined that South African PSL injury statistics of one team is similar to European studies regarding injury incidence and injury severity. This allows for adequate comparative data and illustrates the injury data to be in-line with world football. Some inconsistencies observed will be discussed below.

One similar South African study on a PSL team reported double the injury incidence and a significantly higher injury severity than what was found in this current research study. Both PSL studies demonstrated contusions to be more prevalent compared to what was found in other football research. The higher contusion rates could possibly be a result of a more physical playing style, foul play or decreased technical abilities when compared to the European football leagues.

Another finding in this study, pertaining to the injury time frame throughout the season, demonstrated that 40% of all injuries occurred within the first two months of the competitive season.

This strongly suggests a review of preseason programs with regards to match conditioning and improved match specific adaptation, as players may not be adequately conditioned for competitive match play.

The vast difference between the two PSL studies regarding injury incidence and injury severity highlights the gap in literature and suggests the necessity of extended injury surveillance in the PSL to establish accurate injury data.

6.4 Limitations of the study

One of the major limitations of this study is the small sample size, as it consisted only of one team in a sixteen team-league competition. This results in the findings not being generalisable to the entire South African professional football population. The small number of participants also resulted in data being skewed and should be interpreted with caution.

The injury surveillance was conducted over one season only and injury data could vary from season to season. The study also only included a team from one geographic region and, as described previously, this could have had an influence on the study results.

It should also be considered that the nature of this study is that of a “mini” dissertation and doesn’t necessarily lend itself to an in depth investigation.

Due to the data gathered yielding no significant findings, the researcher opted to categorise the participants into FMS score specific categories. Even though this was not an aim or objective stated at the beginning of the study, categorising and the subsequent discussion thereof may shed some light on the limited findings. Categorisation of participants should have been part of the study objectives including in-depth analysis of these sub-categories.

Inconsistencies with regards to the use of different study definitions and terminology make it difficult to compare the published literature to this current research study. In order to limit these shortcomings an adequate operational definitions section was included.

Other considerations are human errors with regards to accurate coding and data collection. The researcher was ever present throughout the course of the season and research study and did the utmost to ensure that this was done to the most accurate standards.

6.5 Recommendations

The study demonstrated some useful findings with regards to the FMS and its use as a screening tool to identify individuals at risk of injury.

Despite the use of a small sample size and the absence of significant statistical findings, the research supported the possibility of an “optimal range” in the FMS. However, this requires further investigation of a larger sample size in a specific population.

A recommendation for future research is to compare individual FMS scores to individual injury incidence and assess any statistically significant associations in this regard. This was however not the specified research aim and objective for this study.

The study results provided valuable information regarding the PSL injury surveillance, which was in-line with European football injury research. The information gather from this study will benefit all PSL teams and it could possibly be distributed to all medical teams of the PSL and possible discussions held with regards to completing a larger study and injury surveillance program.

However, an alarming difference in injury incidence and injury severity statistics was illustrated when compared to a similar South African study. This urges the need for extended injury surveillance in the South African PSL in order to establish the true extent of injury incidence and injury severity.

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Appendix A: Amazulu Permission Form

Amazulu F.C Request for Permission

Dear Amazulu F.C.

The following serves as a request for permission form for Karel du Toit to complete the following research study on the Amazulu F.C squad.

Functional Movement Screening and Injury profiling in Professional Soccer Players

The aim of this study is to investigate the efficacy of the Functional movement screen (FMS) as an injury predictor for professional soccer players in the National First Division in South Africa.

The FMS is an assessment tool consisting of 7 basic movement tests to evaluate the fundamental movement patterns in sports to identify limitations or asymmetries in individuals.
The FMS will be done in the first week pre-season.

The FMS scores will be correlated to the injuries sustained during the 2017/2018 season to establish whether there is any association between the two.
This information can be very valuable in order to prevent injuries in the future.

The Club will also have the right to refuse and withdraw consent for their information to be used for the research study. No participant will be remunerated for this study.

By completing the informed consent you Amazulu FC provides permission to Karel du Toit, physiotherapist to conduct the research study titled Functional Movement Screening and Injury Profiling in Professional Soccer Players on the employees of the club.
The study will include a FMS test and injury recording of the 2017/2018 season.

This letter confirms as consent for the testing and utilization of any resources needed to complete the research.

I, Lunga grant permission on this day 03 month 06 year 2017 at Durban for Mr. Karel du Toit to conduct his research study.

Lunga Sokhela
General Manager Amazulu FC

Karel du Toit
Physiotherapist

Appendix B: Ethical Approval Certificate

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS·UV
HEALTH SCIENCES
GESONDHEIDSWETENSKAPPE

IRB nr 00006240
REC Reference nr 230408-011
IORG0005187
FWA00012784

26 July 2017

MR KAREL C DU TOIT
DEPT OF PHYSIOTHERAPY
FACULTY OF HEALTH SCIENCES
UFS

Dear Mr Karel C Du Toit

HSREC 75/2017 (UFS-HSD2017/0684)
PRINCIPAL INVESTIGATOR: MR KAREL C DU TOIT
SUPERVISOR: CORLIA BRANDT
PROJECT TITLE: FUNCTIONAL MOVEMENT SCREENING AND INJURY PROFILING IN PROFESSIONAL SOCCER PLAYERS

APPROVED

1. You are hereby kindly informed that the Health Sciences Research Ethics Committee (HSREC) approved this protocol after all conditions were met at the meeting held on 25 July 2017.
2. The Committee must be informed of any serious adverse event and/or termination of the study.
3. Any amendment, extension or other modifications to the protocol must be submitted to the HSREC for approval.
4. A progress report should be submitted within one year of approval and annually for long term studies.
5. A final report should be submitted at the completion of the study.
6. Kindly use the **HSREC NR** as reference in correspondence to the HSREC Secretariat.
7. The HSREC functions in compliance with, but not limited to, the following documents and guidelines: The SA National Health Act. No. 61 of 2003; Ethics in Health Research: Principles, Structures and Processes (2015); SA GCP(2006); Declaration of Helsinki; The Belmont Report; The US Office of Human Research Protections 45 CFR 461 (for non-exempt research with human participants conducted or supported by the US Department of Health and Human Services- (HHS), 21 CFR 50, 21 CFR 56; CIOMS; ICH-GCP-E6 Sections 1-4; The International Conference on Harmonization and Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH Tripartite), Guidelines of the SA Medicines Control Council as well as Laws and Regulations with regard to the Control of Medicines, Constitution of the HSREC of the Faculty of Health Sciences.

Yours faithfully

DR SM LE GRANGE
CHAIR: HEALTH SCIENCES RESEARCH ETHICS COMMITTEE

Health Sciences Research Ethics Committee
Office of the Dean: Health Sciences
T: +27 (0)51 401 7795/7794 | E: ethicsfhs@ufs.ac.za
Block D, Dean's Division, Room D104 | P.O. Box/Posbus 339 (Internal Post Box G40) | Bloemfontein 9300 | South Africa
www.ufs.ac.za

Appendix C: Injury Report Form

Injury Report Form										
Player	**Playing**	**Activity**	**Anatomical Location**		**Diagnosis**		**Severity**	**Type of Injury**		**Previous Injury**
No.	Position	Training / Match	Injured Area	Code	Type of Injury	Code	Absence in days	Contact	Non-Contact	Yes/No

(Dvorak, Junge and Grimm, 2009)

Appendix D: Injury Codes Form

Codes

Location of Injury					
	Trunk		**Upper Extremity**		**Lower Extremity**
1	Head / Face	11	Shoulder	21	Hip
2	Neck / Cervical Spine	12	Upper Arm	22	Groin
3	Thoracic Spine	13	Elbow	23	Thigh
4	Lumbar Spine	14	Forearm	24	Knee
5	Sternum / Ribs	15	Wrist	25	Lower Leg
6	Abdominal	16	Hand	26	Achilles Tendon
7	Pelvis / Sacrum	17	Finger	27	Ankle
		18	Thumb	28	Foot
				29	Toe

Diagnosis					
1	Concussion with loss of consciousness	7	Ligament rupture with instability	13	Bursitis
2	Concussion without loss of consciousness	8	Ligament rupture without instability	14	Tendinopathy
3	Fracture	9	Lesion of meniscus	15	Laceration / Abrasion
4	Dislocation	10	Sprain	16	Other
5	Muscle fiber rupture	11	Strain		
6	Tendon Rupture	12	Contusion		

Severity of injuries	
1	Minimal (1-3 days)
2	Mild (4-7 days)
3	Moderate (8-28 days
4	Severe (>28 days)

(Dvorak, Junge and Grimm, 2009)

Appendix E: Questionnaire

Demographics

Participant

1	Date questionnaire is completed				
2	Age	**Years old**			
3	Height	**cm**			
4	Weight	**Kg**			
5	Position	**1.Attack**	**2.Defender**	**3.Midfielder**	**4.Goalkeeper**
6	Level of Participation	**1.International**	**2.Professional**		
7	Dominant Leg	**1.Left**	**2.Right**		
8	Dominant Arm	**1.Left**	**2.Right**		
9	Number of Matches 12 months				

Medical History

Present and past complaints

15	**General**	**Yes**
	Flu-like symptoms	
	Infections	
	Rheumatic Fever	
	Heart illness	
	Concussion	
	Allergies	
	None	
16	**Heart and Lung**	**Yes**

Chest pain or tightness	
Shortness of breath	
Asthma	
Cough	
Bronchitis	
Palpitations/arrhythmias	
Hypertension	
Seizures/ epilepsy	
Diarrhoea	
None	

Musculoskeletal system

17 **Severe injury >4 weeks**

	Left	**Right**	**When**
Groin Strain			
Quadriceps Femoris Strain			
Hamstring Strain			
Knee Ligaments			
Ankle Ligaments			
Lower back Pain			
Shoulder injury			
None			
Other			

If Other Please Specify _____

18 **Surgery**

	Left	**Right**	**When**
Hip Joint			
Knee Ligaments			
Knee meniscus/cartilage			

Achilles tendon			
Ankle joint			
Shoulder			
None			
Other			
If Other, Please Specify			

19	**Current Complaints/aches/pain**	**Yes**
	Head / Face	
	Cervical Spine	
	Thoracic Spine	
	Lumbar Spine	
	Sternum / Ribs	
	Abdomen	
	Pelvis / Sacrum	
	Shoulder	
	Upper Arm	
	Elbow	
	Forearm	
	Wrist	
	Hand	
	Fingers	
	Hip	
	Groin	
	Thigh	
	Knee	
	Lower leg	
	Achilles tendon	

Ankle	
Foot / Toes	
None	

	Current Diagnosis and Treatment	Left	Right	Rest	Physiotherapy	Surgery
20	**If Yes, specify Treatment**					
	Pubic pain					
	Groin/adductor strain					
	Hamstring Strain					
	Quadriceps Strain					
	Knee Sprain					
	Meniscus Lesion					
	Tendinopathy of Achilles tendon					
	Ankle Sprain					
	Concussion					
	Shoulder injury					
	Lower Back Pain					
	None					
	Other					
	If Other, Please Specify					

(Dvorak, Junge and Grimm, 2009)

Appendix F: Participant Consent Form

CONSENT TO PARTICIPATE IN RESEARCH

PROJECT TITLE: Functional Movement Screening and Injury profiling in Professional Soccer Players.

……

You have been asked to participate in a research study. You have been informed about the study by Karel du Toit. You may contact Karel du Toit at Amazulu FC any time if you have questions about the research or if you are injured as a result of the research.

You may contact the Secretariat of the Health Sciences Research Ethics Committee of the University of the Free State (UFS) at telephone number (051) 4052812 if you have questions about your rights as a research subject.

Your participation in this research is voluntary, and you will not be penalized or lose benefits if you refuse to participate or decide to terminate participation.

If you agree to participate, you will be given a signed copy of this document as well as the participant information sheet, which is a written summary of the research.

The research study, including the above information has been verbally described to me. I understand what my involvement in the study means and I voluntarily agree to participate.

_____ _____

Signature of Participant Date

_____ _____

Signature of Witness Date

(Where applicable)

_____ _____

Signature of Translator Date

(Where applicable)

Appendix G: Participant Information Form

INFORMATION DOCUMENT

Study title: Functional Movement Screening and Injury profiling in Professional Soccer Players

Dear Sir

Introduction:

I am doing research on Functional Movement Screen in Professional Soccer Players. Research is just the process to learn the answer to a question. In this study we want to learn if it will be possible to predict players at risk of injury using the Functional movement screen.

Invitation to participate: We are asking/inviting you to participate in a research study.

What is involved in the study – the study will be a prospective cohort study. The aim of this study is to investigate the efficacy of the Functional movement screen (FMS) as an injury predictor for professional soccer players in the National First Division in South Africa.

The FMS is an assessment tool consisting of 7 basic movement tests to evaluate the fundamental movement patterns in sports to identify limitations or asymmetries in individuals.

The FMS will be done on all participants. The FMS scores will be correlated to the injuries sustained during a five months period to establish whether there is any association between the two. This information can be very valuable to prevent injuries in the future.

Risks of being involved in the study: No risks will be involved as it is part of your routine pre-season schedule.

Benefits of being in the study will help in minimising injury and/or helping to improve injury prevention strategies.

The subject will be given pertinent information on the study while involved in the project and after the results are available.

Participation is voluntary, and refusal to participate will involve no penalty or loss of benefits to which the subject is otherwise entitled; the subject may discontinue participation at any time without penalty or loss of benefits to which the subject is otherwise entitled.

Reimbursements for “out of pocket” expenses.

Confidentiality: Efforts will be made to keep personal information confidential. Absolute confidentiality cannot be guaranteed. Personal information may be disclosed if required by law.

If results are published, this may lead to individual/cohort identification.

Contact details of researcher(s) – for further information/reporting of study-related adverse events.

Contact details of Secretariat and Chair: Health Sciences Research Ethics Committee, University of the Free State – for reporting of complaints/problems: Telephone number (051) 4052812.

Appendix H: Functional Movement Screen Grading Criteria

Movement	Score 3	Score 2	Score 1
Deep Squat	• Upper torso parallel with Tibia or toward vertical • Femur below horizontal • Knees aligned over feet • Dowel aligned over feet	• Add heel raise • Same criteria as score 3	• Unable to perform movement properly with heel raise
Hurdle Step	• Hips, knees and ankles aligned in sagittal plane • Erect posture maintained	• One or more of the scoring criteria for 3 is not performed	• Contact between foot and hurdle • Loss of balance
In-line Lunge	• Dowel contacts remain with head, T-spine and L – spine • Dowel and feet aligned in sagittal plane • Knee touches board	• One or more of scoring criteria for 3 is nor performed	• Loss of balance
Shoulder Mobility	• Fists are within one hand length	• Fists are within 1 and a half hand length	• Fists are not within 1 and a half hand length
Active Straight Leg Raise	• Ankle passes mid-thigh point	• Ankle between knee and mid-thigh	• Ankle does not pass knee
Trunk Stability Push-up	• Males: 1 rep: thumbs aligned with fop of forehead • Females: 1 rep: thumbs aligned with chin	• Males: 1rep: thumbs aligned with chin • Females: 1 rep: thumbs aligned with clavicle	• Males: unable to achieve score 2 • Females unable to achieve score 2
Rotary stability	• Performs unilateral repetition • Spine parallel to board • Knee and elbow touch over board	• Performs diagonal repetition • Same criteria as 3	• Unable to perform diagonal repetition

(Cook et al. 2006a)

Appendix I: Functional Movement Screen Score Sheet

FUNCTIONAL MOVEMENT SCREEN / AP SCORING SHEET

Date: _____

Name: _____ Age: _____ Level: _____ Team/School: _____ Sport & Position: _____

Height: _____ Weight: _____ Hand Dominance: R L Swing Dominance: R L Leg Dominance: R L Throw Dominance: R L

Test	Score	Dysfunction	Grading criteria III	Grading criteria II	Grading criteria I
1. Deep Squat Toe Touch Test Able/Not Able	3 2 1 0		• Upper torso parallel with tibia or towards vertical • Femur below horizontal • Knees over feet • Dowel over feet	• Upper torso parallel with tibia or towards vertical • Femur below horizontal • Dowel aligned over feet on 2x6	• Tibia and upper torso not parallel • Femur not below horizontal • Knees not aligned over feet • Lumbar flexion noted
2. Hurdle Step Inch: ____ Left leg up Right leg up	3 2 1 0 3 2 1 0 3 2 1 0		• Hips, knees & ankles remain aligned in sagital plane • Minimal movement in lumbar spine • Dowel and hurdle remain parallel	• Alignment lost between hips, knees and ankles • Movement in lumbar spine • Dowel and hurdle do not remain parallel	• Contact with foot and hurdle • Loss of balance at any time
3. In-Line Lunge Inch: ____ Left leg forward Right leg forward	3 2 1 0 3 2 1 0 3 2 1 0		• Minimal to no torso movement • Feet remain in sagittal plane on 2x6 • Knee touches 2x6 behind heel of front foot	• Movement in torso • Feet do not remain in sagittal plane • Knee does not touch behind heel of front foot	• Loss of balance at any time
4. Shoulder Mobility Distance: _____ Impingement test (L): ___ Impingement test (R):___	3 2 1 0 L top: __ R top: __ 3 2 1 0 3 2 1 0		• Fists within one hand length	• Fists within one and a half hand lengths	• Fists fall greater than one and a half hand lengths
5. Active Straight Leg raise	3 2 1 0 L: ___ R: ___		• Malleolus resides between mid-thigh and ASIS	• Malleolus resides between mid-thigh and mid-patella	• Malleolus resides below patella
6. Trunk Stability – Push-Up Prone Press up Test: _____	3 2 1 0		• Males perform 1 rep with thumbs above head • Females perform 1 rep with thumbs in line with chin	• Males perform 1 rep with thumbs in line with chin • Females perform 1 rep with thumbs in line with clavicle	• Males unable to perform 1 rep with thumbs in line with chin • Females unable to perform 1 rep with thumbs in line with clavicle
7. Rotary Stability Left up Right up Kneeling Lumbar Flexion Test: ___	3 2 1 0 3 2 1 0 3 2 1 0		• Performs 1 unilateral rep with torso parallel to board • Knee and elbow touch in line with board	• Performs 1 diagonal rep with torso parallel to board • Knee and elbow touch in line with board	• Unable to perform diagonal rep

Total Score (Tests 1-7) = _____/21___ Initials of Tester: _____

(Cook *et al.* 2006a)

Appendix J: Turnitin Report

FUNCTIONAL MOVEMENT SCREENING AND INJURY PROFILING IN PROFESSIONAL SOCCER PLAYERS

ORIGINALITY REPORT

15%	12%	7%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

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