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School of Health Care Sciences

Department Physiotherapy

The epidemiology, clinical characteristics and associated risk factors for injury among football players at an academy in Ghana

Submitted in fulfilment of the requirements for the degree

MPhysT

Samuel Koranteng Kwakye

(u21742198)

Supervisor: Prof. K Mostert

Co-supervisor: Mr D Garnett

This thesis is presented in a publication format

DECLARATION

I, the undersigned, declare that the dissertation hereby submitted to the University of Pretoria for the degree MPhysT and the work contained therein is my own original work and has not previously, in its entirety or in part, been submitted to any university for a degree.

Signed………… …. this 16th day of December 2022

DEDICATION

I dedicate this work to Dr Jonathan Quartey, my friend and undergraduate lecturer and supervisor, who encouraged me to seek this degree and has been a steadfast supporter of me throughout graduate school and my life. I also thank my uncle, Dr Frank Boateng, who helped me out financially and kept me on track. Finally, I dedicate this thesis to my parents and brothers form their emotional support

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Ultimately, I owe everything to the Creator. I can only live and move and breathe by His grace. May the products of my labor bring You honour.

ABSTRACT

Title: The epidemiology, clinical characteristics and associated risk factors for injury among football players at an academy in Ghana.

Candidate: Samuel Koranteng Kwakye

Supervisor: Prof. Karien Mostert

Co-supervisor: Mr Daniel Garnett

Degree: MPhysT

Background: Football is arguably the most common team sport in the world, with a resultant and rapid increase in the formation of young football academies, including Ghana. However, football is significantly associated with a risk of injury. Efforts are being focused on younger populations to reduce injuries through improving understanding of epidemiology and injury prevention strategies. Sparse knowledge on injuries and their risk factors specific to academy football players in Ghana is available.

Aim of the study: To determine the epidemiology, clinical characteristics and risk factors of football injuries, among players at a football academy in Ghana.

Design: Observational prospective cohort study.

Setting: A football academy in the Volta Region of Ghana.

Participants: Fifty-three young (under 18 years) and 27 adult (18 years and above) football players.

Methods: Eighty male, young and adult academy football players were recruited at a football academy in Ghana using total population sampling. Baseline measurements taken before the start of the football season included height using a stadiometer (Seca 213), weight using a digital scale (Omron HN-289), and ankle dorsiflexion (DF) range of motion (ROM) were measured with a tape measure. Functional ankle instability was measured with the Star Excursion Balance Test (SEBT) and the Cumberland Ankle Instability Tool (CAIT). A standardised injury surveillance form (SIS) developed by the International Olympic Committee (IOC), was used by two qualified senior physiotherapists to prospectively document players' injuries and injury characteristics during one season. The first author visited the study site once a month to ensure` validity of data captured to extract data from physiotherapists' files. All data collected were entered into a Microsoft Excel spreadsheet for analysis according to the International Olympic Committee (IOC) reporting guidelines. In addition to descriptive statistics, selected variables associated with football injuries were statistically investigated using Spearman's rank correlation with interpretation at a significance level of 5%.

Results: A total of 126 injuries were reported during the assessed football season, with 66% and 60% occurring during matches and training, respectively. The average weekly injury prevalence was 4.1%, and overall injury incidence was 4.5 injuries per 1 000 hours. Match incidence (27.4 per 1 000 hours) was higher than training incidence (2.3 per 1 000 hours). The U14, U16 and U18 players suffered higher injury incidence (5.8, 5.1, 5.7 injuries per 1 000 hours respectively) compared to senior players (2.7 per 1 000 hours). A total of 109 injuries (86.5%) affected the lower limb, with the knee (n=30, 23.8%) being the most affected, followed by the ankle and the hip/groin (both n=17, 13.5%), and 57 (45.2%) injuries were due to acute trauma, occurring with direct contact with another player (n=42, 33.3%). The most common injury areas were joint sprains (n=54, 43.9%), followed by muscle strains (n=33, 26.2%), and bone contusions (n=11, 8.7%). The severity of injuries was mostly moderate (n=56, 44.4%). New injuries (n=112, 88.9%) occurred more commonly during matches than during training (n=59. 46.8% vs n=53, 42.1%). Of the total recorded number of recurrent injuries (n=14, 11.1%), most occurred among the U18 players (n=10, 17.2%). The following risk factors were associated with overall-, match- or training injury incidence during the season: Age was negatively associated with overall injury incidence (r=-0.589, p=0.000), and training injury incidence (r=-0.314, p=0.005). A record of previous injury among U18 players was associated with training injury incidence (r= 0.436, p=0.023). The Body Mass Index (BMI) was negatively associated with overall injury incidence (r=-0.513, p=0.000) and training injury incidence (r=- 0.395, p=0.000). However, only for U18 players the BMI was negatively associated with overall injury incidence (r=- 0.428, p=0.021), based on age category. CAIT scores (for ankle instability) were positively associated with overall (n=0.263, p=0.019) and match injury incidence (r=0.263, p=0.029) whilst only senior players' range of motion (ROM) of the left ankle (dorsiflexion) was positively associated with training injury incidence (r=0.436, p=0.023). Player position was associated with match injury incidence (r=0.241, p=0.031) while the attacker position among U16 was associated with training injury incidence (r=0.669, p=0.003).

Conclusion: Injury incidence over a competitive season was higher among younger players, compared to senior players. The majority of training injuries occurred in non-contact scenarios, whereas contact injuries were more common during matches. Most reported injuries were joint sprains and muscle strains, which mostly affected the lower limb. A younger age, lower BMI and higher self-reported functional ankle instability were risk factors associated with overall injury incidence of the whole population. In U18 players, a lower BMI and a previous injury were risk factors associated with increased injury incidence. Adult players' ankle dorsiflexion ROM was associated with injury incidence. The 'Attacker' playing position was associated with an increased injury incidence among U16 players. This study's findings contribute to the collective understanding of injuries and risk injury factors among academy football players. These results can guide the development of future injury prevention strategies, specifically in Ghana. Further studies should focus on examining risk factors for specific anatomical locations, especially the ankle and the knee as well as specific injury types.

Keywords: clinical characteristics, epidemiology, injury incidence, physiotherapy, risk factors, soccer/football, sports injuries

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LIST OF ABBREVIATIONS/ACRONYMS

Abbreviation / Acronym	**Meaning**
ACL	Anterior Cruciate Ligament
BMI	Body Mass Index
CAIT	Cumberland Ankle Instability Tool
DF	Dorsiflexion
DWS	Digital Weighing Scale
FAI	Functional Ankle Instability
FIFA	Federation of International Football Association
GFAS	Global Foot and Ankle Scale
ICC	Intra-class Correlation Coefficient
IOC	International Olympic Committee
IR	Incidence Rate
LEFS	Lower Extremity Functional Scale
MDC	Minimum Detectable Change
mWBLT	Modified Weight-bearing Lunge Test
ROM	Range of Motion
SEBT	Star Excursion Balance Test
SEM	Standard Error of Mean
UEFA	Union of European Football Association
WAFA	West African Football Academy
WAFU	West African Football Union
WBLT	Weight-bearing Lunge Test

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Football is a team sport that provides numerous young people worldwide with the advantage of physical activity (Light, Johnson, Williams, Smith, Hale and Thorborg, 2021). Injuries have been reported among professional, elite adult and young football players (Green, Lin, Schache, McClelland, Semciw, Rotstein et al., 2020; Arliani et al., 2021; Kurittu, Vasankari, Brinck, Parkkari, Heinonen, Kannus et al., 2021; Light et al., 2021). Relatively fewer studies have focused on players in a football academy (Light et al., 2021; Materne, Chamari, Farooq, Weir, Hölmich, Bahr et al., 2021) and relatively no study found among Ghanain players. A football academy is considered crucial to the tactical, technical, and physical growth of a young footballer (Jones, Almousa, Gibb, Allamby, Mullen, Andersen et al., 2019). However, younger players may be at an increased risk of injury due to the complexities of the sport and frequent training and matches (Light et al., 2021). Football is categorised as a moderate to high intensity contact sport and therefore most injuries in football are also sustained through contact between players and the turf, ball, or goalpost, rather than overuse (López-Valenciano, Ruiz-Pérez, Garcia-Gómez, Vera-Garcia, De Ste Croix, Myer et al., 2020: Robles-Palazón, López-Valenciano, De Ste Croix, Oliver, García-Gómez, Sainz de Baranda et al., 2021). Injuries in both adult and young football players frequently include joint sprains, fractures, contusions, muscle strains and meniscal tears (López-Valenciano et al., 2020; Robles-Palazón et al., 2021). Increased body mass, altered bony lever lengths, and more vigorous play can all contribute to a higher risk of sprain in young male football players (Bisciotti, Chamari, Cena, Bisciotti, Bisciotti, Corsini et al., 2019; Gebert, Gerber, Pühse, Gassmann, Stamm and Lamprecht, 2019; Jones et al., 2019).

Overall football injury incidences have been reported ranging from 6.2 injuries per 1 000 hours in adult male professional players in the Netherlands (Stubbe, van Beijsterveldt, van der Knaap, Stege, Verhagen, van Mechelen et al., 2015), to 2.8 in Portugal (Martins, França, Marques, Iglésias, Sarmento, Henriques et al., 2022) and 6.9 injuries among professional Spanish players (Torrontegui-Duarte, Gijon-Nogueron, Perez-Frias, Morales-Asencio and Luque-Suarez, 2020). youngyoungInjury incidence reported among adult players in most European studies (Jones et al., 2019; Kurittu et al., 2021; Martins et al., 2022) is relatively higher than those reported in African studies (Owoeye, 2010; Bayne, Schwellnus, van Rensburg, Botha and Pillay, 2018) over a football season, with a substantially higher injury incidence during competitions compared to training. Due to the high injury rate among football players, emphasis is being placed on the reduction of injury prevalence and incidence, performance improvements and expansion of the active lifespan of athletes (Owoeye, 2010; Bayne et al., 2018). Although developing countries have made substantial efforts to minimise sports injury incidences, limited research on football injuries in low- and middle-income countries exist (Adjei, Moses, Nutakor and Gyinaye, 2015; Moses and Duduyemi, 2016).

A number of risk factors, both intrinsic and extrinsic, have been associated with football injuries in general (Ready, Li, Worobey, Lemme, Yang, Yang et al., 2021: Ribeiro-Alvares, Dornelles, Fritsch, de Lima, Medeiros, Severo-Silveira et al., 2020: Kolokotsios, Drousia, Koukoulithras and Plexousakis, 2021). Intrinsic factors among male football players between 18 and 21 years include; but is not limited to, a wide dorsiflexion range of motion (ROM) in the ankles, and a history of previous injury (Niyonsenga and Phillips, 2013). Reduced ankle dorsiflexion ROM raises the risk of injury by modifying the stiffness of the leg and landing forces after a jump (Mason-Mackay, Whatman and Reid, 2017). Reduced ankle dorsiflexion ROM has, therefore, been associated with football injuries to the ankle, hamstring muscles, Achilles and patella tendons, and the anterior cruciate ligament (ACL) (van Dyk, Farooq, Bahr and Witvrouw, 2018; Della Villa, Buckthorpe, Grassi, Nabiuzzi, Tosarelli, Zaffagnini et al., 2020; Ribeiro-Alvares, Dornelles, Fritsch, de Lima, Medeiros, Severo-Silveira et al., 2020; Kolokotsios, Drousia, Koukoulithras and Plexousakis, 2021; Ready, Li, Worobey, Lemme, Yang, Yang et al., 2021; Della Villa, Buckthorpe, Tosarelli, Zago, Zaffagnini and Grassi, 2022). In addition, the ankle is the most frequently injured body part among male football players (Mulcahey, Bernhardson, Murphy, Chang, Zajac, Sanchez et al., 2018; Moreno-Pérez et al., 2020; Kolokotsios et al., 2021). Relatively few studies analysed the effect of ankle dorsiflexion ROM among football players, as compared to the number of those analysing hamstring muscle characteristics (Wollin, Thorborg and Pizzari, 2017; Wollin, Thorborg and Pizzari, 2018; Moreno-Pérez, Soler, Ansa, López-Samanes, Madruga-Parera, Beato et al., 2020). Two of these studies found that although post-match ankle dorsiflexion ROM was decreased, the differences were, however, not statistically meaningful (Wollin et al., 2017; Wollin et al., 2018). Contrarily, other studies have discovered an association between reduced ankle dorsiflexion ROM and muscle injury (Condon, Aguilar and Wikstrom, 2017; Moreno-Pérez et al., 2020), as well as an increased risk of football injuries, in general (López-Valenciano et al., 2020).

Functional ankle instability (FAI) occurs in about 40% of adult professional football players in Europe and may result from severe ankle sprains and reduced range of motion, and has been associated with impaired proprioception, neuromuscular and postural control, and muscle weakness (Jiang, Kim and Choi, 2022; Li, Liu, Luo and Guo, 2022; Petersen, Zebis, Lauridsen, Hölmich, Aagaard and Bencke, 2022). Ankle dorsiflexion ROM and FAI are both reliable and low-cost measurements (Konor et al., 2012: Gribble, Hertel and Plisky, 2012). Moreover, studies of hamstring injury characteristics have been thoroughly researched and measurement of proprioception also require complex and expensive equipment (Romero-Franco, Montaño-Munuera and Jiménez-Reyes, 2017). Since ankle dorsiflexion ROM is important for landing and changing directions in dynamic sports actions (Gonzalo-Skok, Serna, Rhea and Marín, 2015), it is crucial to determine whether ankle dorsiflexion ROM is associated with football injuries among academy players in Ghana. Hence the decision to focus on ankle dorsiflexion ROM and functional ankle instability (FAI) as the intrinsic biomechanical factors in this study. Other intrinsic etiological factors identified include muscle flexibility and muscle strength among both young and adult football players (Yeung, Cleves, Griffiths and Nokes, 2016; Ribeiro-Alvares et al., 2020). Although some studies report no substantial correlation between anthropometric values such as height, weight or BMI and football injuries (Ekstrand, 2008), one study found some correlation between BMI and injury risk among football players. Another study also found a correlation between body mass and hamstring injuries (Petersen, Thorborg, Nielsen, Budtz-Jorgensen and Holmich, 2011; Amoako, Nassim and Keller, 2017). Furthermore, factors associated with hamstring injuries among football players have been extensively researched. For example, studies have shown a positive relationship between muscle fatigue, muscle imbalance, muscle endurance (Freckleton and Pizzari, 2013), as well as age, previous injury, player position (Peterson, Kruse, Meester, Olson, Riedle, Slayman et al., 2017) and football injuries. Recent research, however, found no connection between muscle strength and hamstring injury (van Dyk et al., 2018). Rather, an elevated likelihood of acute hamstring strain injury has been attributed to a substantial decrease in isokinetic hamstring power (Justin Wai-Yuk, Kam-Ming, Hardaway Chun-Kwan, Patrick Shu-Hang and Kai-Ming, 2014).

Extrinsic factors associated with football injuries include exposure time, player position and being a member of a national team (Chalmers, Magarey, Esterman, Speechley, Scase and Heynen, 2013; Kristenson, Walden, Ekstrand and Hagglund, 2013). Longer exposure time during matches or training, is associated with a higher risk of injury (Chalmers et al., 2013). Additionally, players in certain positions, such as defenders and goalkeepers, may be more susceptible to injuries related to contact or collisions with other players, while players in attacking positions may be more prone to muscle strains and sprains due to their high-intensity movements (Hägglund, Waldén, & Ekstrand, 2013). Playing for a national team can also increase a player's risk of injury due to the higher level of competition and physical demands, as well as the potential for fatigue (Bengtsson, Ekstrand, & Waldén, 2018). Agility and proprioception (Bruce and Wilkerson, 2021; Mijatovic, Krivokapic, Versic, Dimitric and Zenic, 2022) are examples of some extrinsic risk factors in football injures among both adult and young football players. Poor agility and proprioception can increase the risk of falls, collisions, and other injuries during play (Le Gall et al. 2014).

Several studies have looked at injury severity, classifying injuries into different time loss categories (Kurittu et al., 2021; Light et al., 2021; Materne et al., 2021; Robles-Palazón et al., 2021). For instance, during the 2011 West African Football Union (WAFU) tournament injuries sustained through contact with another player led to a 19.1% time-loss of competition activity (Akodu, Owoeye, Ajenifuja, Akinbo, Olatona and Ogunkunle, 2012). In addition, Sousa et al (2013) found a mean-time reduction of 20.3 days due to injury in a cohort of amateur football players throughout one season.

According to Tabben et al (2022) report, the prevention of injury is a top priority among football players. Despite the increasing popularity of football in Ghana and the high occurrence of injuries among players, a deficiency in comprehensive strategies and resources for preventing injuries and promoting the physical and mental well-being of players exist. Understanding the trends and causes associated with football injury, regardless of the level of involvement, can help stakeholders establish management measures to effectively mitigate injuries (Robles-Palazón et al., 2021), and possibly decrease injury occurrences and prevalence. Hence, this study determined the epidemiology and clinical characteristics of football injuries among both young and adult academy players in Ghana. Since the participants included all players in the specific academy, where the majority of the players are under the age of 18, this study involved young football players, as well as adult players. In addition, the study also assessed intrinsic and extrinsic factors such as ankle dorsiflexion ROM, FAI, age, BMI, limb dominance, match/training exposure, player position and being a member of the national team and their associations with football injuries.

1.2 PROBLEM STATEMENT

The ability to prevent and/or predict injuries during the developmental periods of young athletes has been a key focus in sports medicine for several years, but few studies have focused on academy football players in Africa. Injuries among adult football players in Ghana seemed to have increased since 2016 (Omoniyi, Kwaku and Francis, 2016). Even though research has been performed on football injuries among adult players in Ghana, most of the studies are retrospective and hence a possible misclassification or recall bias can be introduced. Prospective evaluation of modifiable risk factors is important for assessing injury risk before it occurs and developing tailored risk-reduction strategies. However, there seems to be a dearth of knowledge in prospective studies examining risk factors of football injuries among both male young and adult academy football players in Ghana. No study on football injuries among young football players in Ghana could be found, which makes this study the first of its kind. football players.

A prominent observation noted during the lead researchers' experience working with some young football academies and adult elite teams, was that ankle injuries (especially ankle sprains) were among the most common injuries reported throughout the season. In athletes who did not undergo prompt rehabilitation or who did not comply with their rehabilitation prolonged absences from training and matches were observed. The appointment of team physiotherapists was unsatisfactory in that some teams had no physiotherapists while other teams that employed were not enough. Even with teams that had been allocated physiotherapists, physiotherapists were mostly only present during matches and tournaments. Consistent injury surveillance as part of standardised physiotherapy service is difficult to conduct and maintain. Recurring injuries or injury patterns in this population might easily go undiscovered over the course of a season, and a change in medical professionals can result in a loss of injury data within a young academy.

Football injuries are a major concern for players, coaches, and healthcare providers due to the potential impact on a player's career and overall health (Onakunle, Owoeye, Ajepe, Akodu and Akinbo, 2016: Kohrt, et al., 2004). Despite previous research on the intrinsic and extrinsic factors that contribute to football injuries, limited knowledge about the epidemiology, clinical characteristics, and associated risk factors among academy football players in Ghana. The existing literature on football injuries from other countries exist (Brito, Malina, Seabra, Massada, Soares, Krustrup et al., 2012; Johnson, Broderick, McKay, Doherty and Freemont, 2009; Phillips and Mughogho, 2015; Niyonsenga et al., 2013) may not be applicable to the Ghanaian context due to variations in injury patterns and player characteristics. Therefore, the purpose of this study.

1.3 RESEARCH QUESTION

What are the epidemiological, clinical characteristics and associated risk factors for injury among football academy players in Ghana during a season?

1.4 AIM

To determine the epidemiology and clinical characteristics of injuries among male academy football players in Ghana and to determine if an association between risk factors and injuries exists

1.5 OBJECTIVES

Among academy players in Ghana:

I. To determine the weekly prevalence of injury (% of injured players) among young (below 18 years) and adult (over 17 years) academy players during a season (39 weeks).

II. To determine the incidence of football injuries (injuries per 1 000 match, training and overall hours) among both young (below 17 years) and adult (over 17 years) academy players during a season (39 weeks) using the Standardised Injury Surveillance (SIS) form.

III. To describe the clinical characteristics (type of injury, anatomical region injured, severity of injury, mechanism of injury, tissue type and pathology type) of football injuries sustained among both young and adult academy football players over a season using the SIS form.

IV. To determine if intrinsic factors (age, BMI, limb dominance, previous injury, ankle dorsiflexion ROM, and the FAI) and extrinsic factors (player position, match/training exposure and member of a national team) are associated with football injuries.

1.6 RESEARCH DESIGN

The study utilised anobservational, prospective cohort study design (Bahr, Clarsen, Derman, Dvorak, Emery, Finch et al., 2020). An observational prospective cohort research design is a type of study in epidemiology that follows a group of individuals over a period of time to determine the incidence of a particular health outcome or disease in the population, as well as the factors that may influence it. This design is useful for investigating the relationship between risk factors and long-term health outcomes and can estimate the incidence of the outcome in the study population (Rothman, Greenland & Lash 2008). Participants included male young and adult football players at an academy in the Volta Region of Ghana. Pre-season data namely Body Mass Index (BMI), functional ankle instability (FAI) and ankle dorsiflexion (DF) range of motion (ROM) were collected and recorded. A standardised injury surveillance (SIS) form was used to collect data on injuries and their characteristics prospectively by the resident physiotherapists according to the International Olympic Committee (IOC) guidelines. Data were collected over the period of one season.

1.7 SIGNIFICANCE/CONTRIBUTION OF THE STUDY

The findings of this report provided novel information on injury incidence, prevalence and clinical characteristsic of injuries among academy players in Ghana, as well as defining factors associated with football injuries. As there is limited research available on injury characteristics in Ghana, this information is crucial to improving the understanding of injury characteristics and risk factors specific to this region, in order to prevent injuries. youngThe findings from this study can provide a profile of injuries, highlighting the extent and severities of injuries sustained by players and thereby creating an active awareness of the need for a preventive physiotherapy programme. The findings will assist in devising specific injury prevention programmes for players, and sub-groups of players. For example, exercises that address the ankle joint, which supplies the majority of the proprioceptive feedback required to enable the body to generate adequate motor responses to avoid or mitigate injury, could help players improve their balance and proprioception. The study's results would also benefit all sports stakeholders, including the Ministry of Youth and Sports and the Ghana Football Association, by providing information for the preparation and delivery of injury prevention and rehabilitationservices. The research provides baseline statistics about injuries suffered by academy football players in Ghana and lay foundation for further in-depth investigations.

1.8 DELINEATION

The study only involved injuries sustained by players who were physically assessed, diagnosed and documented on the SIS form by the resident physiotherapists. The study documented all injuries sustained by players during the season. The study also assessed ankle dorsiflexion

ROM and FAI as the only biomechanical factors along with the selected intrinsic and extrinsic risk factors. No other joints were investigated. This study incorporates van Mechelen's (1992) injury prevention framework although, only addressed the first two of the three recommended steps: 1) to establish the extent of the sports injury problem and 2) establish the etiology and mechanism of injury (van Mechelen, Hlobil and Kemper, 1992).

1.9 ASSUMPTIONS

We assumed that:

1. The resident physiotherapists, assisting with data collection, were diligent and honest in the recording of findings.
2. Players reported all injuries on time including injuries sustained in school.
3. All measurements were accurately taken and recorded by the primary researcher and assistants.

1.10 DEFINITIONS OF KEY TERMS

Definitions or meanings for key terms are listed in Table 1.1.

Table 1. 1: Definitions of key terms

Key term	**Operational definition**
Adult: According to the constitution of Ghana an adult is any individual of 18 years and above (Ghana Constitution of 1992),	An adult player was defined as any player above 18 years of age in this study.
Epidemiology: Epidemiology is the study of the distribution and causes of health-related conditions or occurrences (including disease) (WHO, 2017).	Epidemiology in this study was the investigation of injury prevalence, injury incidence, clinical characteristics of football injuries and related risk factors during one football season.
Extrinsic risk factors: An extrinsic risk factor is something external to the body that can cause injury (Wang et al., 2017).	Extrinsic factors included match/training exposure, player position and being a member of a national team.
Football injury: "Any physical complaint sustained by a player that results from a football match or football training, irrespective of the need for medical attention or time loss from football activities" (Fuller, Ekstrand, Junge, Andersen, Bahr, Dvorak et al., 2006: 193).	An injury is defined as any physical complaint sustained by an Academy football player and diagnosed by a resident physiotherapist, that resulted from a football match or football training that resulted in the player missing the next training/match session or seeking medical attention.
Injury incidence is the number of new injuries that occur over a specific period (Hölmich, Thorborg, Dehlendorff, Krogsgaard and Gluud, 2014).	Injury incidence is defined as the number of new injuries sustained by players over the 2021/2022 season (September 2021 to June 2022) as recorded on the SIS form.
Injury prevalence: refers to the number of existing cases divided by the total population	Injury prevalence is described as the result of dividing the total number of injured players by

at risk at a given point in time (Ekstrand, 2008).	the total number of players in the academy over one season.
Intrinsic risk factors: An intrinsic risk factor is a physical aspect of the athlete's body that can cause an injury (Wang, Mayer, Bonaventura and Wippert, 2017).	Intrinsic factors included, age, BMI, ankle dorsiflexion ROM, limb dominance and previous injury.
Match exposure is defined as a play between teams from different clubs over the season (Fuller et al., 2006: 194).	Match exposure will be defined as a play between teams from different clubs over the season (39 weeks).
Training exposure was defined as team-based and individual physical activities under the control or guidance of the team's coaching or fitness staff that are aimed at maintaining or improving players' football skills or physical condition (Fuller et al., 2006:194).	Training exposure is team-based and individual physical exercises under the supervision or direction of the team's coaching or fitness personnel, to retain or enhance players' football skills or physical condition over the 39-week season.
'Medical attention' injury: "A health problem that results in an athlete receiving medical attention is referred to as a 'medical attention' health problem" (Fuller et al., 2006:193).	A medical attention injury is described as an injury or complaint that necessitates a physical examination and/or treatment by a physiotherapist for a football player.
Young player: A young player may be defined as someone who is typically under the age of 23 or 24 (Barnes, 2019**)**	Young player was defined in this study as any player below the age of 18 years.

1.11 OUTLINE OF DISSERTATION

This dissertation consists of five chapters. The first chapter introduces the study and orientates the reader in terms of key elements of the study. The second chapter contains a literature review. The literature begins with a broad overview of football and the the sports' physical demands and sports involvement as a health benefit, before focusing on football injury, clinical characteristics and risk factors. The injury incidence and clinical characteristics of football-related injuries among academy football players are examined in Chapter three, which takes the form of a manuscript (paper one). The manuscript for the second paper is, presented in Chapter 4. This manuscript examines the risk factors for football injuries among young and adult academy players in Ghana. In Chapter 5, the findings of both paper one and paper two are discussed, with concluding observations and recommendations.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The chapter describes football and the sports' physical demands and provides the definitions of injury. This chapter provides a review of published research findings with regard to the prevalence and incidence of football injuries around the world, with a focus on Africa. The type of injury, area or location, injury mechanism, and severity of injuries suffered by male football players, both young and adult, are identified and discussed. The chapter also discusses risk factors, both intrinsic and extrinsic, of football injuries. Specifically, the ankle joint is described in terms of structure and function in relation to injuries sustained during participation in football. This section is followed by a discussion of the objective evaluation of ankle dorsiflexion (DF) ROM and Functional Ankle Instability (FAI).

2.2 Search strategy

The following electronic databases were used to find literature: CINAHL, MEDLINE, Science Direct, SPORTDiscuss, and Worldcat Keywords used were: Football (soccer), injuries, prevalence, incidence, risk factors, intrinsic and extrinsic risk factors functional ankle instability and ankle dorsiflexion ROM.

2.3 Physical demands of football

Football is a high-energy, fast-paced team sport (Jovan, Dusko, Ivan and Marin, 2019), with between 220 and 270 million players worldwide (Nuhu and Kutz, 2017). The main purpose of the sport is to get the ball into the opposing team's goalpost with any body part other than the player's arms. A football match is described by the Fédération Internationale de Football Association (FIFA) as a match between two opposing teams made up of 11 players each (ten players and one goalkeeper), played for 45 minutes in two halves with a 15-minute rest period, except when the rest period or duration of halves are mutually agreed upon by the referee and the two competing sides (Siekmann, 2017). Football among professional football players is played on different levels ranging from academy and club football, to major events like the African cup of Nations (AFCON), Union of European Football Association (UEFA) Champions League and the Federation of International Football Assocation (FIFA) World Cup.

Sustaining an injury is an unavoidable occurrence in almost every footballer's life, irrespective of age and level of competition (Rumpf and Cronin, 2012). The variations in training styles, match schedules, coaching and environmental inconsistencies surrounding play (pitch quality) contribute to varying levels of injury incidence for different teams, even within the same league (Aoki, Kohno, Fujiya, Kato, Yatabe, Morikawa et al., 2010; Dupont, Nedelec, McCall, McCormack, Berthoin and Wisløff, 2010; O'Connor and James, 2013; Enright, Morton, Iga and Drust, 2015).

The nature of football necessitates physical strength as well as a variety of abilities and skills at various levels (Steffen, Andersen and Bahr, 2007). These skills, which require the neuromuscular system to exert maximum strength and anaerobic control, encompass activities such as jumping, intense sprints, running, duels, heading and kicking the ball, as well as tackling (Jovan et al., 2019). Moreover, these activities also necessitate high levels of aerobic and cardiovascular fitness. (Jovan et al., 2019). Other football skills such as accelerations, decelerations, course switches, landing, and jumping tasks require maximum physical strength (Scott, Lockie, Davies, Clark, Lynch and Janse de Jonge, 2014). Football players are required to perform a variety of movements movements during play. Approximately 1 400 movements have been recorded during a football game, indicating a movement change every three to five seconds (Chmura, Rokita, Andrzejewski, Konefal, Mroczek and Chmura, 2017). On average per player, this implies 15 tackles, 10 headers, and nearly infinite times of stopping and change of direction (Stølen, Chamari, Castagna and Wisløff, 2005). These physical and skill demands increase the risk of injury immensely (Ergen and Ulkar, 2008).

In a full game, the average player runs eight to eleven kilometers (Krustrup et al., 2018a). Variations of long-distance running, high speed running, sprinting, to fast running, slow jogging, standing and walking are required during a football game (Scott et al., 2014). During the 2010 World Cup in South Africa, top national teams covered approximately 110 km in a single game (Duk, Min, Kawczyński, Chmura, Mroczek and Chmura, 2011), whereas the distance covered by world-class players range between 9.6 and 13.5 km per match (Bangsbo, Mohr and Krustrup, 2006; Di Salvo, Baron, Tschan, Calderon Montero, Bachl and Pigozzi, 2007; Djaoui, Wong del, Pialoux, Hautier, Da Silva, Chamari et al., 2014). Despite the fact that professional football players spend more than 70% of their play time performing low-intensity activities, body temperature and heart rate measurements reveal that their average oxygen uptake is around

70% of maximum rate of oxygen uptake by the body (Bangsbo et al., 2006). This high oxygen uptake emphasises the extent of physical demands on football players.

Football has varying physical demands depending on the playing position. Central players such as defenders and forwards cover the shortest distances, whilst wide players, like central midfielders, cover the longest distances (Dellal, Wong, Moalla and Chamari, 2010; Carling, 2013). Similarly, the total number of accelerations are substantially higher for wide players than central players (Jørgen, Terje, Geir Håvard, Barry and Ulrik, 2015; Dalen, Ingebrigtsen, Ettema, Hjelde and Wisløff, 2016), as wide areas are less congested compared to central areas, allowing for more chances to travel at high speeds without being hindered. Hence, central defenders and central midfielders are exposed to less high-speed sprints and running distances compared to other positions (Di Salvo et al., 2007; Will, Gary and Nicholas, 2018).

Reviewing the influence of individual biomechanical characteristics on injury may also indicate how training and matches contribute to injury prevalence and incidence within the football academy season. These topics are essential for team preparation and performance, the longevity of a player's career and financial feasibility of academy football, particularly in developing countries such as Ghana (Nuhu et al., 2017).

2.4 Benefits of football

Football training is intensive and flexible and incorporates agility, strength training and aerobic high-intensity interval training for people of all ages and ability levels (Krustrup and Krustrup, 2018). Even recreational football is a high-intensity, flexible sport with significant aerobic and anaerobic fitness benefits (Milanović et al., 2018). As a result, football training provides a wide range of fitness benefits, even for the general public (Krustrup, Aagaard, Nybo, Petersen, Mohr and Bangsbo, 2010). In addition, football, as a form of exercise, promotes health, especially in the prevention of lifestyle diseases such as cardiovascular diseases (Pedersen and Saltin, 2006; Khan, Thompson, Blair, Sallis, Powell, Bull et al., 2012; Oja, Titze, Kokko, Kujala, Heinonen, Kelly et al., 2015). Sedentary people with mild-to-moderate hypertension experienced a reduction in systolic and diastolic blood pressure after practicing football for 12 to 16 weeks (Milanović, Pantelić, Čović, Sporiš, Mohr and Krustrup, 2019).

The player's heart rate is kept up by continual walking, jogging, and running, which provides a good cardiovascular workout during a football game (Vaidya, 2020). This continuous activity aids players in conditioning their heart muscles, preventing plaque build-up in the coronary arteries, lowering blood pressure, and burning calories (Krustrup et al., 2018a). Only an hour of football practice, twice a week offers considerable cardiovascular health benefits (Krustrup et al., 2010; Krustrup, Helge, Hansen, Aagaard, Hagman, Randers et al., 2018b).

The World Health Organization (WHO) recommends that adolescents should engage in at least 60 minutes of moderate- to vigorous level physical activity per week, while adults should engage in at least 150 to 300 minutes of moderate-intensity aerobic physical activity per week (Bull, Al-Ansari, Biddle, Borodulin, Buman, Cardon et al., 2020). Football players tend to exceed these WHO recommendations, as both young and adult players train more than 60 minutes per day and play a match of approximately 90 minutes almost every week (Ekstrand, Spreco, Windt and Khan, 2020). Running for ninety minutes at any intensity requires a lot of stamina (Vaidya, 2020). As a result, football players generally have a high level of aerobic capacity, allowing them to alternate repeatedly between walking and sprinting.

Participating in football also reduces body fat, increases muscle tone, and strengthens muscles (Vaidya, 2020). Football is an excellent fat-burning sport because it engages both your skeletal muscles and your heart in a variety of ways (Vaidya, 2020). Football recruits both slow-twitch and fast-twitch muscle fibers, resulting in an increase in muscle bulk and strengthand provides fat burning (Khan et al., 2012). In approximately twelve to sixteen weeks of football training, there is an improvement in volume of oxygen (VO_2max), fat loss, and a subsequent increment in muscle mass among young and adult players (Milanović et al., 2018). Football players are required to transition between using the aerobic and anaerobic energy pathways, the latter burns more calories in general than other activities (Oja et al., 2015; Vaidya, 2020). Kicking, jumping, tackling, twisting, and turning, all require lower body strength (Vaidya, 2020) and is needed for a burst of speed. Upper body strength is necessary for ball protection, holding off opponents, and throw-ins, as well as contributing to overall power and explosiveness (Oja et al., 2015).

Furthermore, football enhances coordination and bone strength when played on a regular basis (Milanović et al., 2018). In general, as people age, their bone density declines (Krustrup et al., 2010). During a football game, the repetitive weight-bearing stress on the body is an effective way to strengthen the skeletal system (Krustrup et al., 2018b). Complex actions like dribbling, turning, and passing, which are done at various speeds and directions, enhancing body coordination (Vaidya, 2020). Football is an effective rehabilitation, and exercise strategy for a wide variety of people (Vaidya, 2020).

2.5 Injury definition

Table 2.1 indicatesthe various elements involved in defining injuries based on studies used for this literature review.

Table 2. 1: Injury definitions used in sampled studies

Elements of injury definition **Authors**	**Time-loss**	**Medical attention needed**	**Physical signs and symptoms**
Kurittu, E., Vasankari, T., Brinck, T., Parkkari, J., Heinonen, O. J., Kannus, P., et al (2021)	√		
Smpokos, E., Mourikis, C., Theos, C., and Linardakis, M. (2019)	√		
Nogueira, M., Laiginhas, R., Ramos, J., and Costa, O. (2017)	√		
Nilsson, T., Östenberg, A. H., and Alricsson, M. (2016)			√
Calligeris T, Burgess T and Lambert M. (2015)			√
Stubbe, J. H., van			

Beijsterveldt, A. M. M., van der Knaap, S., Stege, J., Verhagen, E. A., Van Mechelen, W., and Backx, F. J. (2015)	√		
Nshimiyimana J. B. and Frantz J. M. (2012)			√
Bailey R, Erasmus, L., Lüttich, L., Theron N. and Joubert G. (2009)	√		
Naidoo, M. A. (2007)		√	

Fuller and Walker (2006a: p. 193) defines injury as ’any physical complaint suffered by a player as a result of a football match or football training, regardless of the need for medical attention or time lost from football practices. A ’medical attention’ injury is one that necessitates urgent medical attention, while a ’time loss, injury is one that prohibits a player from actively engaging in future football training or match play (Fuller et al., 2006a; Timpka, Alonso, Jacobsson, Junge, Branco, Clarsen et al., 2014; Mountjoy, Junge, Alonso, Clarsen, Pluim, Shrier et al., 2016; Orchard, Ranson, Olivier, Dhillon, Gray, Langley et al., 2016). A more recent definition of injury by the International Olympic Committee (IOC), refers to ’tissue damage or other derangement of normal physical function due to participation in sports, resulting from rapid or repetitive transfer of kinetic energy’ (Bahr, Clarsen, Derman, Dvorak, Emery, Finch et al., 2020: p. 374)

Injury definitions commonly incorporate time lost due to the injury compared to the amount of time exposed to the sport (Naidoo, 2007; Calligeris, Burgess and Lambert, 2015; Stubbe, van Beijsterveldt, van der Knaap, Stege, Verhagen, van Mechelen et al., 2015; Nilsson, Östenberg and Alricsson, 2016; Miguel, Rita, José and Ovídio, 2017; Smpokos, Mourikis, Theos and Linardakis, 2019; Kurittu, Vasankari, Brinck, Parkkari, Heinonen, Kannus et al., 2021). Emphasis is placed on the specificity of ‘time loss’ injury to a particular sport, as such injuries could prevent a player from competing in one sport, but not necessarily another (Ekstrand, Waldén and Hägglund, 2004). In sports injury surveillance studies, the IOC recommends that, researchers should be specific in the definition of injury utilised, be it time loss or medical attention or both (Bahr et al., 2020).

Few studies have utilised medical attention injury only, or both time loss and medical attention injury (Nshimiyimana and Frantz, 2012: Nilsson, Östenberg and Alricsson, 2016). Since each current definition has benefits and drawbacks, depending on the study's aims, one optimal injury definition is unlikely. The lack of consistency in injury descriptions impairs study comparability. For the purposes of this analysis, injury is described according to the IOC consensus statement on methods for recording and reporting of epidemiological data on injury and illness in sport (Bahr et al., 2020). This definition combines both time loss and medical attention injuries, which allowed the researcher to gather a larger pool of data as opposed to recording injuries only from players that were forced to stop playing during a match or training due to an injury.

Another type of injury, a 'recurrent injury' is a 'subsequent injury to the same site and tissue as the index injury (i.e., the first recorded injury) (Bahr et al., 2020: 375). The current study divided the classification of recurrent injuries into 'early recurrence', 'late recurrence' and 'delayed recurrence' (Fuller, Ekstrand, Junge, Andersen, Bahr, Dvorak et al., 2006b). When a recurrent injury occurs within two months after a player returns to play, this injury is referred to as an early recurrence injury, while late recurrence injuries are when injuries occur between two to twelve months after a player fully recovered and returned to play (Fuller et al., 2006a). Delayed recurrence injury is classified as a recurrent injury that occurs more than twelve months after a player returns to play (Fuller et al., 2006a).

2.6 Classification of football Injuries

The IOC recommends using existing classification schemes to ensure accuracy in the diagnosis of injury and standardisation of data obtained (Bahr et al., 2020). The first existing schemes integrated into the IOC injury surveillance form are the International Classification of Diseases (ICD) and the Orchard Sports Injury Classification System (OSICS), which are the most widely used schemes (Toohey, Drew, Fortington, Menaspa, Finch and Cook, 2019; Bahr et al., 2020). Even though the ICD system is internationally standardised, the eleventh edition, released in 2018, omits some critical classifications such as postural hypotension and hamstring strain in sports injury surveillance (Ekstrand, Healy, Waldén, Lee, English and Hägglund, 2012; Bahr et al., 2020). Most of the 55 000 codes of the eleventh edition of the ICD, are unrelated to sports medicine, compared to the 750 to 1 500 codes of the OSICS models (Bahr et al., 2020).

The OSICS consists of original codes for body areas and additional codes for types of injury and pathologies. One benefit of the OSICS over the ICD is its ease of use, which is why novice users prefer this ssystem (Rae, Britt, Orchard and Finch, 2005). In addition, the OSICS gives a more comprehensive diagnostic differentiation leading to greater accuracy (Orchard, Rae, Brooks, Hägglund, Til, Wales et al., 2010). The OSICS system is commonly used in studies investigating injury in various sports such as football and basketball (Brooks, Fuller, Kemp and Reddin, 2005; Palmer-Green, Stokes, Fuller, England, Kemp and Trewartha, 2013). The frequent use of the OSICS system may be due to the fact that it includes sports medicine-specific codes and provides for accurate injury tracking. A medical staff member (e.g., physiotherapist or doctor) would be the ideal person to gather injury data (Hägglund, Waldén, Bahr and Ekstrand, 2005b). This study therefore enlisted the help of a physiotherapist to diagnose and classify injuries using the OSICS during all of the season's matches and training sessions.

2.7 Epidemiology of football injuries: introduction to incidence and prevalence

Injury prevalence is the proportion of players in a population who presents with an injury at a specific time, expressed in the form of a percentage (Knowles, Marshall and Guskiewicz, 2006). Prevalence and prevalence proportion are used interchangeably (Nielsen, Debes-Kristensen, Hulme, Bertelsen, Møller, Parner et al., 2019: Knowles, Marshall and Guskiewicz, 2006). Injury prevalence is determined by dividing the total number of players who report an injury by the total number of participants (Bueno, Pilgaard, Hulme, Forsberg, Ramskov, Damsted et al., 2018). Usually, Injury prevalence in sports provides a clearer and more effective means of comparing injury rates between studies (Nielsen et al., 2019).

Injury incidence is the total number of injuries per number of exposure hours in training or match playing, and is the only method of analysing the occurrence of injuries that can be used to calculate the risk for injury or to quantify relationships between risk factors and injury (Brooks and Fuller, 2006a). Injury incidence can be described as the number of injuries for each player per season or tournament (Phillips, 2000; Knowles et al., 2006). In football, injury incidence can be represented using different units of measurement which may include total injuries per either 1 000 exposure hours or 1 000 playing exposures or 1 000 matches (Junge, Chomiak and Dvorak, 2000; Brooks and Fuller, 2006b). The rate of injury for every 1 000 player-hours is calculated using the actual duration of player exposure for each player. Injuries per 1 000 athlete exposures are calculated based on the average number of players exposed in a match, regardless of the duration of their exposure. When the number of injuries per 1 000 matches formula is used, the time of exposure in terms of matches played is calculated, and the number of participating players in every match is not taken into account.

The methodology used by researchers to collect injury data and the duration of exposure to football for statistical analysis will determine how injury incidence is expressed. The majority of injury incidence studies include all the hours of exposure to football, including both matches and all training sessions (gymnasium sessions and field training) (Calligeris et al., 2015). However, for injury incidence calculated during tournaments such as FIFA world cups or the Champions' league, the incidence is expressed as the total number of injuries suffered in matches only (Hägglund, Waldén and Ekstrand, 2009; Ryynänen, Junge, Dvorak, Peterson, Kautiainen, Karlsson et al., 2013; Junge and Dvořák, 2015; Nuhu et al., 2017). Injury prevalence and incidence must be tracked in order to recognise opportunities for progress in the prevention of injury and to understand the most serious forms of injury in football.

Numerous studies on injury prevalence and injury incidence in football have been conducted in Europe (Smpokos et al., 2019; Raya-González, Suárez-Arrones, Navandar, Balsalobre-Fernández and Sáez de Villarreal, 2020; Kurittu et al., 2021). However, only a few studies have been conducted in other continents, especially in Africa (Calligeris et al., 2015: Nuhu & Kutz, 2017: Owoeye et al., 2017).

2.8 Injury incidence and prevalence

2.8.1 Injury incidence and prevalence in Europe

Most European studies were prospectively conducted (see annexure 1), which is vital for objectivity in the calculation of injury incidence (Jones, Almousa, Gibb, Allamby, Mullen, Andersen et al., 2019b). However, most of the studies did not calculate injury prevalence (See annexure 1) as most prospective studies are focused on the incidence of injuries (Noya Salces, Gómez-Carmona, Gracia-Marco, Moliner-Urdiales and Sillero-Quintana, 2014; Stubbe et al., 2015; Bianco, Spedicato, Petrucci, Messina, Thomas, Nese Sahin et al., 2016; Shalaj, Tishukaj, Bachl, Tschan, Wessner and Csapo, 2016; Smpokos et al., 2019; Kurittu et al., 2021).

Generally, a professional football team of 25 players may experience about fifty 'time-loss' injuries in every season, which is approximately two injuries for each player per season (Falese, Della Valle and Federico, 2016; Arliani, Lara, Astur, Pedrinelli, Pagura and Cohen, 2017; Jones, Jones, Greig, Bower, Brown, Hind et al., 2019a; Jones et al., 2019b). The overall injury incidence rate among professional players ranges between five and eight injuries per 1 000 exposure hours (Noya Salces et al., 2014; Stubbe et al., 2015; Bianco et al., 2016; Falese et al., 2016; Shalaj et al., 2016; Smpokos et al., 2019; Kurittu et al., 2021). An average injury incidence rate of 5 to 8 injuries per 1 000 exposure hours is reported by most studies in Europe (Noya Salces et al., 2014; Stubbe et al., 2015; Falese et al., 2016; Shalaj et al., 2016; Smpokos et al., 2019; Kurittu et al., 2021). According to these figures, adult male football players have a high injury rate in Europe. Recently, asystematic review using random effect models to calculate injury incidence, found a total incidence of 8.1 injuries per 1 000 exposure hours, 3.7 injuries per 1 000 hours during training, and 36 injuries per 1 000 match hours (López-Valenciano, Ruiz-Pérez, Garcia-Gómez, Vera-Garcia, De Ste Croix, Myer et al., 2020) which confirms the high injury incidence among professional football players in Europe. Although the studies (See annexure 1) were conducted among different groups of players in different countries in Europe, there is consistency in the higher injury incidence rate during matches when compared to training possibly due to higher intensity and increased contacts during matches, as well as psychological factors such as stress and pressure during matches (Lopez et al., 2020, Kurittu et al., 2021). The injury incidence rate reported among these professional football players during matches ranges from 25 to 55 injuries per 1 000 match hours. During training the injury incidence is between 2 and 6 injuries per 1 000 training hours in a season (Noya Salces et al., 2014; Stubbe et al., 2015; Falese et al., 2016; Shalaj et al., 2016; Smpokos et al., 2019; Kurittu et al., 2021).

Despite the high injury incidence rate among adult male football players, the rate of injury incidence among young football players is much lower, nearly half that of adult male football players (Smith, Chounthirath and Huiyun, 2016). The injury incidence in young football varies greatly between studies and can range from one to 66 injuries per 1 000 hours of exposure (Esquivel, Bruder, Ratkowiak and Lemos, 2015; Nilsson et al., 2016; Smith et al., 2016; Miguel et al., 2017; Read, Oliver, De Ste Croix, Myer and Lloyd, 2018a; Jones et al., 2019a; Jones et al., 2019b; Raya-González et al., 2020). Similar to adult, male football, injury incidence rate in male young football is consistent between matches and training. Higher incidence rates for injury occur during matches (2 to 80 injuries per 1 000 hours) than during training (0.69 to 6 injuries per 1 000 hours) (Nilsson et al., 2016; Miguel et al., 2017; Read et al., 2018a; Raya-González et al., 2020). However, the injury incidence during training is greater aomg young football players than in professional adult players (Stubbe et al., 2015; Pfirrmann, Herbst, Ingelfinger, Simon and Tug, 2016; Kurittu et al., 2021). A common conclusion between the majority of these studies conducted in Europe is a higher injury incidence rate among adult football players compared to young players and a higher indicence rate during matches than training sessions (López-Valenciano et al., 2020; Kurittu et al., 2021).

Several studies present differing rates of injury incidence among young football players, based on age categories (Renshaw and Goodwin, 2016; Jones et al., 2019b; Hall, Larruskain, Gil, Lekue, Baumert, Rienzi et al., 2020). For instance, the rate of injury incidence during training for different age categories among young football players varied from 0.69 to 7.9 injuries per 1 000 hours, while the rate of injury incidence during matches ranged from 0.4 to 80.0 injuries per 1 000 hours (Jones et al., 2019). The average incidence per 1 000 hours for youth players aged 9 to 21 years was reported to be 5.8, while 3.7 for younger players from 9 to 16 years (Jones et al., 2019b). A previous study suggested that players under the age of 15 years are possibly at a high risk of injury during matches, while players older than 15 are more susceptible to injury during training (Renshaw et al., 2016). Similarly, in recent studies, the highest injury incidence was found in players below 16 years (Jones et al., 2019b; Hall et al., 2020). For instance, a more recent study found players below the age of 16 to report a higher injury incidence rate of 7 to 8 injuries per 1 000 hours than the under 18 players during a season (Materne, Chamari, Farooq, Weir, Hölmich, Bahr et al., 2021). As several studies have shown, the incidence of injuries among young football players tend to increase with age (Price, Hawkins, Hulse and Hodson, 2004; Bult, Barendrecht and Tak, 2018; Read, Oliver, De Ste Croix, Myer and Lloyd, 2018b; Cezarino, Grüninger and Scattone Silva, 2020). Due to a lack of literature investigating injury incidence among African youth football players, it is unclear as to whether these values are also representative of the youth infootball playersAfrica. Annexure 1 summarises studies on injury incidence among youth and adult football players in Europe, relevant to this study.

2.8.2 Injury incidence and prevalence in Africa and the Middle East

According to FIFA, Africa accounted for about 17% (46 million) of the global football population (FIFA, 2006). However, limited literature is available on injuries among African football players. Injuries are more than twice as common among the African adult professional football players during matches (See annexure 2) than their European counterparts (Nshimiyimana and Frantz, 2012). An injury prevalence of more than 50% was recorded for professional football players in Rwanda and South Africa (SA) (Naidoo, 2007; Nshimiyimana et al., 2012). An even higher injury prevalence of 74.7% was reported for professional football players in Rwanda by another study (Nshimiyimana et al., 2012), with an even higher injury prevalence of 81.6% among adult male football players in Benin,Nigeria (Azubuike and Okojie, 2009; Nshimiyimana et al., 2012). On the contrary,, another study recorded less than 20% prevalence of football injuries among Nigerian adult football players (Onakunle, Owoeye, Ajepe, Akodu and Akinbo, 2016).

The prevalence of injury also seems higher during matches than in training among African adult football players (see annexure 2). The prevalence of injuries in matches among African adult players is between 40% and 70% while during training it ranges from 30 to 40% (Twizere, 2004; Naidoo, 2007; Azubuike et al., 2009; Nshimiyimana et al., 2012). On average the prevalence of injury in these studies conducted in Africa is higher than in European studies of similar design (Waldén, Hägglund and Ekstrand, 2005; Smith et al., 2016; Kurittu et al., 2021).The rate of injury incidence in African football during matches is more than twice (see annexure 2) that of injury incidence during matches in European adult professional football over one season and during international tournaments possibly due to the more aggressive nature of the sport, as well as, the poor conditions of the playing surfaces (Hägglund, Waldén and Ekstrand, 2006; Dvorak, Junge, Grimm and Kirkendall, 2007; Hägglund et al., 2009; Constantinou, 2010; Dupont et al., 2010; Ekstrand, Hägglund and Waldén, 2011a; Junge and Dvorak, 2013; Kristenson, Waldén, Ekstrand and Hägglund, 2013; Ryynänen et al., 2013; Bjørneboe, Bahr and Andersen, 2014; Calligeris et al., 2015; Junge et al., 2015; Nuhu et al., 2017).

Studies on injury incidence conducted in the Middle East also indicated higher incidence rates during matches than in European professional football (Hassabi, Mohammad-Javad Mortazavi, Giti, Hassabi, Mansournia and Shapouran, 2010; Eirale, Hamilton, Bisciotti, Grantham and Chalabi, 2012), but not as high as in African professional football (Azubuike et al., 2009; Nshimiyimana et al., 2012). The overall injury incidence among adult male football players in Africa is between 10 and 90 injuries per 1 000 hours of exposure, while the incidence rate during matches is between 40 and 90 injuries per 1 000 hours and 7 and 10 injuries per 1 000 hours during training (Bailey, Erasmus, Luttich, Theron and Joubert, 2009; Calligeris et al., 2015; Nuhu et al., 2017). The injury incidence rate during matches in Africa seems significantly higher than that seen in European studies (Hägglund, Waldén and Ekstrand, 2005a; Ekstrand et al., 2011a; Stubbe et al., 2015). The use of objective and accurate injury-recording and injury-incidence calculation methods in the study by Nuhu et al. (2017) makes it possible to compare the results to international research, as well as other African countries (Hägglund et al., 2009; Ekstrand et al., 2011a; Calligeris et al., 2015; Stubbe et al., 2015). However, one study only recorded injuries sustained during matches and as such, the findings cannot be compared to other studies that measured injury incidence using both training and match hours (Calligeris et al., 2015).

From the limited amount of literature available on injury in African football, it is evident that the injury incidence experienced in training and during matches in adult professional football is similar to studies conducted in Europe. However, the injury incidence during matches is significantly greater in African Football than other parts of the world (See annexures 1 and 2). African football research, therefore, needs to be conducted using the terms, objective measures and methodologies that are utilised in, and supported by previous literature and also recognised by the football research community (Brooks et al., 2006b; Fuller et al., 2006a; Junge, Engebretsen, Alonso, Renström, Mountjoy, Aubry et al., 2008). This implementation increasesobjectivity and the strength of findings in local research studies, allowing African football analysis to be comparable to research conducted elsewhere in the world. Annexure 2 shows a brief review of relevant articles investigating the incidence and prevalence of injury in African football.

2.8.3 Injury incidence and prevalence in Ghana

Although football is common in Ghana, there is a paucity of literature on football injuries and their risk factors in this countrys. The methodoly of the few studies conducted on football injuries among players in Ghana makes it difficult to compare to other international studies (Adjei, Moses, Nutakor and Gyinaye, 2015). However, one study, used FIFA-recommended protocols for epidemiological investigations of football injuries among Premier League players from Ghana in the Ashanti Region, Kumasi, during the 2012/2013 and 2013/2014 seasons (Omoniyi, Kwaku and Francis, 2016). This study reported injury characteristics such as playing position and age, as well as treatment/management patterns for injured players. The results showed that players suffered a variety of injuries, but did not provide any values for injury incidence or prevalence hence, the study cannot be compared with other studies in terms of injury incidence (Omoniyi et al., 2016). Another study on sports injury occurrences and management strategies utilised by local sports women and men (including football players) from Kumasi in the Ashanti region of Ghana (Adjei et al., 2015) indicated a higher injury prevalence in matches (57.4%) than during training (39.7%). This study also reported an overall injury prevalence of 2.9% (Adjei et al., 2015) for all sports which included track and field, football, basketball, hockey and handball. In a retrospective analysis of injury trends among football players from Ghana during the 2009/2010 season, 139 injuries out of a total of 30 games were recorded (Larwch, Quartey and Kwakye, 2020). The total number of injuries per match was therefore 4.63, with the number ranging from two to eight. (Larwch et al., 2020).

Most football injuries are traumatic in nature and should therefore attract a definitive preventive therapy that can bolster and maintain the careers of Ghana's young and upcoming football players. Research on football injuries in Ghana is scant, which issurprising, as football is the most common sport in the country. In addition, the few studies conducted are majorly retrospective and make it difficult to compare to other international studies.

2.9 Characteristics of football Injuries

2.9.1 Location/area of injury

The main anatomical areas of injuries in football have been identified in most international epidemiological studies showing that lower extremity injuries are the most common among football players (Onakunle et al., 2016; Pfirrmann et al., 2016; Smpokos et al., 2019; López-Valenciano et al., 2020; Kurittu et al., 2021). On average, most studies reported that 85% to 95% of injuries in football involved the lower extremities (Ekstrand, Hagglund and Walden, 2011b; Brito, Malina, Seabra, Massada, Soares, Krustrup et al., 2012; Jones et al., 2019b). This finding is similar for both European (Hägglund et al., 2009; Ekstrand et al., 2011b; Calligeris et al., 2015; Stubbe et al., 2015) and African football players (Akodu, Owoeye, Ajenifuja, Akinbo, Olatona and Ogunkunle, 2012; Omoniyi et al., 2016; Onakunle et al., 2016; Larwch et al., 2020). However, the particular part of the lower extremity that is commonly injured varies greatly between studies. While some studies report the ankle (Faude, Rößler and Junge, 2013; Bianco et al., 2016) to be the most frequently injured area, other studies reported the knee (Akodu et al., 2012; Larwch et al., 2020) and the thigh (Brito et al., 2012; López-Valenciano et al., 2020).

According to a study conducted among male football players from Hong Kong participating in a professional football league during a competitive season, the ankle was also the most injured part (approximately 15 % of the total number of injuries) (Justin Wai-Yuk, Kam-Ming, Hardaway Chun-Kwan, Patrick Shu-Hang and Kai-Ming, 2014). Similarly, another study conducted among academy youth football players, between nine to nineteen years of age over two seasons, reported the ankle to be the most injured body part causing up to about 20 % of all injuries (Price et al., 2004). The finding by Price et al. (2004) is similar to those of Larwch et al. (2020) although the latter reported a slightly higher percentage (26.6%) of ankle injuries among football players from Ghana (Larwch et al., 2020).

Not as common as ankle injuries, but still on the lower limbs are the prevalence of thigh and knee injuries. The thigh has also been reported in some studies as the most injured body part. In a meta-analysis of football injuries, the thigh had the highest injury incidence rate (1.8 injuries per 1 000 exposure hours), followed by the knee (1.2 per 1 000 hours) and ankle (1.1 per 1 000 hours) (López-Valenciano et al., 2020). Similarly, 30% of all injuries sustained among Portuguese youth football players were on thethigh (Brito et al., 2012). A number of studies have reported the knee to be the most injured body part (Akodu et al., 2012; Larwch et al., 2020). The knee accounted for the most time-loss injuries (29.4%) during the WAFU tournament in West Africa (Akodu et al., 2012). In Rwanda, first-division football players reported approximately 39% of all injuries recorded were ankle injuries, while knee injuries accounted for almost 27% (Twizere, 2004). In addition, a high incidence of head (16.5%) and knee (15.8%) injuries were recorded among football players from Ghana football players (Larwch et al., 2020).

Studies that have reported on injuries to the upper limbs experienced by football players are few owing to the nature of the game and the arms' limited engagement in game activities (Mallo and Dellal, 2012; Bashir, Usman, Aminu and Abdulrahman, 2020; Hall et al., 2020). The goalkeeper is usually the most vulnerable to upper limb injury, due to the nature of his position (Mallo et al., 2012). Only a small percentage of football injuries occur in the upper limbs (Bashir et al., 2020; Hall et al., 2020; Krill, Borchers, Hoffman, Krill and Hewett, 2020).

2.9.2 Type/nature of injury

Approximately 74% of football injuries are caused by direct physical contact between players (Bashir et al., 2020; Cezarino et al., 2020; Ekstrand et al., 2020; Hall et al., 2020; Krill et al., 2020). More than 80% are due to traumaand about 20% or less were characterised as overuse injuries (Bashir et al., 2020; Cezarino et al., 2020; Ekstrand et al., 2020; Hall et al., 2020; Krill et al., 2020).

Muscle strains seems to be the commonest type of injury among both adult and young male football players (Hägglund et al., 2005a; Waldén, Hägglund and Ekstrand, 2013a). For instance, a thigh strain, is the most prevalent form of injury among players in England, France, Spain, Sweden, and Denmark participating in professional leagues, accounting for 13% to 23% of all injuries (Hawkins and Fuller, 1999; Hawkins, Hulse, Wilkinson, Hodson and Gibson, 2001; Hägglund et al., 2005a; Waldén, Hägglund and Ekstrand, 2013a). In addition, thigh strain also represented 12.5% of the total injuries reported during one competitive season among players in the Hong Kong premier football league, with 82% of the injuries involving the posterior thigh (Justin Wai-Yuk et al., 2014). During the FIFA 2014 World Cup, the most common diagnosis was a thigh strain (n=18), with most injuries occurring without contact (Junge et al., 2015). Young football players in Greece, Spain, Portugal and Sweden have reported either strains or sprains, or both, as the most common type of injury sustained during a season (Tsiganos, Sotiropoulos and Baltopoulos, 2007; Brito et al., 2012; Nilsson et al., 2016; Pfirrmann et al., 2016). Reports on the most common types of injuries sustained in African football show a significant discrepancy between local and international studies. There is a notable variation in the findings of these studies regarding the prevalence of different types of injuries. Only a few studies conducted in Africa report muscle strain and/or joint sprains as the most common type of injury sustained among football players (Azubuike et al., 2009; Nuhu et al., 2017). A study conducted among South African adult professional players identified the most frequent injuries as haematomas, contusions and bruising (Calligeris et al., 2015) which are in contrast with similar international studies. Sprains and strains were the most frequent football injuries in the United States and Canada (Agel, Evans, Dick, Putukian and Marshall, 2007), Qatar (Eirale et al., 2012), Hong Kong (Justin Wai-Yuk et al., 2014), Netherlands (Schmikli, de Vries, Inklaar and Backx, 2011; Stubbe et al., 2015 and, Europe (Ekstrand et al., 2011a). Similarly, previous studies in Europe and other African countries have found sprains and strains as the most common injuries (Hägglund et al., 2005a; Hägglund et al., 2006; Azubuike et al., 2009; Ekstrand et al., 2011a; Goldman and Jones, 2011; Hägglund, Waldén and Ekstrand, 2013; Nuhu et al., 2017).

Several other types of injury have been reported and included meniscal tears, ligament ruptures, fractures and lacerations (Owoeye, 2010; Noya Salces et al., 2014; Hall et al., 2020; Krill et al., 2020; López-Valenciano et al., 2020; Raya-González et al., 2020; Materne et al., 2021). A systematic review of the epidemiology of football injuries among professional athletes, from around the world between 1989 and 2018 reported types of injury to be contusions, joint and ligament injuries, fracture/bone stress, laceration/skin lesions, and central/peripheral nervous system injuries and undefined injuries (López-Valenciano et al., 2020).

While there is some discrepancy in the findings of studies on the most common types of injuries sustained in African football, contusions, sprains, strains are consistently reported as prevalent. These types of injuries can have a significant impact on player performance and can result in considerable time off the pitch. Therefore, focusing on preventing and managing these injuries is essential to ensure the health and well-being of African football players.

2.9.3 Mode of onset and mechanism of injury

Mode of onset describes the sequence of events or circumstances that lead to the initial manifestation of the injury or condition, such as a sudden traumatic event, repetitive strain, overuse, or a combination of factors (van Dyk, Bahr, Burnett, Verhagen, von Tiggelen & Witvrouw, 2018). Understanding the mode of onset of an injury or condition can be useful in developing effective prevention strategies and treatment plans (Aoki et al., 2012). It can also help to identify risk factors and potential causes, which can inform efforts to reduce the incidence and severity of future occurrences (Andersen et al., 2003). The mode of onset for football injuries can vary widely, with some injuries resulting from a sudden traumatic event such as a collision with another player, while others may develop over time due to repetitive strain or overuse (Gebert et al., 2019; Bashir et al., 2020). Specifically, contact mechanisms have been found to be a common cause of injuries in football, leading to injuries such as muscle strains and tears, fractures, and ligament damage (Bashir et al., 2020: López-Valenciano et al., 2020: Larwch et al., 2020). However, a study showed that the most common mode of onset for football injuries among young players is non-contact mechanisms, which include movements such as cutting, pivoting, and landing that place stress on the musculoskeletal system (Asperti, Fernandes, Pedrinelli, & Hernandez, 2017). Additionally, overuse injuries, which result from repetitive stress on a particular area of the body, are common in football players, particularly those who participate in high levels of training and competition

Football injuries can be divided into indirect and direct injuries (Petersen & Hlmich, 2005). Because football is a contact sport, players are frequently vulnerable to direct body contact between players. This contact between players causes a variety of injuries, including contusions and blood vessel rupture in soft tissue, which can lead to haematomas or fractures (López-Valenciano et al., 2020). Several studies have reported a range of similar injury mechanisms in football (Andersen, Larsen, Tenga, Engebretsen and Bahr, 2003; Bianco et al., 2016; Bayne, Schwellnus, van Rensburg, Botha and Pillay, 2018; Jones et al., 2019b; Ekstrand et al., 2020). Previously, players were exposed to less direct contact with one study recording injury mechanisms to be primarily non-body contact (Hawkins et al., 1999). In 1999, a study found that 59% of injuries sustained among English professional football players were non-contact injuriaes while 41 % were caused by body contact (Hawkins et al., 1999). However, in recent studies, the most common injury mechanism is due to body contact between opposing players (Gebert, Gerber, Pühse, Gassmann, Stamm and Lamprecht, 2019; Bashir et al., 2020). Some of these mechanisms include tackling or being tackled, running into another player or a goalpost (Wong and Hong, 2005; Gebert et al., 2019; Bashir et al., 2020). The mechanism of injury in football is mostly traumatic, corresponding to 5.9 injuries for every 1 000 exposure hours, which is double the rate of overuse injuries (2.4 per 1 000 hours) (López-Valenciano et al., 2020).

One of the most frequently reported injury mechanisms in football is tackling or being tackled. Tackling typically happens while players are fighting for ball control and are unable to respond rapidly enough to an opponent's abrupt movements (Wong et al., 2005). Being tackled or colliding with an opponent tends to be the most frequent injury cause, accounting for nearly half of all traumatic injuries, followed by cutting and sprinting which are non-contact events (Wong et al., 2005). This finding is true for young and adult male football players in both African and European football (Gebert et al., 2019: Naidoo, 2007). For example, Gebert et al (2018) examined the causes, context and injury characteristics in non-professional football players. An analysis of 708 football injuries was performed retrospectively via a telephone survey with football players who sustained an injury during a football game and reported the injuries to the Swiss National Accident Insurance Fund. The authors found that the majority of the injured players (75.4%) were registered to a football club, and a third of these injuries occurred (30%) during informal or unofficial football games (Gebert et al., 2019). Whereas almost 30% of all injuries were due to foul play, 53% were caused by contact with the majority being tackled (Gebert et al., 2019). The uncontrolled aggressiveness in tackling might be connected to a negative psychological attitude towards the game and opponents, foul play, poor training, and inadequate physical conditions (Naidoo, 2007).

A recent study conducted in Kano, Nigeria, sampled 118 registered players between 16 and 30 years (Bashir et al., 2020). The authors reported that a hard tackle by an opponent was the major causative mechanism of football injuries (67.2%), along with an unintended opponent collision (11.7%), and poor field quality (9.8%). The design of playing surfaces, specifically uneven pitches, has been proven to lead to injury by placing increased loads on ligaments and muscles (Wong et al., 2005). A similar study from Ghana showed that tackling attempts (51.1%) and collisions (23.7%) were the two most common mechanisms leading to mild injuries (Larwch et al., 2020). Moderate injuries in Ghana were most frequently a result of collisions (43.8%) followed by tackling attempts (31.3%). This study reportedthat a sudden turn or twist (2.9%), tackling attempt (2.2%) and awkward landing (1.4%) were the mechanisms that resulted in severe injuries (Larwch et al., 2020).O ther uncommon injury causes may include improper landing and shooting and extreme frictional force on the surface or field, which tend to restrict players' turns and twists, thereby increasing loading and causing injury (Wong et al., 2005). Wearing incorrect footwear also puts players at risk of injury (Wong et al., 2005).

Development of football-specific neuromuscular conditioning programmes aimed at enhancing motor proficiency, joint stability, minimise exertion/fatigue could decrease the relative risk of injury related to acute soft tissue overload in young players (Emery and Meeuwisse, 2010; Silvers, Mandelbaum, Bizzini and Dvorak, 2014; López-Valenciano et al., 2020).

2.9.4 Severity of injury

Several variables or measures may be used to classify the severity of health conditions in sports (van Mechelen, Hlobil and Kemper, 1992; Finch, Valuri and Ozanne-Smith, 1999; Timpka et al., 2014). Some of these criteria include the length of time an individual is unable to participate in either training sessions or matches, self-reported outcomes (a variety of patient-rated wellbeing and athletic performance measures), the intensity of illness/injury, and social expense (i.e., economic evaluation) (Bahr et al., 2020).

In sports medicine, the amount of time lost is the most widely used severity measurement. This is due to the fact that collecting data is easy, even when done by non-experts like coaches, parents, or players (Bahr et al., 2020). With regards to time loss-injury, the day a player sustains an injury is counted as day zero and not taken into account when assessing the seriousness of an injury (Fuller et al., 2006b). As a result, if an athlete is unable to actively participate on the day of the injury, but is able to do so the following day, that injury should be reported 'as a time loss injury for severity of zero days' according to the Injury Consensus Group established under the auspices of FIFA Medical Assessment and Research Centre (Fuller et al., 2006a). Many researchers tend to use this type of measure of injury severity in football (Reis, Santos, Lasmar, Oliveira Júnior, Lopes and Fonseca, 2015; Nilsson et al., 2016; Smpokos et al., 2019; Cezarino et al., 2020; Hall et al., 2020; Krill et al., 2020; Raya-González et al., 2020; Materne et al., 2021). However, authors define the severity of injury in different ways. For example, in one study, the injuries that caused a player to miss zero to six days of training or match playingwere classified as minor. Moderate injuries were described as players that missed seven to 29 days, and injuries were severe when players missed over 30 days (Gallo, Argemi, Batista, Garcia and Liotta, 2006). Another study also categorised injuries that caused the absence of players for less than a week as minor, more than one week but less than one month, as moderate, while those that caused absence for more than 30 days as major (Morgan and Oberlander, 2001). Other authors, divide the minor injury group even further: slight (absent for 1 to three days) and minor (absent for four to seven days) (Söderman, Adolphson, Lorentzon and Alfredson, 2001; Kakavelakis, Vlazakis, Vlahakis and Charissis, 2003). Another study described a minor injury as an incident when a player received 'first aid' on the field (but without any additional treatment on the sideline); and a moderate injury was when the player received treatment off the field, but continued for the remainder of the game. A major injury was when the player received treatment and left the field for the remainder of the game (Larwch et al., 2020).

Football-related injuries range from minor sprains and fractures to more serious head, eye and neck injuries. Many studies have reported most injuries to be either mild or moderate in a season among male football players (Larwch et al., 2020; Kurittu et al., 2021). However, a study among Greek professional football players found a high percentage of moderate-to-severe injuries (72%) (Smpokos et al., 2019). Out of the 139 injuries reported among football players from Ghanafootball players, 82% were mild injuries, while moderate injuries accounted for 11.5 % of the injuries and severe injuries (6.5%) were the least type of injuries recorded (Larwch et al., 2020). In a meta-analysis conducted among European, Asian, America and Africa, the most frequent injuries were mild (3.1 per 1 000 exposure hours), moderate (2.0 per 1 000 exposure hours), minor (1.7 per 1 000 exposure hours), and severe (0.8 per 1 000 exposure hours) (López-Valenciano et al., 2020).

Similar to adult football, the most frequent injuries sustained by young football playerss are mild to moderate (Nilsson et al., 2016; Pfirrmann et al., 2016; Raya-González et al., 2020). For instance, a systematic review found that the severity of injuries was relatively constant across all age groups, and no differences among the young football players were noted (Pfirrmann et al., 2016). However, one study found the severity of injuries to differ according to age in young football players (Brito et al., 2012). According to Brito and colleagues, the 199 injuries recorded in their analysis resulted in 2 896 days away from training and match playing throughout the season (Brito et al., 2012). During the season, each injury cost the team 14.6 days of absence from training and matches. Furthermore, the investigators discovered that U19 players spent more time without training or playing (18 days) due to injuries than U13 players (9.8 days). Although match injuries did not vary by age category, training injuries were linked to more time missed by U19 players (≈20 days) than by U17 (≈12 days) and U13 players (≈10 days) (Brito et al., 2012). In addition, the incidence of severe injuries was thrice as high in the U19s compared to U13s, while the incidence of minimal, mild, and moderate injuries did not vary between age groups (Brito et al., 2012).

2.10 Incidence of ankle injuries

Ankle injuries account for approximately 33%of most sport injuries (Walls et al., 2016; Junge, Dvorak, Graf-Baumann, Peterson, 2004; Wong and Hong, 2005; Giza*,* Fuller, Junge, Dvorak, 2003).football playersAt the 2004 Olympics, a higher proportion of ankle injuries was recorded in football than in all the other sports (Badekas, Papadakis, Vergados et al., 2009). This finding is similar to studies conducted among English professional football players which report an average of approximately20% of ankle injuries over a season (Woods, Hawkins, Maltby, Hulse, Thomas, Hodson et al., 2004; Jain, Murray, Kemp and Calder, 2014).

Most of the ankle injuries were sustained during player-to-player contact, especially in tackling or being tackled (Doherty, Delahunt, Caulfield, Hertel, Ryan and Bleakley, 2014; Jain et al., 2014; Cezarino et al., 2020). When the medial part of a player’s kicking limb is tackled directly from a lateral force, the player usually lands with an inverted ankle (Andersen, Floerenes, Arnason and Bahr, 2004). The damage to the ankle joint and soft tissue structures ate usually more serious if the injured foot is rooted on the ground and in a weight-bearing position during the impact (Giza, Fuller, Junge and Dvorak, 2003). This occurs frequently during a football game, increasing the risk of sustaining an ankle injury.

Ankle joint injuries like ankle sprain are characterised as impairment or injury to one or more ligaments surrounding the ankle joint complex and may be an inversion or eversion sprain (Czajka et al., 2014). An ankle sprain is among the most common pathologies suffered during athletic performances (Petersen, Rembitzki, Koppenburg, Ellerman, Bruggemann, 2011; van den Bekerom, Kerkhoffs, McCollum, et al., 2013), accounting for approximately 67% of all ankle injuries in football (Kofotolis, Kellis and Vlachopoulos, 2007; Woods, Hawkins, Hulse and Hodson, 2003). Inversion sprains occur with excessive foot inversion (dorsiflexion and supination), along with an external rotation of the lower limb (Czajka, Tran, Cai and DiPreta, 2014). This type of injury isoften caused by landing on an unbalanced pronated foot while walking, running, sprinting, making a sudden directional transition, or landing on uneven surfaces (Hertel, 2000). Inversion sprain, is the most prevalent form of ankle sprain, accounting for about 85% of all ankle injuries in sports and mostly affects the lateral ligaments because the lateral ankle ligaments are weaker and less supportive compared to the medial ankle ligaments, making them more susceptible to injury (Munn, Beard, Refshauge and Lee, 2003). Alternatively, eversion sprains damage the ankle's medial ligament (deltoid ligament) (Abassi, Bleakley and Whiteley, 2019).

Ankle injuries, especially ankle sprains, are the most prevalent injury experienced in most studies undertaken among football players all over the world. Ankle sprains were, indeed, among the most common diagnoses in the 2010 FIFA World Cup, with nearly half of the injuries preventing participation in matches or training (Dvorak, Junge, Derman and Schwellnus, 2011). Similar studies in local club leagues identified, the ankle as one of the most commonly injured body parts for both adult and young football teams (Fong, Hong, Chan, Yung and Chan, 2007; Kofotolis, Kellis and Vlachopoulos, 2007; Nery, Raduan and Baumfeld, 2016). In most of these studies, both adults and young, who have previously sustained ankle sprains, were about five times more likely to suffer another ankle sprain injury than players who have not previously sustained ankle sprains (Fong et al., 2007; Kofotolis et al., 2007; Nery et al., 2016).Studies conducted in male football players in Hong Kong (Lee, Mok, Chan, Yung and Chan, 2014), England (Price et al., 2004), Australia (Chalmers, Magarey, Esterman, Speechley, Scase and Heynen, 2013), the USA (Elias, 2001) and Greece (Kakavelakis et al., 2003) all reported ankle sprain to be the most common form of injury sustained.

A study conducted among 118 Nigerian male young football players between the ages of 16 and 30 years, reported ankle injury to be among the most common injuries (Bashir et al., 2020).

Additionally, other ankle injuries have been reported among both adult and young football players. Some of these ankle injuries were sprains, osteochondral lesion, anterolateral impingement, ankle instability posterior ankle impingement and fractures (Walls, Ross, Fraser, Hodgkins, Smyth, Egan et al., 2016; Bayne et al., 2018; López-Valenciano et al., 2020).

Despite the difference in injury definitions, study designs, as well as methodologies between studies, ankle injuries are one of the most common football-related injuries among players in Europe and Africa. Hence, injury reduction in the regions of the ankle joint is a priority for coaches, medical staff, and fitness personnel (Bahr, Clarsen and Ekstrand, 2017).

2.11 Risk factors of football injuries among adult and young players

2.11.1 Introduction

It is important to keep track of a player's injury profile in order to correctly identify vulnerable individuals and potential risk factors for injury. Most of the information on football risk factors comes from Europe and America (Hägglund et al., 2005a; Waldén et al., 2005; Agel et al., 2007; Hägglund et al., 2009; Werner, Hägglund, Waldén and Ekstrand, 2009; Ekstrand et al., 2011a; Hägglund et al., 2013; Vilamitjana, Lentini and Masabeu, 2013; Waldén et al., 2013a). European data on football injuries may not be directly applicable to Africa due to differences in playing style, facilities, and medical practices. Injury risk factor analysis with a prospective design is a critical way to learn how and why injury profile differs between countries and may show the connection between intrinsic and extrinsic risk factors and injury (Owoeye et al., 2019). In Europe and during World Cup competitions, researchers investigated injury risk factors in football (Bradley and Portas, 2007; Dupont et al., 2010; Zerguini, Kakala, Junge and Dvorak, 2010; Fousekis, Tsepis, Poulmedis, Athanasopoulos and Vagenas, 2011; Fousekis et al., 2012; Hägglund et al., 2013; O'Connor et al., 2013; Ryynänen et al., 2013; Junge et al., 2015), but existing research in Ghana has not investigated the association between these factors, either intrinsic or extrinsic

2.11.2 Intrinsic factors

2.11.2.1.1 Age

The risk of injury rincreases as players get older (Read, Oliver, De Ste Croix, Myer and Lloyd, 2015; Watson et al., 2019). This finding has been confirmed in both male adult and young elite football players (Engebretsen, Myklebust, Holme, Engebretsen and Bahr, 2011; Rumpf et al., 2012; Hagglund, Walden and Ekstrand, 2013; Bjorneboe, Bahr and Andersen, 2014; Bourne, Opar, Williams and Shield, 2015; Read et al., 2015). Despite the fact that senior football players are more likely to get injured (Engebretsen et al., 2011; Hägglund et al., 2013), controversy exists about whether age is indeed an injury risk factor in football. According to one study, Australian football players over the age of 23 were more prone to experience calf and hamstring muscle strains (Orchard and Seward, 2002). In addition, athletes aged 26 to 30 years old, as well as those older than 30 years, have a 55% greater chance of injury (Stevenson, Kresnow, Hamer, Elliot and Finch, 2000). Increased injury rates among adult players in sports can be attributed to age-related decline in physical function, overuse injuries, poor training and conditioning, and underlying medical conditions (Engebretsen et al., 2011; Hägglund et al., 2013). Contrastingly, two other studies, found no link between age and injuries (Chomiak, Junge, Peterson and Dvorak, 2000; Söderman et al., 2001). Due to the controversy and opposing findings, more research on age and association with football injuries is required.

The risk of sports-related injuries among young players increases at different levels of their development, as well as their maturation (Rumpf et al., 2012). A child is subject to further training and competition with increasing age, which necessitates high amounts of repetitive loading that can lead to injuries (Hawkins and Metheny, 2001). Differences in the development of distinct physiological systems, especially during periods of fast growth i.e., maturation age, might also be considered a risk factor for injuries (Sheehan, Sipprell and Boden, 2012). For example, when skeletal systems grow faster, the muscular system must increase in both length and size, resulting in higher levels of force output which supports the skeleton (Sheehan et al., 2012). However, because the development of skeletal structures serves as a stimulus for muscle tissue structural adaptation, there is an intrinsic temporal difference between the rate at which the bone grows and the muscle lengthens (Sheehan et al., 2012). This difference has implications for traction on apophyseal injuries, which are most common in young players between 11 and 14 years, with males having the highest incidence in the U13 and 14 age groups (Sheehan et al., 2012). Male athlete's injury rates increased linearly from nine to 15 years of age, with a sharp rise at age thirteen (Pollard et al., 2006; Read et al., 2015). These ages correspond chronologically to the gradual increases in mass and stature due to maturation (Read et al., 2015). Elite male athletes are four times at risk of overuse injury in the year leading up to and following peak height velocity, which corresponds to ages 13.5 to 14.5 years (van der Sluis, Elferink-Gemser, Coelho-e-Silva, Nijboer, Brink and Visscher, 2014). Similarly, boys between the ages of nine and 16, whose skeletal age was older than their physical age, were more susceptible to overuse injuries (Malina, Cumming, Morano, Barron and Miller, 2005).

In general, poor proprioception, muscle imbalance, a loss of muscle control, muscle fatigue and ligamentous laxity have all been associated to an elevated risk of recurrent injury in athletes who have previously been injured (Aoki et al., 2012; Askling, Tengvar and Thorstensson, 2013; Arliani et al., 2017; Bayne et al., 2018). A prospective study among boys aged nine to 16 years old from a football academy in England, included repetitive measurements, between 2001 and 2007 (Johnson, Broderick, McKay, Doherty and Freemont, 2009). The authors found that players who matured early presented with more injuries than players who matured late (Johnson et al., 2009). The fact that boys might attain peak height velocity (PHV) at age 14 during puberty, which coincides with the period when their growth rate is at its highest, is one of the key reasons for this discovery (Rumpf et al., 2012; van der Sluis et al., 2014).

2.11.2.1.2 Previous injury

Previous injury is the most significant injury risk factor in football (Hägglund et al., 2013; Falese et al., 2016; Jones et al., 2019a; Watson et al., 2019; Cezarino et al., 2020; López-Valenciano et al., 2020). In one study, players with a history of injury were 2.56 times more likely to sustain another injury than those who had not suffered any form of injury before (Kucera, Marshall, Kirkendall, Marchak and Garrett, 2005). In general, the findings of most of these studies revealed that athletes who had previously sustained an injury had almost double the injury rate as those who had not (Knowles, Marshall, Bowling, Loomis, Millikan, Yang et al., 2009; Engebretsen et al., 2011; Arliani et al., 2017)

A risk factor analysis in adult male football players showed that prior knee and ankle injury is a risk factor for future knee and ankle injuries (Arnason, Sigurdsson, Gudmundsson, Holme, Engebretsen and Bahr, 2004; Kucera et al., 2005), as well as other types of injuries, indicating that previous injury tends to increase athletes' overall risk of injury (Fong et al., 2007; Manoel, Xixirry, Soeira, Saad and Riberto, 2020: Arliani et al., 2017: Engebretsen et al., 2011). A study comparing the risk of sustaining an ankle sprain among athletes who used braces with athletes who did not, showed that the control group who had sustained an injury before had a considerably greater rate of ankle injuries than the group without a history of injury (Surve, Schwellnus, Noakes and Lombard, 1994). The comparatively high rate of re-injury among football players may be due to poor rehabilitationor delayed healing (Surve et al., 1994).

In one study, a muscle strain sustained during the previous eight months raised the likelihood of a muscular strain in the same area for the calf, hamstring and quadriceps (Orchard, 2001). Previous injury, therefore, is undoubtedly the main risk factor for recurrent injuries in football.

2.11.2.1.3 Body mass index (BMI)

Although BMI is commonly used to estimate adiposity in children and teenagers (Mei, Grummer-Strawn, Pietrobelli, Goulding, Goran and Dietz, 2002), it is only a proxy indicator of body fat and does not adequately account for adolescents or athletes, who may have a higher lean mass to height ratio (Nevill, Stewart, Olds and Holder, 2006). Despite this, some studies have looked at the relationship between BMI and sports injuries (Tyler, McHugh, Mirabella, Mullaney and Nicholas, 2006; Richmond, Kang and Emery, 2013; Haxhiu, Murtezani, Zahiti, Shalaj and Sllamniku, 2015).

Adult and young athletes with a lower BMI have a lower risk of injury. A recent study revealed a positive statistically significant association between adult, male athletes' BMI and injury risk (Manoel et al., 2020). In a related study, researchers discovered that having a higher BMI made adult football players more vulnerable to ankle sprains (Fousekis et al., 2012). Greater ligament overloading, especially during the support phase of complicated football motions like spinning and pivoting, is thought to be the cause of this higher risk. These higher biomechanical pressures on soft tissue and joints of larger and heavier athletes cause higher injury rates (Emery, 2003).

The research findings on the association between BMI and injursy risk are however contradictory. . For example, a cross-sectional study that explored the effect of BMI among high-school-age youngs' sports injuries (Richmond et al., 2013), found that obese teenagers had a higher chance of injury than healthy teens. Another study that tracked two high school university teams for injuries found that a high BMI was associated with 2.5 times higher injury risk (Kaplan, Digel, Scavo and Arellana, 1995). Furthermore, another study looked at 152 young athletes from four football teams throughout three seasons and reported the breakdown of injury risk per BMI scores (Tyler et al., 2006). The researchers found that injury rates for players with normal BMI and overweight were 0.52 and 2.03 respectively while for players at risk of becoming overweight were 1.05 (Tyler et al., 2006). In the same study, the incidence of injury for players of normal weight who had never had an ankle sprain before was 0.22, compared to 4.27 for overweight players who had sustained an ankle sprain before (Tyler et al., 2006). Specifically, one study found the impact of BMI on football injuries to be only positive for training injuries (Rössler, Junge, Chomiak, Němec, Dvorak, Lichtenstein et al., 2018).

Contrastingly, increased injuries in overweight and obese youngsters were associated with the amount of sports activity, not their BMI (Warsh, Pickett and Janssen, 2010). In addition, BMI was not linked to injuries among professional male football players in Kosovo during one season (Haxhiu et al., 2015), which is consistent with prior research on adult football players in Europe (Ostenberg and Roos, 2000; Beynnon, Renström, Alosa, Baumhauer and Vacek, 2001). As a result, more research is required to investigate the association between BMI and risk profile among football players.

2.11.2.1.4 Limb dominance

The association between limb dominance and football injury is uncertain, due to conflicting resaerch findings. Specific limb preferences in football players may result in residual muscle imbalances and different power characteristics in their dominant and non-dominant legs, which can contribute to an increased proclivity for injury (Rahnama, Lees and Bambaecichi, 2005).

Some studies, as expected showed that limb dominance affects injury (Ekstrand and Gillquist, 1983; Baumhauer et al., 1995; Murphy, Connolly and Beynnon, 2003). For example, dominant leg ankle injuries were more frequent (92.3%) than non-dominant leg ankle injuries in football players, but limb dominance had no effect on those who suffered muscle strains (Ekstrand et al., 1983). Limb dominance was demonstrated to be a risk factor for lower extremity injuries in football players aged 14 to 18 than non-dominant leg (Emery, Meeuwisse and Hartmann, 2005). A significant number of athletes reported self-perceived instability in their dominant limbs, in Portugal (Cruz, Oliveira and Silva, 2020). It is indisputable that athletes establish a plethora of instinctive behaviours or patterns (kicking, landing after a jump, starting a sprint) with a dominant limb preference, putting that limb under more stress and demand. However, another study indicated that limb dominance had no influence on lower extremity injuries (Beynnon et al., 2001).

In several research studies, the link between limb dominance and football injury has been found to be specific to certain types of injuries. For example, a study conducted among football players in ten European countries found that adductor muscle injuries were more frequent in the dominant limb, but that limb dominance had no effect on hamstring injury (Hägglund et al., 2013). Furthermore, the dominant limb sustained many quadriceps injuries, while calf injuries were distributed equally between the limbs (Hägglund et al., 2013). Similarly, a systematic review reported no correlation between limb dominance and hamstring, patella tendinopathy and calf injuries, however, found that injuries to the ankle joint, knee joint and quadriceps muscles occurred more often in the dominant limb (Thompson and Watson, 2019). These findings are corroborated by other studies (Thompson et al., 2019; DeLang, Salamh, Farooq, Tabben, Whiteley, van Dyk et al., 2021).

2.11.2.1.5 Ankle dorsiflexion (DF) range of motion (ROM) and Functional Ankle Instability (FAI)

In most sports that involve movements in multiple directions, ankle DF ROM has a significant impact on change of direction and landing (Lockie, Callaghan, Berry, Cooke, Jordan, Luczo et al., 2014; Gonzalo-Skok, Serna, Rhea and Marín, 2015). When the ankle DF ROM is limited, the stiffness of the lower limb and forces of landing after a jump is usually altered which has the tendency to increase the injury risk (Mason-Mackay, Whatman and Reid, 2017). A cut-off score of greater than 2 cm was indicated as the lowest beneficial change for identifying ankle dorsiflexion ROM deficiencies (Charlton, Raysmith, Wollin, Rice, Purdam, Clark et al., 2018).

Several lower limb injuries were related to a reduced ankle DF ROM, including hamstring strains, Achilles- and patellar tendon injuries, ACL ruptures, and ankle injuries (Gabbe, FincAh, yes h, Bennell and Wajswelner, 2005; Gabbe, Bennell, Finch, Wajswelner and Orchard, 2006; Malliaras, Cook and Kent, 2006; Bisseling, Hof, Bredeweg, Zwerver and Mulder, 2008; Youdas, McLean, Krause and Hollman, 2009; Whitting, Steele, McGhee and Munro, 2011; Wahlstedt and Rasmussen-Barr, 2015; van Dyk, Farooq, Bahr and Witvrouw, 2018). Limited ankle DF ROM was independently correlated with the risk of injury to the hamstring muscle (Gabbe et al., 2006). Despite the fact that ankle DF ROM was revealed as a risk factor for football injury, one study found no obvious association between ankle DF ROM and the occurrence of muscle strain injuries among English elite football players during a season (Bradley et al., 2007).

‘Functional ankle instability is the subjective feeling of ankle instability ‘or’ recurrent, symptomatic ankle sprains (OR both) due to proprioceptive and neuromuscular deficits’ (Tropp, 2002:512). Ankle stability is critical for avoiding injury. If the ankle is unstable, it may result in a change in foot placement when running and/or kicking. This puts the ankle as well as other lower-limb structures at risk of injury (Cezarino et al., 2020).

Functional ankle instability (FAI) occurs in 40%t of football players after a lateral ankle sprains (Hertel, 2000). In both adult populations and adult football players, the incidence and prevalence of ankle sprains, as well as the prevalence and cause of functional ankle instability, has been studied (Tropp, 2002; Hubbard and Hicks-Little, 2008; Delahunt, Coughlan, Caulfield, Nightingale, Lin and Hiller, 2010; Jain et al., 2014).. Athletes are more likely to sustain the same injury after an initial injury, and there is a correlation between repeating the sprain and future instability, increasing the risk of a chain of occurrences leading to chronic ankle instability (Cruz et al., 2020). Recurrent incidences of instability and ankle sprains are most likely to cause a secondary tissue injury, which results in additional pathomechanical impairment (Hertel and Corbett, 2019). In Portugal, half of the players who presented with a re-injury developed self-perceived ankle instability, and two out of every five players with instability presented an ankle injury (Cruz et al., 2020). When such instability indicates a considerable loss of player availability as well as accompanying cost, both technical and medical teams should reflect on it. In essence, it is critical to understand the relationship between functional ankle instability and football injuries.

2.11.3 Extrinsic risk factors

2.11.3.1 Player position

Tthe playing position of a football player may have an impact on injury incidence (Deehan, Bell and McCaskie, 2007; Cloke, Moore, Shah, Rushton, Shirley and Deehan, 2012), however, limited research is available on this topic (Della Villa, Mandelbaum and Lemak, 2018). In contemporary football, a player's role at one position may differ significantly from that of another player at the same position due to specific instructions given to himby the coach or the style of play. Due to the varying loads, movement patterns, and distinctive mixture of planned and unanticipated reactionary movements, various playing positions may have varied injury rates and patterns (Della Villa et al., 2018). In addition, the same player may play different positional roles due to the demands and objectives of a football match. Due to the variety of playing styles and players at each position, it may be difficult to provide unambiguous information regarding playing position and injury risk even with the best study design (Della Villa et al., 2018). A study conductedamong French professional football players indeed, found no such relationship (Dauty and Collon, 2011).

In comparison to outfield players in male football, the present evidence implies that goalkeepers (GK) are at a decreased risk of general injury whereas forwards are otherwise more prone to sustain injuries in games rather than in training (Della Villa et al., 2018). In a number of studies, forwards were found to be at a higher risk of injury (Andersen et al., 2003; Carling, Orhant and LeGall, 2010; Arliani et al., 2017), although one study reported that forwards and defenders were at similar risk of injury (Mallo et al., 2012). According to a systematic review, forwards were found to have a higher risk of injury during match play, which may be attributed to factors such as increased running distance, higher intensity sprints, and greater exposure to physical contact (Della Villa et al., 2018).

Defenders may also have a potential high risk of injury (Mallo et al., 2012, Shalaj et al. 2016). A video analysis study, found that over 73% of ACL injuries occurred during defending situations in a football match, hence, making defenders more predisposed to knee injuries (Brophy et al., 2015; Waldén, Krosshaug, Bjørneboe, Andersen, Faul and Hägglund, 2015).

Midfielders cover the most ground during a football match, therefore, they are prone to a high volume of acceleration/deceleration activities (Cloke et al., 2012). Accordingly, midfielders, particularly young players, have a much greater injury risk than attackers and defenders, in particular muscle injuries (Morgan et al., 2001; Deehan et al., 2007; Cloke et al., 2012; Khodaee, Currie, Asif and Comstock, 2017). Due to the workload of midfielders, the midfield position has the highest injury risk among young football players between nine and nineteen years of age (Deehan et al., 2007; Cloke et al., 2012). In contrast, no difference was observed in injury incidence or severity based on playing position among French professional players (Dauty et al., 2011). Despite relatively few studies in Africa, a positive relationship was found between playing positions and football injuries (Jacobs and Van den Berg, 2012). The study collected retrospective data on the injuries sustained over two seasons and compared them to demographic and anthropometric characteristics of an elite young football population representing multiple African nationalities (Jacobs et al., 2012). The authors discovered that the position of the player was a significant risk factor for football injury (Jacobs et al., 2012).

In conclusion, football players in certain positions, such as midfielders and forwards, are at a higher risk of lower limb injuries, particularly in the ankle and knee regions, highlighting the importance of injury prevention strategies and targeted rehabilitation programs for these specific areas. Exposure time and being a member of the national team

2.11.3.2 Exposure hours

Professional football players are exposed to more football playing every year through league, friendly and tournament matches, which might influence injuries and overall performance throughout a season (Hägglund et al., 2006). Injuries tend to be more common during the latter part of the season compared to the beginning of the season. As match exposure hours increase, players are more likely to develop injuries. (Ekstrand, Hägglund and Waldén, 2009; Chalmers et al., 2013; Calligeris et al., 2015). The pattern of increased injury rate towards the end of the season also occurred in Europe. For example, overuse injuries were shown to be far less common in the pre-season period than trauma-related injuries (Ekstrand et al., 2020). In that same study, pre-season contact injuries were much lower than in-season contact injuries (Ekstrand et al., 2020).

Even in studies conducted among European football players, there seems to be some differences regarding the injury incidence per 1 000 hours of exposure during competitions (Hägglund et al., 2005a; Hägglund et al., 2006; Stubbe et al., 2015). A key reason for the disparities in results is that teams from northern Europe seem to have much higher total injury rates than those from southern Europe (Waldén, Hägglund, Orchard, Kristenson and Ekstrand, 2013b). By extension, football teams in Africa may have a different overall injury rate, as well as different training and severe injury rates, depending on exposure time. As per a survey conducted on South African players, injury frequencies were found to be higher during pre-season training, with 12% of all injuries occurring during this period (Calligeris et al., 2015). The reason for this notioncould be attributed to a lack of strength, conditioning and match fitness during the early part of the season, as well as the combined impact of frequent and continuous exposure to football near the latter part of the season (Calligeris et al., 2015).

Furthermore, female athletes who also played for their national team were more likely to be injured than women who did not participate for their country (Niyonsenga and Phillips, 2013). Being chosen for the national squad not only increases exposure time, but it also increases competitiveness and tiredness as the level of competition at the national team appears to be higher than club football. Players' desire to remain in the national team should not be overlooked (Niyonsenga et al., 2013).

2.12 Evaluation of ankle DF ROM and FAI

Clinical DF ROM assessments are beneficial in detecting risk of injuries, such as anterior cruciate ligament (ACL) tear and ankle sprain (Fong, Blackburn, Norcross, McGrath and Padua, 2011). Some instruments used in the assessment of ankle DF ROM include a metric tape measure, goniometer, and an inclinometer (See annexure 3) (Chisholm, Birmingham, Brown, Macdermid and Chesworth, 2012; Konor, Morton, Eckerson and Grindstaff, 2012; Cipriani, Pera, Pomerantz, Reid and Brown, 2020).

Different techniques and tools for assessing ankle DF ROM are described in Annexure 3 (Chisholm et al., 2012; Konor et al., 2012; Cipriani et al., 2020). The most common test of evaluating or quantifying the ankle DF ROM among athletes is the weight-bearing lunge test (WBLT) (Chisholm et al., 2012; Konor et al., 2012; Cipriani et al., 2020). One rationale for adopting the WBLT is that differences in the raters' skill levels and experience do not appear to affect the WBLT's reliability (Hall and Docherty, 2017). Although most sports include weight-bearing activities, there are a little research that uses a non-weight-bearing technique (Fong et al., 2011; Baumbach, Braunstein, Seeliger, Borgmann, Böcker and Polzer, 2016; Howe, Bampouras, North and Waldron, 2020). Other methods used in measuring the ankle DF ROM involve using a tape measure to take the measurement with the knee flexed and or extended in supine lying (Baumbach et al., 2016) and in either weight-bearing (Howe et al., 2020) or non-weight bearing (Fong et al., 2011) or both (Baumbach et al., 2016), depending on the objectives of the study.

The majority of research that measured ankle DF ROM utilised a standard goniometer to collect data (Venturini, Ituassú, Teixeira and Deus, 2006; Johanson, Baer, Hovermale and Phouthavong, 2008; Youdas et al., 2009). In recent years, however, instruments such as the tape measure, digital inclinometer, motion capture system, and leg motion system have shown to be more reliable than the goniometer (see annexure 3) in assessing ankle DF ROM (Konor et al., 2012; Calatayud, Martin, Gargallo, García-Redondo, Colado and Marín, 2015; Howe et al., 2020). According to several studies, some of these new devices are more reliable than others (Konor et al., 2012; Calatayud et al., 2015; Howe et al., 2020). For instance, the digital inclinometer is more reliable than the tape measure and the standard goniometer in most studies, but the tape measure is likewise more reliable than the standard goniometer (see annexure 3) (Konor et al., 2012). Furthermore, as compared to the tape measure and digital inclinometer, motion capture is more reliable, but the digital inclinometer is likewise more reliable (see annexure 3) than the tape measure (Hall et al., 2017). The leg motion system has also been shown to be more reliable compared to the tape measure when measuring ankle DF ROM (Calatayud et al., 2015). Nonetheless, any of these instruments can be utilised as valid clinical measures when performing the WBLT (Hall et al., 2017). As a result, most studies utilise a tape measure instead of a digital inclinometer or a motion capture system since it is easier to use and less expensive.

2.13 Functional ankle instability (FAI)

Functional ankle instability is characterised by weakness of the muscle (Kazemi, Arab, Abdollahi, López-López and Calvo-Lobo, 2017), ankle proprioceptive deficit (Kim, Choi and Kim, 2014), increased neuromuscular reaction time (Méndez-Rebolledo, Guzmán-Muñoz, Gatica-Rojas and Zbinden-Foncea, 2015) and impaired balance control (Ha, Han and Sung, 2018), which may or may not be accompanied by joint laxity (Croy, Saliba, Saliba, Anderson and Hertel, 2012). In order to quantify this type of dysfunction, assessments should measure the subjective feeling as well as the objective physical presence of physical dysfunction. Annexure 4 lists the objective measures used to assess functional ankle instability that is relevant to this study.

The Cumberland ankle instability tool (CAIT) is a self-reported questionnaire that has been shown to be valid and reliable in assessing the severity of FAI on a subjective level (see annexure 4) (Gribble, Kelly, Refshauge and Hiller, 2013). The CAIT score is capable of predicting future sprains in persons with FAI (Wilkin, Hunt, Nightingale, Munn, Kilbreath and Refshauge, 2012). Individuals with a low CAIT score with a previously sprained ankle are more likely to encounter a re-injury than those with a high CAIT score (Hiller et al., 2006). The existence of chronic ankle instability is indicated by a CAIT cut-off score of less than or equal to 25 (Arnold, Wright, Linens and Ross, 2011). The use of only the CAIT to assess FAI may not be comprehensive as the tool is subjective or self-reported. Hence it is important to use an objective tool in conjunction with the CAIT in order to comprehensively detect and quantify the physical presence of FAI (Gabriner, Houston, Kirby and Hoch, 2015).

The star excursion balance test (SEBT) is a dynamic and reliable objective test (see annexure 4) that requires the individual to be flexible, strong and possess good proprioception (Powden, Dodds and Gabriel, 2019). The tool has been used to evaluate physical performance, diagnose chronic ankle instability, and identify athletes who are more likely to sustain a lower limb injury (see annexure 4) (Hiller et al., 2006; Arnold et al., 2011; Gribble et al., 2012; van Lieshout, Reijneveld, van den Berg, Haerkens, Koenders, de Leeuw et al., 2016). The SEBT involves the individual performing eight different leg reach exercises while keeping a single-leg squat stance (van Lieshout et al., 2016). However, the anterior, posteromedial, and posterolateral reach directions are the most beneficial in diagnosing functional impairments in persons with chronic ankle instability, therefore, the eight directions have been reduced to these three due to redundancy (Powden et al., 2019). To test dynamic balance, the distance travelled by the participant is usually standardised to the person's leg length. However, the distance travelled can be calculated without taking into account leg length (Powden et al., 2019). This study utilised the CAIT and SEBT to assess FAI among participants.

2.14 Conclusion

Football is a repeated-sprint sport in which players engage in brief bursts of high-intensity exercise followed by periods of low-intensity activity. The sport involves high physical demands, but has many health benefits A footballer's exercise training and conditioning should incorporate the use of both aerobic and anaerobic systems due to the complexity and demands of the sport.. There are various definitions for injury, but for the purpose of this study injury was defined as any physical complaint sustained by academy football player and diagnosed by a physiotherapist, resulting from a football match or training which resulted in the player missing the next training or match session and or seeking a medical encounter or not.

There is a high injury prevalence and incidence among both adult and youth football players in Europe and Africa. However, there are a few distinctions between African football and football in other regions of the world. Injury rates among football players in Africa are relatively higher than players in other parts of the world, especially during matches. There appears to be no study conducted among young players from Ghana while the few studies on adultsare retrospective. These studies though reported high injury prevalence, and are difficult to compare to other international studies due the methodology.

The ankle, thigh and knee are among the most commonly injured body part. Ankle sprains are one of the most common injuries among adult and youth football players. Up to one-third of all football injuries are ankle injuries Other common types of injuries reported among both adult and youth football players include contusion, meniscal tear, ligament rupture, fracture and laceration. Most of these injuries are primarily contact injuries, although a few previous studies have reported non-contact injuries. The severity of football injuries is usually expressed as amount of time loss. For example, despite differences in injury classifications, study designs, and methodology, ankle injuries are among the most common injuries sustained by both adult and youth football players all around the world.

There have been a number of risk factors associated with football injuries. Although the majority of these elements are the same for adult and youth football players, certain studies have found minor discrepancies. Football injuries can be caused by internal or external sources. Age, previous injury, muscular strength, limb dominance, ankle DF ROM, and FAI are all examples of intrinsic factors for both adult and young football players. Extrinsic factors include, but are not limited to, exposure time, playing position, national team membership, diet, and type of training.

Understanding how and why injury profiles differ between countries and devising more focused injury prevention programmes requires critical evaluation of injury risk factors.

The ankle DF ROM and FAI have been found to be excellent predictors of lower extremity injury. Some studies have reported limited ankle DF ROM with ankle injuries. In other studies, the presence of FAI has been associated with ankle joint injury. As a result, assessing ankle DF ROM and FAI objectively (SEBT) and subjectively (CAIT) over the course of a season can help determine their association with football injuries in both adult and youth football players. No studies have investigated the presence of FAI and its impact on injury in both adult and youth football players in Ghana.

The findings of this study will aid in the development of more focused and evidence-based exercise and training programmes that may help to prevent injuries more effectively. It is critical to obtain a deeper understanding of performance and injury in male adult and youth football players in Ghana, as they represent the future of professional football.

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CHAPTER 3
ORIGINAL RESEARCH: PAPER 1

(In press at BMJ Sports Exercise and Medicine)

Epidemiology and clinical characteristics of football injuries among academy players in Ghana

Samuel Koranteng Kwakye[1], Karien Mostert[1], Daniel Garnett[2], Andries Masenge[3]

1 Department of Physiotherapy, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa
2 Department of Sport, Health Sciences and Social Work, Faculty of Health and Life Sciences, Oxford Brookes University, Oxford, England
3 Department of Statistics, University of Pretoria, Pretoria, South Africa

Address for correspondence

Daniel Garnett

Telephone: +44 7835 394134

Email: dgarnett@brookes.ac.uk

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ABSTRACT

Objective: To determine the epidemiology and clinical characteristics of match and training injuries among football players at an academy in Ghana.

Methods: In this prospective observational study, we followed 80 youth and adult football players at a Ghanaian academy over a season of 39 weeks. Medical attention and time-loss injuries, as well as exposure times of players, were recorded by resident physiotherapists using a standardised injury surveillance form. The average weekly injury prevalence was calculated. Injury incidence rates were calculated per 1000 exposure h, with significance indicated as 95% confidence intervals (CIs).

Results: 126 injuries were recorded during the season, with an average weekly injury prevalence of 4.1%. The overall injury incidence was 4.5 [95% CI 3.8–5.4] injuries per 1000 h with U14 (5.8 [3.3–10.2]/1000 h) and U18 players (5.7 [4.4–7.4]/1000 h) recording a higher incidence than U16 (5.1 [3.5–7.4]/1000 h) and senior players (2.7 [1.9–3.9]/1 000 h). Match injury incidence was 13 times higher than training injury incidence (27.4 [21.5–34.9] vs 2.3 [1.8–3.0] injuries/1000 h). Injuries to the lower extremities had the highest incidence (3.9 [2.1–7.2] injuries/1000 h), with the knee being the most commonly injured site (n = 30, 23.8%). The most common type of injury was a joint sprain (1.9 [1.5–2.5] injuries/1 000 h), and the most common injury mechanism was direct contact with another player (1.5 [1.1–2.0] injuries/1 000 h). Most injuries were moderately severe (2.0 [1.5–2.6] injuries/1000 h).

Conclusion: Ghanaian academy football players have a substantial risk of sustaining injuries, especially among younger players. Further studies should focus on developing specific injury prevention programmes in under-researched football-playing populations.

Keywords: epidemiology, football injury, incidence, prevalence

SUMMARY BOX

What is already known on this topic?

In European football, the injury incidence among academy players reportedly ranges from 3.7 to 7.9 injuries per 1000 h. However, this rate is only half that reported in adult African football players.

What this study adds

The overall injury incidence for Ghanaian academy football players is comparable to previous European reports but relatively lower than studies on adult players in Africa.

U14, U18, and U16 Ghanaian academy football players reported higher injury incidences (5.8 [3.3–10.2], 5.7 [4.4–7.4] and 5.1 [3.5-7.4] injuries/1000 h, respectively) than senior players (2.8 [1.9–3.9] injuries/1000 h).

How might this study affect practice, research, or policy?

Our study provides the first epidemiological findings for Ghanaian academy football players. Our results highlight that preventive efforts in the Ghanaian context should target youth football players and focus specifically on the knee and ankle.

INTRODUCTION

Football academies are essential for footballers' tactical, technological, and physical growth. However, footballers may still be exposed to certain injury risks due to the complexities (running and sprinting, passes and dribbles, tactical, technical and quick reactions) of football during routine training and matches (1, 2, 3). In a Spanish youth academy, the incidence of injury was reported as 2.93 injuries per 1000 h (2), while a rate of 6.8 injuries per 1000 h was reported for Swedish youth players (3). Both studies recorded higher injury incidence rates during matches than training (2, 3). Other studies involving youth football players in Europe reported 1.8 to 6.8 injuries per 1000 h (2-6). In contrast, a higher injury incidence (between 13 and 82 injuries per 1000 h) has been reported for football players from Africa (7, 8, 9).

Ghana is a football nation with a great history of success in international tournaments and a passionate fan base that shows enthusiasm by attending games and cheering for their national team (10, 11). However, no prospective studies have been conducted on football players from Ghana, especially among youth players, making this study important. Generally, few prospective epidemiology studies focus on academy football players from Africa. The few studies on football injuries have not followed recognised reporting guidelines for epidemiology studies hampering comparisons with other studies (12, 13, 14). The few studies focussing on adult Ghanaian football players were retrospective, which may result in possible misclassification or recall bias. Conducting detailed epidemiology studies on football injuries is necessary to identify unique characteristics of the Ghanaian football population concerning injury incidence and prevalence. This information may guide clinicians in assessing injury patterns, incidence, and characteristics in these players (15). This study aimed to determine the epidemiology and clinical characteristics of academy football players in different age groups over one football season.

METHODS

Study design

An observational prospective cohort study was conducted among youth and adult male football players at the West African Football Academy in Ghana. The study was conducted over one season of 39 weeks. Ethics approval was granted by the Ethics Committee of the Faculty of Health Sciences at the University of Pretoria (Reference no. 268/2021). Participants older than 18 years signed informed consent forms before the study. Players under 18 assented, and their parents gave informed written consent. Assent and parent consent forms were given to players to be given to parents during vacation after an introductory email was sent to parents. Weekly phone calls and text messages were sent to parents to confirm receipt and completion of forms. All forms were retrieved when the academy resumed.

Setting and participants

One hundred-five players were enrolled in the academy at the time of the study. We invited all players to participate in the study. However, 25 players did not participate. Fifteen players were 'on-trial', five were transferred to another team, three young players could not obtain parental consent, and two were scheduled to end their contracts in the month data was collected. Resultantly, 80 players participated in the study (n = 80). Players were grouped into four age groups, namely, Under 14 (U14), Under 16 (U16), Under 18 (U18), and senior (adult) players. The football academy in the Volta region of Ghana comprises three standard artificial turfs, a physiotherapy unit, one gymnasium, and accommodation for all players and some staff. The academy enrolled only male football players, who stay in the football camp for approximately ten months each year, are given a special diet three times a day, monitored sleep by supervisors, attend a government school, and have access to physiotherapists every day. Physiotherapists are the only employed health professionals resident at the academy; hence, they are the primary contact regarding any health issues among players. In a week, the training involved five to seven training sessions for all age groups, each spanning between 90 to 120 min. The senior team attended an additional strength, agility, and quickness (SAQ) session (30 min), one power training session (30 min), and one injury prevention session (45 min) per week. The U18 players attend one additional SAQ session (30 min) and one injury prevention session (45 min) per week. The U14 and U16 players do not attend any additional specific training sessions.

Patient and public involvement

The study was discussed with the management and medical staff of the football academy when developing the study proposal. The staff of the football academy facilitated data collection, and we distributed the findings to the academy.

Data collection

Before the start of the season, participants completed a questionnaire regarding demographic and previous injury information, including age, player position, dominant leg, previous injury, and being a member of the national team.

Injury definitions and data collection procedures followed the IOC model for recording injury (16) and the 2006 consensus statement on epidemiological studies in football (17). An injury was recorded as a result of any physical complaint resulting from a match or training that resulted in the player seeking medical attention (medical attention injury) from the physiotherapist or missing the next training or match (time-loss injury). Injuries were documented prospectively on a standardised injury surveillance (SIS) form (16). Two resident physiotherapists were trained to collect injury data. The following injury data were recorded: match or training, mode of onset, injury mechanism, injured body region, injury type, new/index injury (first injury of one type recorded during the study), recurrent injury (injury to the same body part and same structure type as the index injury), severity (number of days of time loss). Injury severity was classified as follows: slight (0 days); minimal (1–3 days); mild (4–7 days); moderate (8–28 days); and severe (> 28 days).

Weekly player exposure hours were recorded on exposure forms. The primary researcher visited the study setting once a month to assist with recording, ensuring that reporting procedures were maintained, and extracting data from physiotherapists' files. Data collection continued for one season, from September 2021 to June 2022.

To minimise confounding variables in this study, several measures were taken. Firstly, all players, except those in the senior team, played on artificial turf for all their games. Secondly, the coaching and technical staff were consistent across all age groups throughout the season, ensuring similar training styles. Finally, the environment and climate were standardised as all training and matches occurred at Ghana's Volta Region Academy. There were only a few exceptions where the senior team played in other regions.

Data analysis

Data were analysed using SPSS IBM Statistics version 28 software. All injuries (medical attention and time-loss) were included in the analysis. The data analysis consisted of descriptive statistics (means and standard deviations) for continuous variables and frequency tables (counts and percentages) for categorical variables. Injury incidence was calculated per 1000 h and interpreted at 95% confidence intervals. For the average weekly prevalence, the injury prevalence (number of injuries by the total number of players expressed in percentage) was calculated for each week. Subsequently, the mean prevalence was calculated for the study period of 39 weeks, at 95% confidence interval.

RESULTS

Demographics and player-specific factors

All participants completed the 39-week study period. The total exposure hours for all participants for the 2021/2022 academy season was 28082.4 h. The match exposure hours were 2406.6 h, while the training exposure hours were 25675.8 h. Table 1 shows participants' demographics and player-specific factors for the total population and per age group.

Table 1: Demographic characteristics of football players at an academy in Ghana (n = 80)

Age groups	Total players	Age (years)	BMI	Player position				Member of the national team	
	N (%)	Mean ±S D	Mean ± SD	GK n (%)	DF n (%)	MF n (%)	ATT n (%)	Yes n (%)	No n (%)
U14	7 (8.8)	13 ±0.38	17.6 ± 2.0	0 (0)	2 (28.6)	3 (42.9)	2 (28.6)	0 (0)	7 (100)
U16	17 (21.2)	15 ± 0.51	18.5 ± 1.2	3 (17.7)	7 (41.2)	3 (17.7)	4 (23.5)	0 (0)	1 (100)
U18	29 (36.2)	17 ± 0.51	20.3 ± 1.9	3 (10.3)	11 (37.9)	5 (17.2)	10 (34.5)	3 (10.3)	26 (89.7)
Senior team	27 (33.8)	21 ± 2.65	21.7 ± 1.7	3 (11.1)	9 (33.3)	8 (29.6)	7 (25.9)	6 (22.2)	21 (77.8)
Total population	80 (100)	17 ± 3.10	20.1 ± 2.2	9 (11.3)	29 (36.3)	19 (23.8)	23 (28.8)	9 (11.3)	71 (88.8)

ATT, Attacker; BMI, Body mass index; DF, Defender; GK, Goalkeeper; MF, Midfielder; , n= Number of players, SD = Standard deviation; U14, Under 14 years; U16, Under 16 years; U18, Under 18 years

Injury prevalence and injury incidence

The average weekly injury prevalence for the population was 4.1% (95% CI 2.94-5.56), with 2.1% (1.30-3.21) in matches and 1.9% (1.14-2.97) in training. As long as a player was not injured or sick, the player participated in all the training and matches in the season. The overall injury incidence rate was 4.5 (95% CI 3.8–5.4) per 1000 h, while match and training incidence rates were 27.4 (21.5–34.9) and 2.3 (1.8–3.0) per 1000 h, respectively. A total of 126 injuries were recorded, of which 52.4% (n = 66) occurred during matches, and 47.6% (n = 60) occurred in training. Table 2 shows the injury incidence for the study population per age group.

Table 2: The incidence of injuries among football players at an academy in Ghana

Age	Overall	Match	Training

category									
	n (%)	**Exposure hours**	**IR (95% CI)**	**n (%)**	**Exposure hours**	**IR (95% CI)**	**n (%)**	**Exposure hours**	**IR (95% CI)**
U14	12 (9.5)	2069.0	5.8 (3.3–10.2)	8 (12.1)	186.9	42.8 (21.4–85.6)	4 (6.7)	1882.2	2.1 (0.8–5.6)
U16	28 (22.2)	5522.9	5.1 (3.5–7.4)	13 (19.7)	510.2	25.5 (14.8–43.9)	15 (25.0)	5012.7	3.0 (1.8–5.0)
U18	58 (46.10)	10138.0	5.7 (4.4–7.4)	31 (47.0)	964.5	32.1 (22.6–45.6)	27 (45.0)	9173.5	2.9 (2.0–4.2)
Senior team	28 (22.2)	10078.9	2.8 (1.9–3.9)	14 (21.2)	745.1	18.8 (11.1–31.7)	14 (23.3)	9333.8	1.5 (0.9–2.5)
Total	126 (100)	28082.4	4.5 (3.8–5.4)	66 (100)	2406.6	27.4 (21.5–34.9)	60 (100)	25675.8	2.3 (1.8–3.0)

n= Number of injuries, IR, the Injury incidence rate per 1000 exposure hours; U14, Under 14 years; U16, Under 16 years; U18, Under 18 years

Injury characteristics

Mode of onset and mechanism of injury

The mode of onset of most injuries was sudden after acute trauma (n = 57, 45.2%). About 24.6% (n = 31) of injuries occurred suddenly but no acute trauma and 30.2% (n = 38) occurred gradually. Most injuries were sustained via direct contact with another player (n = 42, 33.3%). Details of the frequency and incidence by mechanism are shown in Table 3.

Table 3: The number (n), frequency (%) and incidence rate (per 1 000 hours) of all injuries, match, and training injuries by the injury mechanism per age category.

	All injuries (n = 126)									
Mode of onset	**Total population**		**U14**		**U16**		**U18**		**Senior team**	
	n (%)	**IR (95%CI)**	**n (%)**	**IR (95%CI)**	**n (%)**	**IR (95%CI)**	**n (%)**	**IR (95%CI)**	**n (%)**	**IR (95%CI)**
No single identifiable event	29 (23.0)	1.0 (0.7–1.4)	4 (33.3)	1.9 (0.7–5.1)	5 (17.9)	0.9 (0.4–2.2)	11 (19.0)	1.1 (0.6–2.0)	9 (32.1)	0.9 (0.5–1.7)
Acute non-contact trauma	32 (25.4)	1.1 (0.8–1.6)	4 (33.3)	1.9 (0.7–5.1)	11 (39.3)	2.0 (1.1–3.6)	16 (27.6)	1.6 (1.0–2.6)	1 (3.6)	0.1 (0.0–0.7)
Direct contact with another player	42 (33.3)	1.5 (1.1–2.0)	3 (25.0)	1.4 (0.5–4.3)	8 (28.6)	1.4 (0.7–2.8)	21 (36.2)	2.1 (1.4–3.2)	10 (35.7)	1.0 (0.5–1.9)
Following contact with another player	8 (6.3)	0.3 (0.2–0.6)	0 (0.0)	0	2 (7.1)	0.4 (0.1–1.6)	3 (5.2)	0.3 (0.1–0.9)	3 (10.7)	0.3 (0.1–0.9)
Direct contact with an object	11 (8.70	0.4 (0.2–0.7)	1 (8.3)	0.5 (0.5–3.5)	1 (3.6)	0.2 (0.0–1.4)	5 (8.6)	0.5 (0.2–1.2)	4 (14.3)	0.4 (0.2–1.1)
Following contact with an object	4 (3.2)	0.1 (0.0–0.3)	0 (0.0)	0	1 (3.6)	0.2 (0.0–1.4)	2 (3.4)	0.2 (0.1–0.8)	1 (3.6)	0.1 (0.0–0.7)
	Training injuries (n = 60)									
No single identifiable event	14 (23.3)	0.5 (0.3–0.8)	2 (50.0)	1.1 (0.3–4.4)	3 (20.0)	0.6 (0.2–1.9)	6 (22.2)	0.7 (0.3–1.6)	3 (21.4)	0.3 (0.1–0.9)

Acute non–contact trauma	17 (28.3)	0.6 (0.4–1.0)	2 (50.0)	1.1 (0.3–4.4)	7 (46.7)	1.4 (0.7–2.9)	7 (25.9)	0.8 (0.4–1.7)	1 (7.1)	0.1 (0.0–0.7)
Direct contact with another player	13 (21.7)	0.5 (0.3–0.9)	0 (0.0)	0	2 (13.3)	0.4 (0.1–1.6)	7 (25.9)	0.8 (0.4–1.7)	4 (28.6)	0.4 (0.2–1.1)
Following contact with another player	6 (10.0)	0.2 (0.1–0.4)	0 (0.0)	0	2 (13.3)	0.4 (0.1–1.6)	3 (11.1)	0.3 (0.1–0.9)	1 (7.1)	0.1 (0.0–0.7)
Direct contact with an object	8 (13.3)	0.3 (0.2–0.6)	0 (0.0)	0	1 (6.7)	0.2 (0.0–1.4)	3 (11.1)	0.3 (0.1–0.9)	4 (28.6)	0.4 (0.2–1.1)
Following contact with an object	2 (3.3)	0.1 (0.0–0.4)	0 (0.0)	0	0 (0.0)	0	1 (3.7)	0.1 (0.0–0.7)	1 (7.1)	0.1 (0.0–0.7)
Match injuries (n = 66)										
No single identifiable event	2 (25.0)	10.7 (2.7–42.8)	2 (15.4)	3.9 (1.0–15.6)	5 (16.1)	5.2 (2.2–12.5)	6 (42.9)	8.1 (3.6–18.0)	2 (25.0)	10.7 (2.7–42.8)
Acute non–contact trauma	2 (25.0)	10.7 (2.7–42.8)	4 (30.8)	7.8 (2.9–20.8)	9 (29.0)	9.3 (4.8–17.9)	0 (0.0)	0	2 (25.0)	10.7 (2.7–42.8)
Direct contact with another player	30 (37.5)	16.1 (11.3–23.0)	6 (46.2)	11.8 (5.3–26.3)	14 (45.2)	14.5 (8.6–24.5)	6 (42.9)	8.1 (3.6–18.0)	3 (37.5)	16.1 (5.2–49.9)
Following contact with another player	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0	2 (14.3)	2.7 (0.7–10.8)	0 (0.0)	0
Direct contact with an object	1 (12.5)	5.4 (0.8–38.3)	0 (0.0)	0	2 (6.5)	2.1 (0.5–8.4)	0 (0.0)	0	1 (12.5)	5.4 (0.8–38.3)

Following contact with an object	0 (0.0)	0	1 (7.7)	2.0 (0.3–14.2)	1 (3.2)	1.0 (0.1–7.1)	0 (0.0)	0	0 (0.0)	0

Injured body region

The most commonly injured body region was the knee (n = 30, 23.8%), followed by the ankle (n = 18, 14.3%), hip/groin (n = 17, 13.5%), and hamstring (n = 16, 12.7%). A slightly different pattern was observed for match injuries (Table 4).

Table 4: The number (n), frequency (%) and incidence rate per 1 000 hours of all injuries, match and training injuries by body region.

Body region	Total population		U14		U16		U18		Senior team	
	n (%)	IR (95%CI)	n (%)	IR (95%CI)	n (%)	IR (95%CI)	n (%)	IR (95%CI)	n (%)	IR (95%CI)
All injuries (n = 126)										
Face	1 (0.8)	0 (0.0–0.0)	0 (0.0)	0	1 (3.6)	0.2 (0.0–1.4)	0 (0.0)	0	0 (0.0)	0
Upper limb (All)	**4 (3.2)**	**0.1 (0.0–0.3)**	**0 (0.0)**	**0**	**3 (10.7)**	**0.5 (0.2–1.6)**	**1 (1.7)**	**0.1 (0.0–0.7)**	**0 (0.0)**	**0**
Shoulder	2 (1.6)	0.1 (0.0–0.4)	0 (0.0)	0	1 (3.6)	0.2 (0.0–1.4)	1 (1.7)	0.1 (0.0–0.7)	0 (0.0)	0
Elbow	1 (0.8)	0 (0.0–0.0)	0 (0.0)	0	1 (3.6)	0.2 (0.0–1.4)	0 (0.0)	0	0 (0.0)	0
Forearm	1 (0.8)	0 (0.0–0.0)	0 (0.0)	0	1 (3.6)	0.2 (0.0–1.4)	0 (0.0)	0	0 (0.0)	0
Trunk (All)	**12 (9.5)**	**0.4 (0.2–0.7)**	**2 (16.7)**	**1 (0.3–4.0)**	**4 (14.3)**	**0.7 (0.3–1.9)**	**4 (6.9)**	**0.4 (0.2–1.1)**	**2 (7.1)**	**0.2 (0.1–0.8)**
Upper back	1 (0.8)	0 (0.0–0.0)	0 (0.0)	0	1 (0.8)	0.2 (0.0–1.4)	0 (0.0)	0	0 (0.0)	0
Chest	1 (0.8)	0 (0.0–0.0)	0 (0.0)	0	0 (0.0)	0	1 (1.7)	0.1 (0.0–0.7)	0 (0.0)	0
Lumbosacral spine	10 (7.9)	0.4 (0.2–0.7)	2 (16.7)	1 (0.3–4.0)	3 (10.7)	0.5 (0.2–1.6)	3 (5.2)	0.3 (0.1–0.9)	2 (7.1)	0.2 (0.1–0.8)
Lower limb (All)	**109 (86.5)**	**3.9 (3.2–7.2)**	**10 (35.7)**	**4.8 (2.6–8.9)**	**20 (71.4)**	**3.6 (2.3–5.6)**	**53 (91.4)**	**5.2 (4.0–6.8)**	**25 (89.3)**	**2.5 (1.7–3.7)**
Hip/Groin	17 (13.5)	0.6 (0.4–1.0)	2 (16.7)	1 (0.3–4.0)	5 (17.9)	0.9 (0.4–2.2)	6 (10.3)	0.6 (0.3–1.3)	4 (14.3)	0.4 (0.2–1.1)
Thigh	6 (4.8)	0.2 (0.1–0.4)	0 (0.0)	0	1 (0.8)	0.2 (0.0–1.4)	3 (5.2)	0.3 (0.1–0.9)	2 (7.1)	0.2 (0.1–0.8)
Hamstring	16 (12.7)	0.6 (0.4–1.0)	2 (16.7)	1 (0.3–4.0)	5 (17.9)	0.9 (0.4–2.2)	5 (8.6)	0.5 (0.2–1.2)	4 (14.3)	0.4 (0.2–1.1)
Knee	30 (23.8)	1.1 (0.8–1.6)	4 (33.3)	1.9 (0.7–5.1)	3 (10.7)	0.5 (0.2–1.6)	15 (25.9)	1.5 (0.9–2.5)	8 (28.6)	0.8 (0.4–1.6)
Tibia/Fibula	9 (7.1)	0.3 (0.2–0.6)	0 (0.0)	0	1 (0.8)	0.2 (0.0–1.4)	7 (12.1)	0.7 (0.3–1.5)	1 (3.6)	0.1 (0.0–0.7)
Calf	1 (0.8)	0 (0.0–0.0)	0 (0.0)	0	1 (0.8)	0.2 (0.0–1.4)	0 (0.0)	0	0 (0.0)	0
Ankle	17 (13.5)	0.6 (0.4–1.0)	1 (8.3)	0.5 (0.1–3.5)	2 (16.7)	0.4 (0.1–1.6)	12 (20.7)	1.2 (0.7–2.1)	2 (7.1)	0.2 (0.1–0.8)
Achilles tendon	1 (0.8)	0 (0.0–0.0)	0 (0.0)	0	0, (0.0)	0	0 (0.0)	0	0 (0.0)	0
Foot	12 (9.5)	0.4 (0.2–0.7)	1 (8.3)	0.5 (0.1–3.5)	2 (16.7)	0.4 (0.1–1.6)	5 (8.6)	0.5 (0.2–1.2)	4 (14.3)	0.4 (0.2–1.1)
Match injuries (n = 66)										
Face	1 (1.5)	0.4 (0.1–2.8)	0 (0.0)	0	1 (7.7)	2 (0.3–14.2)	0 (0.0)	0	0 (0.0)	0
Upper limb (All)	1 (1.5)	0.4 (0.1–2.8)	0 (0.0)	0	1 (7.7)	2 (0.3–14.2)	0 (0.0)	0	0 (0.0)	0
Shoulder	1 (1.5)	0.4 (0.1–2.8)	0 (0.0)	0	1 (7.7)	2 (0.3–14.2)	0 (0.0)	0	0 (0.0)	0
Elbow	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0
Forearm	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0
Trunk (All)	6 (9.1)	2.5 (1.1–5.6)	1 (12.5)	5.4 (0.8–38.3)	2 (15.4)	3.9 (1.0–15.6)	1 (3.2)	1 (0.1–7.1)	2 (14.3)	2.7 (0.7–10.8)
Upper back	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0
Chest	1 (1.5)	0.4 (0.1–2.8)	0 (0.0)	0	0 (0.0)	0	1 (3.2)	1 (0.1–7.1)	0 (0.0)	0
Lumbosacral spine	5 (7.6)	2.10.9–5.8)	1 (12.5)	5.4 (0.8–38.3)	2 (15.4)	3.9 (1.0–15.6)	0 (0.0)	0	2 (14.3)	2.7 (0.7–10.8)
Lower limb (All)	58 (87.9)	24.1 (18.6–31.2)	7 (87.5)	37.5 (17.9–	9 (69.2)	17.6 (9.2–	30 (96.8)	31.1 (21.7–	11 (78.6)	14.8 (8.2–

13

				78.7)		33.8)		44.5)		26.7)
Hip/Groin	8 (12.1)	3.3 (1.7–6.6)	1 (12.5)	5.4 (0.8–38.3)	1 (7.7)	2 (0.3–14.2)	4 (12.9)	4.1 (1.5–10.9)	2 (14.3)	2.7 (0.7–10.8)
Thigh	2 (3.0)	0.8 (0.2–3.2)	0 (0.0)	0	0 (0.0)	0	2 (6.5)	2.1 (0.5–8.4)	0 (0.0)	0
Hamstring	9 (13.6)	3.7 (1.9–7.1)	1 (12.5)	5.4 (0.8–38.3)	3 (23.1)	5.9 (1.9–18.3)	3 (9.7)	3.1 (1.0–9.6)	2 (14.3)	2.7 (0.7–10.8)
Knee	19 (28.8)	7.9 (5.0–12.4)	3 (37.5)	16.1 (5.2–49.9)	1 (7.7)	2 (0.3–14.2)	10 (32.3)	10.4 (5.6–19.3)	5 (35.7)	6.7 (2.8–16.1)
Tibia/Fibula	5 (7.6)	2.1 (0.9–5.0)	0 (0.0)	0	1 (7.7)	2 (0.3–14.2)	3 (9.7)	3.1 (1.0–9.6)	1 (7.1)	1.3 (0.2–9.2)
Calf	1 (1.5)	0.4 (0.1–2.8)	0 (0.0)	0	1 (7.7)	2 (0.3–14.2)	0 (0.0)	0	0 (0.0)	0
Ankle	7 (10.6)	2.9 (1.4–6.1)	1 (12.5)	5.4 (0.8–38.3)	1 (7.7)	2 (0.3–14.2)	5 (16.1)	5.2 (2.2–12.5)	0 (0.0)	0
Achilles tendon	1 (1.5)	0.4 (0.1–2.8)	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0
Foot	6 (9.1)	2.5 (1.1–506)	1 (12.5)	5.4 (0.8–38.3)	1 (7.7)	2 (0.3–14.2)	3 (9.7)	3.1 (1.0–9.6)	1 (7.1)	1.3 (0.2–9.2)
Training injuries (n = 60)										
Face	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0
Upper limb (All)	3 (5.0)	0.1 (0.0–0.3)	0 (0.0)	0	2 (13.3)	0.4 (0.1–1.6)	1 (3.7)	0.1 (0.0–0.7)	0 (0.0)	0
Shoulder	1 (1.7)	0 (0.0–0.0)	0 (0.0)	0	0 (0.0)	0	1 (3.7)	0.1 (0.0–0.7)	0 (0.0)	0
Elbow	1 (1.7)	0 (0.0–0.0)	0 (0.0)	0	1 (6.7)	0.2 (0.0–1.4)	0 (0.0)	0	0 (0.0)	0
Forearm	1 (1.7)	0 (0.0–0.0)	0 (0.0)	0	1 (6.7)	0.2 (0.0–1.4)	0 (0.0)	0	0 (0.0)	0
Trunk (All)	6 (10.0)	0.2 (0.1–0.4)	1 (25.0)	0.5 (0.1–3.5)	2 (13.3)	0.4 (0.1–1.6)	3 (11.1)	0.3 (0.1–0.9)	0 (0.0)	0
Upper back	1 (1.7)	0 (0.0–0.0)	0 (0.0)	0	1 (6.7)	0.2 (0.0–1.4)	0 (0.0)	0	0 (0.0)	0
Chest	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0
Lumbosacral spine	5 (8.3)	0.2 (0.1–0.5)	1 (25.0)	0.5 (0.1–3.5)	1 (6.7)	0.2 (0.0–1.4)	3 (11.1)	0.3 (0.1–0.9)	0 (0.0)	0
Lower limb (All)	51 (85.0)	2 (1.5–2.6)	3 (75.0)	1.6 (0.5–5.0)	11 (73.3)	2.2 (1.2–4.0)	23 (85.2)	1.5 (1.0–2.3)	14 (100)	1.5 (0.9–2.5)
Hip/Groin	9 (15.0)	0.4 (0.2–0.8)	1 (25.0)	0.5 (0.1–3.5)	4 (26.7)	0.8 (0.3–2.1)	2 (7.4)	0.2 (0.1–0.8)	2 (14.3)	0.2 (0.1–0.8)
Thigh	4 (6.7)	0.2 (0.1–0.5)	0 (0.0)	0	1 (6.7)	0.2 (0.0–1.4)	1 (3.7)	0.1 (0.0–0.7)	2 (14.3)	0.2 (0.1–0.8)
Hamstring	7 (11.7)	0.3 (0.1–0.6)	1 (25.0)	0.5 (0.1–3.5)	2 (13.3)	0.4 (0.1–1.6)	2 (7.4)	0.2 (0.1–0.0.8)	2 (14.3)	0.2 (0.1–0.8)
Knee	11 (18.3)	0.4 (0.2–0.7)	1 (25.0)	0.5 (0.1–3.5)	2 (13.3)	0.4 (0.1–1.6)	5 (18.5)	0.5 (0.2–1.2)	3 (21.4)	0.3 (0.1–0.9)
Tibia/Fibula	4 (6.7)	0.2 (0.1–0.5)	0 (0.0)	0	0 (0.0)	0	4 (14.8)	0.4 (0.2–1.1)	0 (0.0)	0
Calf	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0
Ankle	10 (16.7)	0.4 (0.2–0.7)	0 (0.0)	0	1 (6.7)	0.2 (0.0–1.4)	7 (25.9)	0.8 (0.4–1.7)	2 (14.3)	0.2 (0.1–0.8)
Achilles tendon	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0	0 (0.0)	0
Foot	6 (10.0)	0.2 (0.1–0.4)	0 (0.0)	0	1 (6.7)	0.2 (0.0–1.4)	2 (7.4)	0.2 (0.1–0.8)	3 (21.4)	0.3 (0.1–0.9)

Injury type

The most commonly reported injury type was joint sprain (n = 54, 42.9%) and muscle strain (n = 30, 23.8%), similar during training and matches. A detailed summary is shown in Table 5.

Table 5: The number (n), frequency (%) and incidence rate (per 1 000 hours) of all injuries, match and training injuries by injury type per age category.

Injury Type	Total		U14		U16		U18		Senior team	
	n (%)	IR (95% CI)	n (%)	IR (95% CI)	n (%)	IR (95% CI)	n (%)	IR (95% CI)	n (%)	IR (95% CI)
					All injuries (n = 126)					
Bone										
Fracture	2 (1.6)	0.1 (0.0–0.4)	0 (0.0)	0.0	0 (0.0)	0.0	1 (1.7)	0.1 (0.0–0.7)	1 (3.6)	0.1 (0.0–0.7)
contusion	11 (8.7)	0.4 (0.2–0.7)	0 (0.0)	0.0	2 (7.1)	0.4 (0.1–1.6)	7 (12.1)	0.7 (0.3–1.5)	2 (7.1)	0.2 (0.1–0.8)
Stress injury	4 (3.2)	0.1 (0.0–0.3)	0 (0.0)	0.0	0 (0.0)	0.0	4 (6.9)	0.0	0 (0.0)	0.0
Ligament										
Joint sprain	54 (42.9)	1.9 (1.5–2.5)	6 (50.0)	2.3 (1.0–5.1)	8 (28.6)	1.4 (0.7–2.8)	29 (50.0)	2.9 (2.0–4.2)	11 (39.3)	1.1 (0.6–2.0)
Muscle/ Tendon										
Muscle strain	33 (26.2)	1.2 (0.9–1.7)	4 (33.3)	1.9 (0.7–5.1)	11 (39.3)	2.0 (1.1–3.6)	9 (15.5)	0.9 (0.5–1.7)	9 (32.1)	0.9 (0.5–1.7)
Muscle contusion	5 (4.0)	0.2 (0.1–0.5)	0 (0.0)	0.0	2 (7.1)	0.4 (0.1–1.6)	2 (3.4)	0.2 (0.1–0.8)	1 (3.6)	0.1 (0.0–0.7)
Tendinopathy	2 (1.6)	0.1 (0.0–0.4)	0 (0.0)	0.0	1 (3.6)	0.2 (0.0–1.4)	0 (0.0)	0.0	1 (3.6)	0.1 (0.0–0.7)
Meniscus										
Meniscus tear	1 (0.8)	0.2 (0.0–1.4)	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0	1 (3.6)	0.1 (0.0–0.7)
Superficial/ tissue skin										
Bruise	6 (4.8)	0.2 (0.1–0.4)	1 (8.3)	0.5 (0.1–3.5)	3 (10.7)	0.5 (0.2–1.6)	1 (1.7)	0.1 (0.0–0.7)	1 (3.6)	0.1 (0.0–0.7)
Laceration	2 (1.6)	0.1 (0.0–0.4)	0 (0.0)	0.0	1 (3.6)	0.2 (0.0–1.4)	0 (0.0)	0.0	1 (3.6)	0.1 (0.0–0.7)
Abrasion	4 (3.2)	0.1 (0.0–0.4)	0 (0.0)	0.0	0 (0.0)	0.0	4 (6.9)	0.4 (0.2–1.1)	0 (0.0)	0.0
Non–specific										
Chest pains	1 (0.8)	0.2 (0.0–1.4)	0 (0.0)	0.0	0 (0.0)	0.0	1 (1.7)	0.1 (0.0–0.7)	0 (0.0)	0.0
Osgood–Schlatter disease	1 (0.8)	0.2 (0.0–1.4)	1 (8.3)	0.5 (0.1–3.5)	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0
					Match injuries (n = 66)					
Bone										
Fracture	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0
contusion	7 (10.6)	2.9 (1.4–6.1)	0 (0.0)	0.0	1 (7.7)	2 (0.3–14.2)	5 (16.1)	5.2 (2.2–12.5)	1 (7.1)	1.3 (0.2–9.2)
Stress injury	1 (1.5)	0.4 (0.1–2.8)	0 (0.0)	0.0	0 (0.0)	0.0	1 (3.2)	1.0 (0.1–7.1)	0 (0.0)	0.0
Ligament										

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Joint sprain	32 (48.5)	13.3 (9.4–18.8)	6 (75.0)	32.1 (14.4–71.5)	4 (30.8)	7.8 (2.9–20.8)	15 (48.4)	15.6 (9.4–25.9)	7 (50.0)	9.4 (4.5–19.7)
Muscle/ Tendon										
Muscle strain	15 (22.7)	6.2 93.7–10.3)	1 (12.5)	5.4 (0.8–38.3)	4 (30.8)	7.8 (2.9–20.8)	6 (19.4)	6.2 (2.8–13.8)	4 (28.6)	5.4 (2.0–14.4)
Muscle contusion	2 (3.0)	0.8 (0.2–8.3)	0 (0.0)	0.0	1 (7.7)	2 (0.3–14.2)	1 (3.2)	1.0 (0.1–7.1)	0 (0.0)	0.0
Tendinopathy	2 (3.0)	0.8 (0.2–8.3)	0 (0.0)	0.0	1 (7.7)	2 (0.3–14.2)	0 (0.0)	0.0	1 (7.1)	1.3 (0.2–9.2)
Meniscus										
Meniscus tear	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0
Superficial/ tissue skin										
Bruise	2 (3.0)	0.8 (0.2–3.2)	1 (12.5)	5.4 (0.8–38.3)	1 (7.7)	2 (0.3–14.2)	0 (0.0)	0.0	0 (0.0)	0.0
Laceration	2 (3.0)	0.8 (0.2–3.2)	0 (0.0)	0.0	1 (7.7)	2 (0.3–14.2)	0 (0.0)	0.0	1 (7.1)	1.3 (0.2–9.2)
Abrasion	2 (3.0)	0.8 (0.2–3.2)	0 (0.0)	0.0	0 (0.0)	0.0	2 (6.5)	2.1 (0.5–8.4)	0 (0.0)	0.0
Non–specific										
Chest pains	1 (1.5)	0.4 (0.1–2.8)	0 (0.0)	0.0	0 (0.0)	0.0	1 (3.2)	1.0 (0.1–7.1)	0 (0.0)	0.0
Osgood–Schlatter disease	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0
Training injuries (n = 60)										
Bone										
Fracture	2 (3.3)	0.1 (0.0–0.4)	0 (0.0)	0.0	0 (0.0)	0.0	1 (3.7)	0.1 (0.0–0.7)	1 (7.1)	0.1 (0.0–0.7)
contusion	4 (6.7)	0.2 (0.1–0.5)	0 (0.0)	0.0	1 (6.7)	0.2 (0.0–1.4)	2 (7.4)	0.2 (0.1–0.8)	1 (7.1)	0.1 (0.0–0.7)
Stress injury	3 (5.0)	0.1 (0.0–0.3)	0 (0.0)	0.0	0 (0.0)	0.0	3 (11.1)	0.3 (0.1–0.9)	0 (0.0)	0.0
Ligament										
Joint sprain	22 (36.7)	0.9 (0.6–1.4)	0 (0.0)	0.0	4 (26.7)	0.8 (0.3–2.1)	14 (51.9)	1.5 (0.9–2.5)	4 (28.6)	0.4 (0.2–1.1)
Muscle/ Tendon										
Muscle strain	18 (30.0)	0.7 (0.4–1.1)	3 (75.0)	1.6 (0.5–5.0)	7 (46.7)	1.4 (0.7–2.9)	3 (11.1)	0.3 (0.1–0.9)	5 (35.7)	0.5 (0.2–1.2)
Muscle contusion	3 (5.0)	0.1 (0.0–0.3)	0, (0.0)	0.0	1 (6.7)	0.2 (0.0–1.4)	1 (3.7)	0.1 (0.0–0.7)	1 (7.1)	0.1 (0.0–0.7)
Tendinopathy	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0
Meniscus										
Meniscus	1 (1.7)	0.0	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0	1 (7.1)	0.1 (0.0–0.7)

tear										
Superficial/ tissue skin										
Bruise	4 (6.7)	0.2 (0.1–0.5)	0 (0.0)	0.0	2 (13.3)	0.4 (0.1–1.6)	1 (3.7)	0.1 (0.0–0.7)	1 (7.1)	0.1 (0.0–0.7)
Laceration	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0
Abrasion	2 (3.3)	0.1 (0.0–0.4)	0 (0.0)	0.0	0 (0.0)	0.0	2 (7.4)	0.2 (0.1–0.8)	0 (0.0)	0.0
Non–specific										
Chest pains	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0
Osgood–Schlatter disease	1 (1.7)	0.0 (0.0–0.0)	1 (25.0)	0.5 (0.1–3.5)	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0

CI, Confidence interval; IR, the Incidence rate per 1000 player hours, n= Total number of injuries

Injury severity

Most injuries were classified as 'moderate' severity (8–28 days) (n = 56, 44.4%) and occurred during matches and training sessions (n = 26, 39.4% and n = 30, 50%), respectively. Table 6 shows injury severity for all match and training injuries per age group.

Table 6: The number (n) and percentage (%) of injury severity categories for all injuries, match, and training injuries per age category

Severity category	**All injuries (n = 126)**			**Match injuries (n = 66)**			**Training injuries (n = 60)**		
				Total population (n = 80)					
	n	**%**	**IR (95% CI)**	**n**	**%**	**IR (95% CI)**	**n**	**%**	**IR (95% CI)**
Slight (0 days)	8	6.3	0.3 (0.2–0.6)	4	6.1	1.7 (0.6–4.5)	4	6.7	0.2 (0.1–0.8)
Minimal (1–3 days)	14	11.1	0.5 (0.3–0.8)	7	10.6	2.9 (1.4–6.1)	7	11.7	0.3 (0.1–0.7)
Mild (4–7 days)	26	20.6	0.9 (0.6–1.3)	17	25.8	7.1 (4.4–11.4)	9	15.0	0.4 (0.2–0.8)
Moderate (8–28 days)	56	44.4	2.0 (1.5–2.6)	26	39.4	10.8 (7.4–15.9)	30	50.0	1.2 (0.8–1.7)
Severe (> 28 days)	22	17.5	0.8 (0.5–1.2)	12	18.2	5.0 (2.8–8.8)	10	16.7	0.4 (0.2–0.8)
				U 14 (n = 70)					
Slight (0 days)	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Minimal (1–3 days)	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Mild (4–7 days)	2	16.7	1.0 90.3–4.0)	1	12.5	5.4 (0.8–38.3)	1	25.0	0.5 (0.3–0.8)
Moderate (8–28 days)	9	75.0	4.3 (2.2–8.3)	6	75.0	32.1 (14.4–71.5)	3	75.0	1.6 (1.2–2.1)
Severe (> 28 days)	1	8.3	0.5 (0.1–3.5)	1	12.5	5.4 (0.8–38.3)	0	0.0	0.0
				U 16 (n = 17)					
Slight (0 days)	2	7.1	0.4 (0.1–1.6)	2	15.4	3.9 (1.0–15.6)	0	0.0	0.0
Minimal (1–3 days)	7	25.0	1.3 (0.6–2.7)	4	30.8	7.8 (2.9–20.8)	3	20.0	0.6 (0.3–1.1)
Mild (4–7 days)	4	14.3	0.7 (0.3–1.9)	2	15.4	3.9 (1.0–15.6)	2	13.3	0.4 (0.2–0.8)

Moderate (8–28 days)	12	42.9	2.2 (1.2–3.9)	3	23.1	5.9 (1.9–18.3)	9	60.0	1.8 (1.3–2.5)
Severe (> 28 days)	3	10.7	0.5 (0.2–1.6)	2	15.4	3.9 (1.0–15.6)	1	6.7	0.2 (0.1–0.5)
U 18 (n = 29)									
Slight (0 days)	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Minimal (1–3 days)	6	10.3	0.6 (0.3–1.3)	3	9.7	3.1 (1.0–9.6)	3	11.1	0.3 (0.1–0.7)
Mild (4–7 days)	17	29.3	1.7 (1.1–2.7)	11	35.5	11.4 (6.3–20.6)	6	22.2	0.7 (0.4–1.2)
Moderate (8–28 days)	24	41.4	2.4 (1.6–3.6)	12	38.7	12.4 (7.0–21.8)	12	44.4	1.3 (0.9–1.9)
Severe (> 28 days)	11	19.0	1.1 (0.6–2.0)	5	16.1	5.2 (2.2–12.5)	6	22.2	0.7 (0.4–1.2)
Senior team (n = 27)									
Slight (0 days)	6	21.4	0.6 (0.3–1.3)	2	14.3	2.7 (0.7–10.8)	4	28.6	0.4 (0.2–0.7)
Minimal (1–3 days)	1	3.6	0.1 (0.0–0.7)	0	0.0	0.0	1	7.1	0.1 (0.0–0.7)
Mild (4–7 days)	3	10.7	0.3 (0.1–0.9)	3	21.4	4.0 (1.3–12.4)	0	0.0	0.0
Moderate (8–28 days)	11	39.3	1.1 (0.6–2.0)	5	35.7	6.7 (2.8–16.1)	6	42.9	0.6 (0.4–0.9)
Severe (> 28 days)	7	25.0	0.7 (0.3–1.5)	4	28.6	5.4 (2.0–14.4)	3	21.4	0.3 (0.2–0.5)

New vs recurrent injury

The overall injury incidence rate for new injuries was 17.8 [14.8–21.4] injuries per 1000 h, with 111.4 [86.3–143.8] and 8.7 [6.6–11.4] injuries per 1000 h occurring during matches and training, respectively. The overall injury incidence for recurrent injuries was 1.5 [0.9–2.5] injuries per 1000 h, with 7.9 [3.8–16.6] and 0.8 [0.4–1.7] injuries per 1000 h occurring during matches and training, respectively. About 88.9% (n = 112) of injuries recorded were considered 'new injuries', while 11.1% (n = 14) were recurrent injuries. 47.3% (n = 53) of new injuries occurred during training, and 52.7% (n = 59) during matches. Most recurring injuries were reported among U18s (n = 10, 71.4%). The U14s reported no recurrent injuries, the U16s reported 1 (7.1%), and senior players reported 3 (21.4%).

DISCUSSION

This may be the first prospective study to report injuries' epidemiology and clinical characteristics among Ghanaian adolescent and adult academy football players. The study sought to determine the epidemiology and clinical characteristics of football injuries among players at an academy in Ghana. The study found the overall injury incidence rate to be 4.5 [3.8–5.4] injuries per 1000 h with a higher incidence of 27.4 [21.5–34.9] per 1000 h in matches than in training (2.3 [1.8–3.0] injuries/1000 h). The most common type of injury was an ankle sprain, with the knee being the most frequently injured. The injury mechanism was mostly direct contact with another player, and most injuries were moderate in severity.

Injury incidence and prevalence

Some epidemiological studies showed injury risks to be age-related among young football players (18-20). The reported injury incidence in this study (4.5 injuries/1000 h) is similar to other European studies in amateur and youth players (5.1 to 10.9 injuries/1000 h) (4, 21-23). However, the injury incidence in this study is lower than that reported among South African youth academy players (13.4 to 36.4 injuries/1000 h) (7, 9).

The overall injury incidence among adult male football players in Africa is between 10 and 90 injuries per 1000 h (7, 9, 39) which is contrary to our findings (2.8/1000 h) but similar to some European studies (2, 24). One reason for the wide discrepancy in results may be attributed to the variations in the methodologies where only time-loss injuries were recorded over two seasons for some studies (9, 39). In contrast, we reported time loss and medical injuries over only one season. It is plausible that older athletes may experience fewer injuries due to their increased strength, stamina, and coordination than reported in younger age groups (25). We found that senior players experienced fewer injuries than younger players. Younger players may have a higher risk of injury because they have more obligations, including attending classes, studying for examinations, and attending field and gymnasium practice sessions before and after the daily academic class schedule, which may impact sleep, rest, and recovery times (26).

In our study, football players experienced more injuries during matches than during training sessions, which supports recent international research (1, 27-29). During matches, players may experience increased physical demands, contact and collisions, and fatigue (4, 20, 27). Our study recorded the highest training injury incidence in U16 and U18 players and the highest match injury incidence in U18 players. This finding was similar to previous results in English Premier League academy football players (27). Our finding, however, was contrary to Qatari male youth football players who reported U15 and U17 players to be more prone to suffering injuries during training (30). The difference in exposure hours (30, 31), as well as higher match intensity (32) and aggression with age (15), may well explain this finding.

We calculated the average weekly injury prevalence to reflect the overall injury frequency throughout the season accurately. We found that approximately 4% of players sustain an injury weekly during a playing season. Previous studies in Africa that determined injury prevalence utilised a retrospective data collection method, making comparison enigmatic (33-36).

Injury characteristics

Mode of onset and injury mechanism

Most reported injuries were sustained as sudden onset after acute trauma (45.2%). Injuries sustained gradually had a similar incidence to those sustained suddenly after acute trauma. Per the age groups, the overall injury incidence rate for injuries brought on suddenly without acute trauma was slightly higher than the 'gradual' and 'sudden after acute trauma' mode of onsets for the U14 players. Football's contact and physical nature may explain the high prevalence of contact injuries. Most studies have reported the traumatic nature of football injuries (27, 37).

As reported in most studies, most football injuries are contact injuries (9, 36, 38, 39). Our research supports this finding and identifies 'direct contact with another player' as the most common cause of injury among all age groups of players, similar to other studies in South Africa (9), Asia (30) and Europe (2, 22, 38). Direct contact with another player accounted for one-third (n = 42, 33%) of all injuries and was associated with more severe injuries. Comparatively, a considerable percentage of injuries were caused by overuse/gradual and acute but non-contact trauma during training. Bester and colleagues' study corroborates our finding (9).

Injured body region

The most frequently reported injury locations were general across players in all age groups. The knee was the most commonly injured body region for all players, which corroborates findings in a few studies (36, 40). However, several studies conducted in Europe and America have reported the thigh as the most common injured body part (27, 41, 42). Nevertheless, most of these studies report the knee as the second or third most commonly injured body part (27, 41, 42). The difference in injury definition may explain the discrepancy in results. The knee accounted for four of the most severe injuries sustained during the season, with a total time loss of 1035 days. A study conducted among South African players corroborates the finding (40).

Although the knee was the most commonly injured body part during both training and matches, there was only one injury to the knee among the U16 players during a match. The U16 players reported the hip/groin as the most commonly injured body region, with 80% occurring during training. The relatively low number of absolute injuries in the U16 group could have influenced and possibly biased the results for this group.

Injury type

Joint sprains were the most injuries, followed by muscle strains during matches and training. Together, these injuries accounted for 71% of lost playing time. One study has reported similar findings among South African players (40). However, previous studies among youth and academy players in Portugal (43), New Zealand (44), and England (45) have reported muscle strains as the most common type of injury. The assertion that growth-related injuries are sometimes mistakenly diagnosed as muscle injuries among younger players (46) might explain the difference between studies.

The U14 and U16 players recorded the fewest joint sprains, while the U18 teams recorded the most. Older players involved in more competitive matches and intensive training with longer duration and increased frequency might explain the higher prevalence and incidence of joint sprains in the U18 and senior team players. More than half of all reported injuries were joint sprains and muscle strains, followed by bone contusions, which were mostly caused by acute contact trauma. This could indicate how different Ghanaian football is from football played elsewhere, with Ghanaian football involving a potentially heightened physicality between players. Therefore, to provide safer football practice, referees must be thoroughly trained to discern foul play and appropriately issue yellow and/or red cards (47). In addition, physiotherapists and fitness professionals should be urged to employ interventions primarily aimed at preventing the number and severity of joint sprains, such as proprioceptive and neuromuscular control exercises (48).

Severity

Most of the injuries reported in this study were classified as 'moderate' (8–28 days lost), followed by 'mild' (4–7 days lost), which are in contrast to similar international studies which reported minimal (1–3 days lost) severity (18, 49-51). A study conducted among Uruguayan, Brazilian and Spanish academy players reported a higher percentage of severe injuries among U14 and U16 players (41), whilst our study found that U18 players suffered the greatest injury severity. This difference may be explained by the comparatively high incidence of severe injuries, such as joint sprains, muscle strains and bone contusions, in the U18 players in our cohort.

Players around 14 and 16 years have been observed to miss more days per injury than players in other age groups since their biological maturation frequently coincides with increases in training load at these ages (52). This was not the case in our study, as U18 players reported the most severe injuries, possibly due to the greater number of players in that age group than in the others. Many studies have established that most severe injuries usually occur during matches (50), as our study shows. However, a different pattern was observed among the U18 and U16 players, where training injuries were more severe than match injuries. The high volume of training loads among the groups, especially the U18 players, as they get ready to be promoted to the senior squad, may contribute to the disparity in findings.

New vs recurrent Injury

As expected, the new injury incidence was higher than the recurrent injury rate (4.0 vs 0.5 injuries/1000 h). Most epidemiological studies on football corroborate this finding, though the incident rates may differ between studies (2, 20, 27, 29, 30, 37, 41, 53). Regarding age groups, U18 players recorded the highest number of recurrent injuries split equally during training and matches (n = 10). In contrast, U16 players reported only one injury during training, and U14 players not reporting any recurrent injuries throughout the season. This finding suggests that rehabilitation for injuries should be adequate to prevent a premature return to play, which is one of the main reasons for recurrent injuries (54).

Implications The high frequency of match injuries and their traumatic characteristics suggested that player workload should be managed to limit the frequency of injuries, especially among the U18 players. The authors encourage other Ghanaian football academies to create their objective and affordable injury database using the techniques described in this study. By modifying training and recovery programmes, coaching staff and physiotherapists would be better equipped to respond to changes in injury patterns during a competitive season.

Limitations

The study was conducted in one football academy in Ghana, which might limit its generalisability. One of the limitations of the data collection was that the precise date for some of the players' final return to play could not be determined; instead, an estimate was given based on the clinical judgement of the physiotherapists regarding the general return to play period for each diagnosis. More prospective studies should be conducted in other football academies in different regions to allow for comparisons and a broader picture.

CONCLUSION

The study showed that the injury incidence rate among academy football players is similar to that reported among most European studies, with U14 and U18 players recording the highest injury incidence. A relatively moderate weekly injury prevalence was reported over the season. The knee was the most commonly injured body part. Joint sprains were the most common type of injury, mostly due to direct contact with other players, with most injuries classified as moderate severity. Future research should focus on the epidemiology of specific football injuries among academy players in different regions of Ghana.

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Author contribution

SK was responsible for the study concept, study design, constructing database, extracting and cleaning data, protocol development and protocol writing. SK was in charge of data collection and interpretation and wrote the first draft of the manuscript. AM conducted the data analysis and provided statistical guidance. KM and DG oversaw all the phases of the study, critically read the drafts of the manuscript, and All authors read and approved the final manuscript.

Competing interests

The authors declare no competing interests.

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Data sharing

No additional data is available.

Ethical approval

Ethics approval was granted by the Ethics Committee of the Faculty of Health Sciences at the University of Pretoria (Reference no. 268/2021).

Equity, diversity, and inclusion statement

Our study was on youth and adult male academy football players in Ghana. The research team included one woman and three men (the first author is a final year master's student and three senior authors, of which one is a woman and two are men) from the physiotherapy and statistics disciplines. Three authors are from and/or based in low-and middle-income countries (Ghana and South Africa), and one is in a high-income country (United Kingdom). We acknowledge that our study used only players in a single football academy, with most of the players being young.

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CHAPTER 4

ORIGINAL RESEARCH: PAPER 2

(Published in scientific reports) (Appendix 10)

Article

Risk factors associated with football injury among male players from a specific academy in Ghana: a pilot study

Samuel Koranteng Kwakye ✉
Email : kwamed88@gmail.com
Affiliationids : Aff1, Correspondingaffiliationid : Aff1

Karien Mostert Affiliationids : Aff1

Daniel Garnett Affiliationids : Aff2

Andries Masenge Affiliationids : Aff3

Aff1 Department of Physiotherapy, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa

Aff2 Department of Sport, Health Sciences and Social Work, Faculty of Health and Life Sciences, Oxford Brookes University, Oxford, England

Aff3 Department of Statistics, University of Pretoria, Pretoria, South Africa

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Abstract

There seems to be no information on the incidence of injury and associated risk factors for academy football players in Ghana. We determine the risk factors associated with match and training injuries among male football players at an academy in Ghana. Preseason measurements of players' height, weight, and ankle dorsiflexion (DF) range of motion (ROM) were measured with a stadiometer (Seca 213), a digital weighing scale (Omron HN-289), and tape measure, respectively. The functional ankle instability (FAI) of players was measured using the Cumberland Ankle Instability Tool (CAIT), and dynamic postural control was measured with the Star Excursion Balance Test. Injury surveillance data for all injuries were collected by resident physiotherapists throughout one season. Selected factors associated with injury incidence were tested using Spearman's rank correlation at a 5% significance level. Age was negatively associated with overall injury incidence ($r = -0.589$, $p = 0.000$), match ($r = -0.294$, $p = 0.008$), and training incidence ($r = -0.314$, $p = 0.005$). Previous injury of U18s was associated with training injuries ($r = 0.436$, $p = 0.023$). Body mass index (BMI) was negativelyassociated with overall injury incidence ($r = -0.513$, $p = 0.000$), and training incidence ($r = -0.395$, $p = 0.000$). CAIT scores were associated with overall injury incidence ($n = 0.263$, $p = 0.019$) and match incidence ($r = 0.263$, $p = 0.029$). The goalkeeper position was associated with match incidence ($r = 0.241$, $p = 0.031$) while the U16 attacker position was associated with training incidence. Exposure hours was negatively associated with overall injury incidence ($r = -0.599$, $p = 0.000$). Age, BMI, previous injury, goalkeeper and attacker positions, ankle DF ROM, and self-reported FAI were associated with injury incidence among academy football players in Ghana.

Introduction

Football injuries and risk factors have been reported among professional, elite adult, and youth players[1,2]. AQ1 Relatively few studies have focused on elite players between 16 and 32 years in Africa[3,4]. Currently, emphasis is placed on reducing injury prevalence and incidence, improving performance, and extending athletes' active lifespan[5,6]. Recent research has shown that preventing sports injuries can improve the long-term health and wellness of players[7,8]. Reduced ankle dorsiflexion (DF) range of motion (ROM) may increase the risk of certain lower extremity injuries by modifying the stiffness of the leg and landing forces after a jump[9]. Reduced ankle DF ROM has been shown to be associated with ankle injuries, hamstring injuries, Achilles tendon injuries, patellar tendon injuries, and anterior cruciate ligament (ACL) tears[10,11,12,13,14,15]. Intrinsic factors, such as age and previous injuries, have also been shown to be associated with hamstring injuries[4]. Proprioception has been associated with ankle injuries[16], and limb dominance has been associated with ACL injuries[17]. Dynamic postural control has been associated with lower extremity injuries[18]. Extrinsic factors that have been shown to be associated with lower extremity football injuries in some studies include exposure time, player position, and being a member of a national team[19,20].

Risk factor analysis in any sport is important for preventing injuries per the van Mechelen model[21]. Understanding the trends of injury and associated risk factors, regardless of the level of involvement, may help stakeholders establish effective measures to mitigate injuries[22]. Prospective studies identifying risk factors associated with football injuries among male academy football players are scarce worldwide, including Africa. Only a few retrospective studies have been conducted on Ghanaian football injury and its risk factors, and the validity of these studies may be influenced by possible misclassification or recall bias. Specific injury prevention programs are developed per injury rates, injury types, and anatomical sites among other injury characteristics and environmental factors[23]. These factors appear to differ according to the contexts of players[1,2]. In the Ghanaian region, little is known about the context of academy football players, thus more information is needed to plan and implement successful injury prevention programs. Moreover, translating injury prevention concepts into actual practice involves having a thorough understanding of the individual, social, environmental, and sporting delivery aspects[23]. To the best of our knowledge, this is the first prospective study assessing the incidence of football injuries and associated risk factors among Ghanaian academy footballers. Additionally, the academy players who participated in the study trained and competed primarily on artificial turf, which is uncommon in Africa, particularly Ghana. With the increasing number of budding football academies and the installation of artificial turfs in Ghana, it is imperative to assess the risk factors associated with football injuries among different age groups of footballers over a season to implement optimum training strategies. The aim of the study, therefore, was to determine the risk factors associated with football injuries among youth and adult football players at an academy in Ghana.

Methods

Study design and participants

An observational prospective cohort study was conducted among 80 male players at a football academy in Ghana. In addition to the informed consent provided by each participant, players under the age of 18 also gave their assent and their parents' consent. Participants included male youth and adult football players who were enrolled into the football academy. All players who were scheduled to be transferred to other teams, or players whose contracts were set to expire in the month following data collection were excluded from the study. Players were grouped into four teams according to their age, which included U14 (< 14 years), U16 (< 16 years), U18 (< 18 years), and a senior team (≥ 18 years). The football academy situated in the Volta region of Ghana comprises three standard artificial turfs, a physiotherapy unit, one gymnasium, and accommodation for all players and some staff. The academy enrolled only male football players, who stay in the football camp for approximately ten months each year and are given a special diet three times a day, monitored sleep by supervisors, attend a government school, and have access to physiotherapists every day. In a week, training involved five to seven training sessions for all age groups with each session spanning between 90 and 120 min. The senior team, in addition, have one strength, agility and quickness (SAQ) session (30 min); one power training session (30 min); and one injury prevention session (45 min) per week. The U18 players have one SAQ session (30 min) and one injury prevention session (45 min) per week. The U14 and U16 players do not have specific training sessions.

Data collection

Before the start of the season, two resident physiotherapists who worked at the academy administered a questionnaire to collect demographic and injury information, including current injury status, previous injury (defined as any injury sustained by a player and was diagnosed by the resident physiotherapists and recorded in their notes in the last 12 months), age, player position, dominant leg, and being a member of a national team. Selected risk factors that were investigated included previous injury, age, dominant leg, ankle dorsiflexion (DF) range of motion (ROM), functional ankle instability (FAI), dynamic postural control, body mass index (BMI), player position, being a member of a national team, match and training exposure hours.

Preseason measurements of height, weight, and ankle dorsiflexion ROM were measured and recorded on a standardised injury surveillance (SIS) form by the primary researcher and two trained physiotherapists using a stadiometer (Seca 213), a digital weighing scale (Omron HN-289), and a tape measure, respectively. FAI was assessed using the Cumberland ankle instability tool (CAIT). The CAIT is a valid and reliable questionnaire for measuring subjective FAI with an outstanding test–retest efficiency of 0.96 intra-class correlation coefficient (ICC)[24]. The questionnaire took approximately 7 min to complete. For the CAIT, the cut off for self-reported FAI was 27.5, with FAI ≤ 27.5 indicating ankle instability[24]. The Star Excursion Balance Test (SEBT) was used to assess dynamic postural control. The SEBT has demonstrated excellent reliability (ICC = 0.89–0.94) for the measurement of dynamic postural control[25]. The composite score of the SEBT was calculated as the sum of the maximum score for reach distances divided by three times the limb length and multiplied by 100[28]. The procedure of SEBT was completed as described by Ness et al.[25]. All procedures were performed in accordance with relevant guidelines and regulations.

The injury surveillance period began after the preseason measurements had been completed in August 2021 and the season started in September 2021. The season lasted for 39 weeks, from September 2021 to June 2022. The physiotherapists were trained on how to record injuries on the injury surveillance form according to the International Olympic Committee (IOC) guidelines[26] over the season. The physiotherapists were always present at training and matches, and they identified injuries as and when they occurred or when they were reported by players on the SIS form. Injury data collection included multiple categories of information but for the purpose of this study, only the occurrence of a 'medical attention' injury (an injury that results in the player seeking medical attention from the physiotherapist or causing the player to be absent from the next match or training) was included in the analysis. Weekly records (in min) of each player's exposure during training and matches were recorded on an exposure form by the assistant coaches after every match or training session on the field.

Confounding variables were minimized because all players, with the exception of the senior team, played all their games on artificial turf. Additionally, training styles were the same for each age group as coaches and technical personnel remained unchanged throughout the season. In addition, the environment or climate for each player was comparable because all training and matches were held at the academy in Ghana's Volta Region, with the exception of the senior team, which participated in a few matches in other parts of the country.

Data analysis

The SPSS IBM Statistics version 28 software was used to perform the analysis. Injury incidence was calculated per 1000 exposure hours. The data analysis consisted of descriptive statistics (means, median, and standard deviations) for continuous variables (BMI, ankle DF ROM, SEBT scores, CAIT scores and exposure hours) and frequency tables (counts and percentages) for categorical variables (age, limb dominance, previous injury, player position, national team membership) to describe the characteristics of the population. The non-parametric Spearman's rank correlation was performed to determine if the selected factors were associated with injury incidence. The Spearman rank correlation was appropriate because the following extrinsic factors (player position, national team member) and intrinsic factors (previous injury, limb dominance) were dichotomised to have a value of 0 or 1, while the dummy variables were created for the factor position of the player, and some of the continuous data were not normally distributed. AQ2 The Spearman rank correlation coefficients range between − 1 and 1, with values close to − 1 indicating a negative perfect relationship and values close to 1 indicating a positive perfect relationship. Results were interpreted at a significance level of 5% ($p < 0.05$).

Ethical approval and consent

Ethics approval was granted by the Ethics Committee of the Faculty of Health Sciences at the University of Pretoria (Reference no. 268/2021). All procedures were performed in accordance with relevant guidelines and regulations. AQ3 Adult players gave informed consent while players below 18 years gave assent and parents' consent before participating in the study. Informed consent was obtained from all participants and/or their legal guardian(s).

Results

Demographic and player-specific factors

The population of players at the academy for the 2021/2022 season was 105. All players were invited to participate, but only 80 (76%) players participated in the study based on inclusion criteria, willingness to participate, and obtaining of consent. Out of the 105 players who were present at the academy during the time of data collection period, a total of 25 players were excluded from the study. Notably, this included 15 trial players, five players who were in the process of being transferred to another team, three young players who could not obtain parental consent, and two players whose contracts were scheduled to end within the following month. Table 1 shows th demographic and player-specific variables for the total population and the different age groups.

Table 1

Description of population by demographic and player-specific variables [n = 80].

Variable	Total population [n = 80]	U14 [n = 7]	U16 [n = 17]	U18 [n = 29]	Senior Team [n = 27]
Age [mean, SD]	17, ± 3.10	13, ± 0.38	15, ± 0.51	17, ± 0.51	21, ± 2.65
BMI [mean, SD]	20.14, ± 2.19	17.6, ± 2.0	18.47, ± 1.21	20.28, ± 1.87	21.69, ± 1.71
Previous injury					
Yes [n, %]	63, 78.8	5, 71.4	12, 70.6	25, 86.2	21, 77.8
No [n, %]	17, 21.3	2, 28.6	5, 29.4	4, 13.8	6, 22.2
Limb dominance					
Left [n, %]	13, 16.3	1, 14.2	0.0	6, 20.7	6, 22.2
Right [n, %]	67, 83.8	6, 85.7	17, 100	23, 79.3	77.8

Variable	Total population [n = 80]	U14 [n = 7]	U16 [n = 17]	U18 [n = 29]	Senior Team [n = 27]
Member of a national team					
Yes [n, %]	9, 11.3	0, 0.0	0.0	3, 10.3	6, 22.2
No [n, %]	71, 88.8	7, 100	17, 100	26, 89.7	21, 77.8
Player position					
Goalkeeper [n, %]	9, 11.3	0, 0.0	3, 17.7	3, 10.3	3, 11.1
Defender [n, %]	29, 36.6	2, 28.6	7, 41.2	11, 37.9	9, 33
Midfielder [n, %]	19, 23.8	3, 42.9	3, 17.7	5, 17.2	8, 29.6
Attacker [n, %]	23, 28.8	2, 28.6	4, 23.5	10, 34.5	7, 25.9

Injury incidence

There were 126 injuries in total, most of which were acute (n = 97, 77%), while only 29 (23%) were overuse injuries. About 65 (51.6%) injuries involved contact, while 61 (48.4%) injuries were non-contact injuries. The most frequently injured body site was the knee (n = 30, 23.8%), and the most frequent injury type was joint sprain (n = 54, 42.9%). The overall injury incidence rate was 4.5 injuries per 1 000 exposure hours. Table 2 shows the injury incidence rates per age group.

Table 2

Injury incidence rate among male football players at a Ghanaian football academy.

	Overall incidence			Match incidence			Training incidence		
Age category	n	%	IR	n	%	IR	n	%	IR
Under 14	12	9.5	5.8	8	12.1	42.8	4	6.7	2.1
Under 16	28	22.2	5.1	13	19.7	25.5	15	25.0	3.0
Under 18	58	46.0	5.7	31	47.0	32.1	27	45.0	2.9
Senior team	28	22.2	2.7	14	21.2	18.8	14	23.3	1.5
Total population	126	100	4.5	66	100	27.4	60	100	2.3

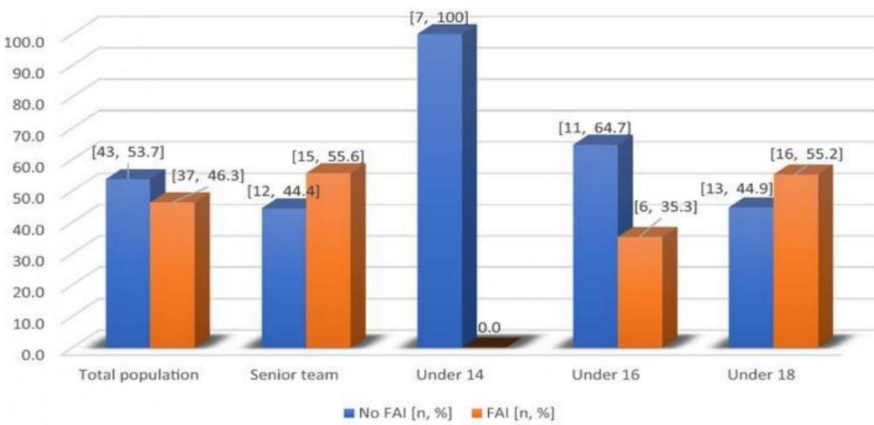
IR = injury incidence rate, n = number of injuries.

Functional ankle instability (FAI) and dynamic postural control

Based on the CAIT questionnaire responses, 46.25% of the players (n = 37) reported having FAI. Figure 1 shows the self-reported presence and absence of FAI among players.

Figure 1

Self-reported functional ankle instability (FAI) among all players and per age categories per the Cumberland ankle instability test (CAIT).



FAI=Functional Ankle Instability

The mean composite score for the mean reach distances for the population according to the SEBT was 90.8 ± 6.7 (left limb) and 91.7 ± 6.8 (right limb). Table 3 shows the mean result for the SEBT composite s cores for the total population and age categories.

Table 3

Results of the SEBT for the total population and age categories.

	SEBT	Mean	SD	95% CI
	Lower limb	Composite scores		
Total population [n = 80]	Left	90.8	± 6.7	89.3–92.3
	Right	91.7	± 6.8	90.2–93.2
U 14 [n = 7]	Left	98.6	± 6.6	92.5–104.8
	Right	97.7	± 6.6	91.6–103.7
U 16 [n = 16]	Left	91.1	± 5.9	88.0–94.11
	Right	92.8	± 6.1	89.7–96.0
U18 [n = 29]	Left	89.1	± 5.8	86.9–91.3
	Right	89.6	± 5.7	87.5–91.8
Senior team [n = 27]	Left	90.4	± 6.8	87.8–93.2
	Right	91.7	± 7.6	88.8–94.7

CI = Confidence Interval, n = Number of participants, SD = Standard Deviation, SEBT = Star Excursion Balance Test.

Ankle dorsiflexion (DF) range of motion (ROM)

The average ankle DF ROM for the left ankle joint was 10.35 ± 2.9 cm and right ankle joint was 10.48 ± 3.0 cm. Table 4 shows the ankle DF ROM for the total population, as well as, per age group.

Table 4

The ankle dorsiflexion (DF) range of motion (ROM) of football players at a football academy in Ghana for the total population and per age group.

	Ankle DF ROM	Mean	SD	95% CI
Total population (n = 80)	Left	10.4	2.9	9.7–11.0
	Right	10.5	3.0	9.8–11.1
Under 14 (n = 7)	Left	10.6	3.6	7.2–13.9
	Right	10.4	3.0	7.7–13.2
Under 16 (n = 17)	Left	10.3	3.6	8.4–12.2
	Right	10.8	3.5	9.0–12.6
Under 18 (n = 29)	Left	10.8	2.7	9.7–11.8
	Right	10.8	2.8	9.8–11.9
Senior team (n = 27)	Left	9.9	2.6	8.9–10.9
	Right	9.9	3.0	8.7–11.1

CI, confidence interval; DF, dorsiflexion; n = number of participants; ROM, range of motion; SD, standard deviation.

Association between intrinsic factors and injury

The associations between the selected intrinsic factors and injury incidence were calculated using Spearman's rank correlation and represented in Table 3. Age was negatively associated with both match (r = − 0.294, p = 0.008) and training injury incidence (r = − 0.314, p = 0.005), while BMI was associated with overall (r = − 0.513, p = 0.000) and training incidence (r = − 0.395, p = 0.000), and CAIT score was associated with match injury (r = − 0.244, p = 0.029). See Table 5 for details.

Table 5

Association between intrinsic factors and injury incidence among football players at a football academy in Ghana (n = 80).

	Overall injury incidence rate					Match injury incidence rate					Training injury incidence rate				
Variables	Total sample (n = 80)	U 14 (n = 7)	U 16 (n = 17)	U 18 (n = 29)	Senior team (n = 27)	Total Sample (n = 80)	U 14 (n = 7)	U 16 (n = 17)	U 18 (n = 29)	Senior team (n = 27)	Total Sample (n = 80)	U 14 (n = 7)	U 16 (n = 17)	U 18 (n = 29)	Senior team (n = 27)
Age	**− 0.589****					**− 0.294****					**− 0.314****				
BMI	**− 0.513****	0.292	− 0.295	**− 0.428***	0.144	− 0.215	0.658	0.074	− 0.287	0.095	**− 0.395****	− 0.655	− 0.42	− 0.279	0.057

BMI body mass index, *CAIT* Cumberland ankle instability, *DF* dorsiflexion, *IR* injury incidence rate, *ROM* range of motion.

***$p \leq 0.001$, **$p \leq 0.01$, *$p \leq 0.05$.

Significant values are in bold.

Variables	Overall injury incidence rate					Match injury incidence rate					Training injury incidence rate				
	Total sample (n = 80)	U 14 (n = 7)	U 16 (n = 17)	U 18 (n = 29)	Senior team (n = 27)	Total Sample (n = 80)	U 14 (n = 7)	U 16 (n = 17)	U 18 (n = 29)	Senior team (n = 27)	Total Sample (n = 80)	U 14 (n = 7)	U 16 (n = 17)	U 18 (n = 29)	Senior team (n = 27)
Previous injury (yes)	0.133	0.171	0.338	**0.453***	−0.306	0.072	0.502	−0.028	0.22	0.02	0.127	−0.548	0.453	**0.458***	−0.259
Limb dominance (right)	−0.001	−0.22		−0.141	−0.021	−0.156	0.108		−0.188	−0.337	0.08	−0.354		0.097	0.227
Ankle DF ROM (left)	−0.073	−0.28	−0.374	−0.148	0.303	−0.219	−0.49	−0.211	−0.096	−0.178	0.122	0.599	−0.16	−0.164	**0.436***
Ankle DF ROM (right)	−0.033	0.059	−0.358	−0.163	0.258	−0.181	0.048	−0.445	−0.156	−0.062	0.099	0.147	−0.049	−0.116	0.289
Left composite score (SEBT)	0.126	0.154	−0.036	−0.036	−0.066	0.024	−0.038	−0.05	−0.05	−0.071	0.039	0.433	−0.168	−0.168	0.047
Right composite score (SEBT)	0.118	−0.27	0.121	0.121	−0.103	−0.016	−0.378	0.034	0.034	−0.171	0.045	0.433	−0.032	−0.032	0.026
CAIT score	**0.263***	0.241	0.123	0.123	0.071	**0.244***	0.189	0.039	0.039	0.139	0.051	0	0.028	0.028	−0.076

BMI body mass index, *CAIT* Cumberland ankle instability, *DF* dorsiflexion, *IR* injury incidence rate, *ROM* range of motion.

***$p \leq 0.001$, **$p \leq 0.01$, *$p \leq 0.05$.

Significant values are in bold.

Association between extrinsic factors and injury

The association between the selected extrinsic factors and injury incidence were calculated using the Spearman's rank correlation, represented in Table 6.

Table 6

Association between extrinsic factors and injury incidence among football players at a football academy in Ghana (n = 80).

Variables	Overall injury incidence				Match injury incidence					Training injury incidence				
	Total sample (n = 80)	U 14 (n = 7)	U 16 (n = 17)	U 18 (n = 29)	Total sample (n = 80)	U 14 (n = 7)	U 16 (n = 17)	U 18 (n = 29)	Senior team (n = 27)	Total sample (n = 80)	U 14 (n = 7)	U 16 (n = 17)	U 18 (n = 29)	Senior team (n = 27)
Player position														
Goalkeeper	−0.171		0.371	0.159	**0.241***		0.272	−0.363	−0.131	−0.01		−0.237	0.173	0.12
Defender	−0.021	−0.171	−0.038	−0.231	0.085	−0.502	0.263	−0.054	0.367	−0.122	0.548	−0.21	−0.312	−0.12
Midfielder	−0.058	0	−0.113	0.056	−0.044	0.229	0.136	0.052	−0.349	−0.084	−0.417	−0.237	0.087	0.024
Attacker	0.196	0.171	0.479	0.293	0.119	0.251	−0.183	0.247	0.063	0.215	−0.091	**.669****	0.138	0.018
Member of a national team														
Yes				−0.166				0.007	0.337				−0.23	−0.143
No	0.193			0.166	−0.03			−0.007	−0.337	0.204			0.23	0.143
Exposure hours														
Total exposure	**0.599****				**0.302****					**−0.302****				
Match Exposure	−0.192				−0.176					−0.037				
Training Exposure	**0.599****				**0.302****					**−0.302****				

BMI, body mass index; CAIT, Cumberland Ankle Instability; DF, dorsiflexion; IR, injury incidence rate; ROM, range of motion;

***$p \leq 0.001$, **$p \leq 0.01$, *$p \leq 0.0$.

Significant values are in bold.

Discussion

This may be the first prospective study to report on the risk factors associated with football injuries among elite youth and adult academy players in Ghana. The aim of the study was to determine risk factors such as age, BMI, limb dominance, previous injury, ankle DF ROM, SEBT scores, self-reported FAI, national team membership, player position and exposure hours associated with match and training injuries among Ghanaian male academy football players. The study found that age, BMI, and exposure hours were negatively associated with overall, match, and training injury incidence.

Controversy exists whether age is indeed an injury risk factor in football. While some studies have suggested that increased age is associated with injury among youth and adult players[27, 28], other studies have reported no evidence of such an association[29, 30]. We observed a negative association between age and overall injury incidence, as well as, match and training injury incidence. In our study, younger players may tend to have a high injury incidence compared to older players, which corroborates a few other studies[31, 32]. Younger players experience stronger forces and strain as their muscular systems expand in both length and size to compensate for their skeletal system's faster growth at younger ages[33]. During this stage of maturation, high amounts of repetitive loading from training and matches are more likely to increase injury incidence[33]. Further studies should compare the relationship between biological and maturation age with injury prevalence and incidence.

Hägglund et al.[34] found that neither height, weight, nor BMI was significantly associated with injury incidence among players with a mean age of 25 ± 5 years. Though preliminary, our findings are interesting as they contradict previous studies that found that higher BMI was associated with an increased incidence of injuries[30, 35]. The reason for our finding is uncertain. However, a recent study among English Premier League professional footballers revealed that players with decreased BMI may be prone to greater injury burden[36] which corroborates our finding. Our findings suggest that football academies should be aware that smaller or lighter players are at a higher risk of injury and that additional attention should be placed on screening and training loads, as well as injury prevention techniques.

Our findings revealed that U18 players with a previous injury in the last 12 months were at risk of sustaining an injury in training. Most risk factor studies[30, 37, 38, 39] corroborate our findings. Previous injury has also been reported as a risk factor among U12 and U18 players who experienced a previous injury presenting a double-fold risk of a second occurrence[40]. About 79% of the players in our study had sustained an injury in the past 12 months prior to the study, most of which were U18s, who also sustained 71.4% of recurrent injuries recorded. As a result of a first injury, there may be physiologic or skeletal alterations in the joints or muscles that make players more prone to re-injury[41]. This discovery emphasises the necessity of thorough injury history reporting during the initial screening of players and follow-up observation of changes in movement patterns following an injury. Additionally, to facilitate adequate neuromuscular control, proper rehabilitation and training treatments of players are needed.

Evidence suggests that it is important to keep track of the history of football-related injuries to identify at-risk players in male football population[37, 38, 39]. Injury prevention strategies might then be targeted to these players[37, 38, 39]. However, since a risk factor may not be the same as a predictive factor[42], injury prevention programs such as neuromuscular training[43] and proprioceptive training[44] have been shown to benefit football players and should be made available to all players and not only players at risk. For instance, joint sprain was the most common injury in our study. To reduce the number of joint sprain injuries, there should be an initiative to incorporate strengthening exercises of muscles around the joint[45] for all academy players (especially the knee and ankle).

Generally, the association between limb dominance and injury risk or injury rates is well known[27, 28, 46]. However, the literature is not clear as to the significance of limb dominance being a risk factor for suffering injuries, specifically ankle sprains or instability. Our findings suggest that limb dominance was not associated with injury incidence among Ghanaian players which is supported by one study[30]. The fact that many players place more stress on their dominant limb, especially during high-demand activities, results in increased frequency and magnitude of moments about the ankle, which is one of the main reasons why limb dominance has been implicated as a risk factor for lower extremity injuries[47, 48]. A previous study indicated that football players aged 14 to 18 who were left-leg dominant tended to be at a higher risk of injury than those who were right-leg dominant[32]. The reasons for these discoveries are still speculative.

About 40% of football players exhibit functional ankle instability after lateral ankle sprains[49, 50]. We found that approximately 46% of players presented with FAI per CAIT measurements. Hertel[50] proposed that multiple sensory deficiencies brought on by ankle sprains can result in instability, which raises the possibility of subsequent sprains. Numerous studies have looked into this notion; however, the results are mixed[51, 52]. In a study of Portuguese athletes, a significant portion of the participants displayed indicators of self-perceived instability in their dominant limbs with regard to injury rates[28]. In our study, there was a significant association between self-perceived FAI (measured by the CAIT) and overall injury incidence, as well as, match injury incidence but not with training injury incidence. Despite the paucity of studies on FAI, particularly in Africa, it is vital to appreciate the CAIT as an important marker of potential injury and should be used regularly as a screening tool during the season.

In our study, about 42.5% of players were at risk of injury per dynamic postural control on the SEBT. However, players' dynamic postural control on the SEBT was not significantly associated with injury incidence in our study which is corroborated by one study conducted among female football players with an average age of 21 ± 4.0 years[53]. A previous study among college American football players showed an association between dynamic postural control and injury risks[54]. The difference in findings may be attributed to the type of sport as well as, the age differences of the study samples.

In most sports that involve movements in multiple directions, ankle DF ROM has a significant impact on change of direction and landing[55, 56]. When the ankle DF ROM is limited, the stiffness of the lower limb and forces of landing after a jump are usually altered which has the tendency to raise the risk of injury[55, 56]. We found a significant association between left ankle DF ROM and the incidence of injuries during training for players older than 17 years (senior team). Though our findings are preliminary, Bradley and Porta's[57] study supports our finding, where a relatively weak association was found between ankle DF ROM and ankle injury rates. However, Arnason et al.[58] reported no association between ankle DF ROM and injury incidence as was observed among younger players in our study. The lack of significant association observed in our study might be due to the relatively small sample size. A larger sample size might have revealed significant correlations; our findings regarding ankle DF ROM are thus preliminary.

In our study, being a goalkeeper was weakly but significantly associated with the incidence of injury during matches, while being in the U16 attacker position was strongly associated with the incidence of injury. A possible explanation for this finding is that goalkeepers appear to be under higher expectations during matches, especially when their injuries can occasionally affect individual and team performance[59]. Young attackers may not be skilled enough and may lack the technique to protect themselves during training or matches, hence their higher injury rate. Contrary to these findings, some studies have reported that playing position is not associated with injury rates[60, 61]. Investigations on playing position and injury rate have been constrained by a dearth of individual exposure documentation, and many of the available studies used small samples or only included match injuries; hence, there may be a possible discrepancy in findings[60, 61, 62]. However, even with the finest study design, it may be challenging to provide a straightforward and unambiguous message concerning playing position and injury risk due to the variety of playing styles and same players playing different positions in modern football[63]. The current study did not examine the relationship between playing position and specific injuries. Future research should concentrate on risk factor associations with specific injuries to give a more complete picture.

Interestingly, we found a negative association between exposure hours and injury incidence which means that players with less exposure hours reported higher injury rates. This could be explained by the fact that being under-loaded during games may act as a mediator for injury[64]. Moreno and colleagues[64] found that players sustaining most muscle injuries typically displayed substantially less accumulated match playing exposure in a season, which corroborates our findings. Contrastingly, most studies have argued that the cumulative effect of repeated and prolonged exposure to football at the end of the season may increase the prevalence or incidence of injury[65, 66]. Though a relationship between exposure hours and injury incidence has been widely reported, recorded injury incidences are different for every country[1, 29]. For example, players from northern Europe have substantially greater total injury rates than those from southern Europe[67] possibly due to the aggressive style of play among the Southern European football players. Although our findings showed a negative correlation between injury incidence and exposure hours, we observed a high total exposure for U18s (10 138 h) which is the stage for promotion to the senior team to start a professional career. This result can provide insight into the coaching staff's efforts to get players physically ready for the demands of professional football.

Being a member of a national team was not associated with injury incidence in our study. Only nine of the 80 players in our study were members of the national team. The small number of players who participated for their national teams may explain this finding. A retrospective study in adult female football players[68], found a significant association between players who were members of their national team and increased injury rates. The studies attributed their finding to possible higher exposure to football when part of a national team as well as the level of competitiveness and the desire to stay in the national team.

Although our study is the first of its kind in Ghana, the small sample size is a potential weakness and thus limits the generalisability of the findings. Another problem with sample size was also evident when finding the associations of selected factors and injury rates for the age categories where injury cases were small. As suggested by Bahr and Holme[69], about 20–50 injury cases are required to detect moderate to strong associations in a risk factor study, whereas small to moderate associations would need about 200 injured subjects. Our study recorded 128 injury cases for the combined sample size and 12, 28, 58 28 injury cases for U14, ~~u~~U16, U18 and senior players, respectively. Due to this limitation, we urge using caution when interpreting the results, particularly with regard to their generalizability, as our findings are preliminary. Our research cannot give a complete account of the injury risk among male academy football players since injuries are likely the result of a complex interaction of several factors, all of which were not investigated in this study. The current study could not investigate the influence of match and training loads, the playing surface, and weather conditions, which we acknowledge may have influenced the injuries sustained. One strength of the study was that it relied on prospectively recorded data avoiding the risk of recall bias. Another strength was recording individual player exposure hours during training and matches, which allowed for risk factor analysis.

Conclusion

The study identified possible risk factors associated with injury among both young and adult academy players. Specifically, the study found an association between overall, match or training injury incidence and age, BMI, previous injury, goalkeeper and attacker position, ankle DF ROM, and self-perceived FAI. These results offer preliminary evidence for further research encompassing other risk factors and multivariate analyses, as well as for the creation of practical and pertinent preventive measures tailored specifically for the population of football academies. Further studies should focus on examining risk factors for specific anatomical locations, especially the ankle and the knee as well as specific injury types among players using a larger sample size.

Publisher's note

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Author contributions

S.K.K. was responsible for the study concept, study design, constructing database, extracting and cleaning data, protocol development and protocol writing. S.K.K. was in charge of data collection, and interpretation and wrote the first draft of the manuscript. A.M. conducted the data analysis and provided statistical guidance. K.M. and D.G. oversaw all the phases of the study, critically read the drafts of the manuscript. All authors read and approved the final manuscript.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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GENERAL DISCUSSION AND CONCLUSIONS

The aim of this study was to determine the epidemiology, characteristics of football injury and associated factors among U14 (n=7), U16 (n=17), U18 (n=29) and senior players (n=29) at an academy in Ghana.

4.1 PRIMARY FINDINGS

The primary findings with regards to epidemiology and clinical characteristics are summarised in the next sections.

Objective I

1) A weekly injury prevalence of 4.1% was calculated for the season.

Objective II

1) Overall, 126 injuries were recorded, with 66% during matches and 60% in training. The U18s recorded the most injuries (n=58, 46.0%).
2) The overall injury incidence was 4.5 injuries per 1 000 player hours, with 27.4 injuries per 1 000 hours for matches and 2.3 injuries per 1 000 player hours for training. The U14, U16 and U18 players had relatively higher overall injury incidence of 5.8, 5.1 and 5.7 injuries per 1 000 exposure hours, respectively.

Objective III

1) Newly sustained injuries accounted for the majority of all injuries (n= 112, 88.9%) with most occurring during matches than during training (n= 59, 46.8% vs n= 53, 42.1%). Recurrent injuries were low (n=14,11.1%).

2) The lower limb was the most common injured body region (86.5%, IR= 3.9 injuries per 1 000 hours), with the knee sustaining most injuries (23.8%), followed by the ankle (13.5%) and the hip/groin areas (13.5%).

3) The most commonly affected tissue type for all injuries was joint sprain (n=54, 42.9%, IR= 1.9 injuries per 1 000 hours) followed by muscle strains (n=33, 26.2%, IR= 1.2 injuries per 1 000 hours). Muscle strain injuries were more common during training sessions (n=18, 30%) than during matches (n= 15, 22.7%).

4) Moderate injuries (8 to 28 days) accounted for almost half (n=56, 44.4%) of all injuries, followed by mild injuries (4 to 7 days) (n= 26, 20.6%).

5) For most injuries, the mode of onset was sudden after acute trauma (n=57, 45.2%). Injury mechanisms for the majority of the injuries were direct contact with another player (n=42, 33.3%) followed by acute non-contact trauma (n= 32, 25.4%).

Objective IV

The following risk factors associated with injury incidences were identified:

1) Age with overall injury incidence (r= -0.589, p= 0.000), match incidence (r= -0.294, p= 0.008) and training incidence (r= -0.314, p= 0.005).

2) Previous injury of U18s with overall injury incidence (r= 0.453, p= 0.014) and training incidence (r= 0.485, p= 0.012).

3) Body Mass Index with overall injury incidence (r = - 0.513, p-value= 0.000) and training injury incidence (r = - 0.395, p-value= 0.000).

4) Body Mass Index of U18 players with overall injury incidence (r = -00.428, p-value= 0.021).

5) Higher CAIT scores with overall injury incidence (r = 0.263, p-value= 0.019) and match injury incidence (r=0.244, p-value= 0.029).

6) Left ankle DF ROM of senior players with training incidence (r=0.436, p=0.023).

7) Goalkeepers with match injury incidence (r =-0.241, p-value= 0.031).

8) Exposure hours with overall injury incidence (r=-0.599, p= 0.000), match incidence (r= -0.302, p= 0.007) and training incidence (r= -0.302, p=0.006)

4.2 GENERAL DISCUSSION

5.2.1 Injury incidence and prevalence

Studies conducted among amateur and youth players have recorded injury incidence in the range of 5.1 to 10.9 injuries per 1 000 exposure hours with a higher match incidence than training incidence (Stubbe et al., 2015; Bianco, Spedicato, Petrucci, Messina, Thomas, Nese Sahin et al., 2016; Jones, Jones, Greig, Bower, Brown, Hind et al., 2019a; Kurittu, Vasankari, Brinck, Parkkari, Heinonen, Kannus et al., 2021), which is consistent with this current study.

However, the injury incidence reported among South African youth academy players (Calligeris, Burgess and Lambert, 2015; Bester, Dawood and Mostert, 2021). is about eight times that youth academy players in Ghana The substantial variation in the number of players in each study may explain the difference in findings. In addition, Bester et al's (2021) study only included oyouth players, whereas the current study included both youth and adults.

5.2.2 Injury characteristics

Injury characteristics

Mode of onset and injury mechanism

The prevalent mode of onset for most of the injuries sustained by the players in all the age groups was sudden, after acute trauma, while direct contact with another player was the commonest injury mechanism. This finding is corroborated by similar studies among South African players (Bester et al., 2021), Asian (Materne, Chamari, Farooq, Weir, Hölmich, Bahr et al., 2021) and European players (Raya-González, Suárez-Arrones, Navandar, Balsalobre-Fernández and Sáez de Villarreal, 2020; Jaber, Weishorn, Berrsche, Ott and Bangert, 2021; Kurittu et al., 2021). Direct contact with another player accounted for approximately 33% of injuries and was associated with injuries of higher severity. Most of these injuries caused by direct contact with another player occurred more during matches than in training, except for the U16s which reported acute non-contact trauma as the most common injury mechanism during matches and training. This finding could indicate the more intense physical nature of football in Ghana.

Injured body region and injury type

The most commonly injured body region for all players was the knee, which corroborates with findings from several studies (Bayne et al., 2018; Lategan and Conley, 2019). Although other studies conducted in Europe and America (Ekstrand, Hägglund and Waldén, 2009; Hall, Larruskain, Gil, Lekue, Baumert, Rienzi et al., 2020; López-Valenciano, Ruiz-Pérez, Garcia-Gómez, Vera-Garcia, De Ste Croix, Myer et al., 2020) have reported the thigh as the most common injured body part, the knee was reported to either be the second or third most commonly injured body part (Ekstrand et al., 2009; Hall et al., 2020; López-Valenciano et al., 2020).

Joint sprains were by far the most common injuries, followed by muscle strains during both match and training periods. Together, these injuries accounted for 71% of lost playing time. One study has reported similar findings among South African players (Bayne et al., 2018). However, previous studies among youth and academy players in Portugal (Brito et al., 2012), New Zealand (Junge, Cheung, Edwards and Dvorak, 2004) and England (Price, Hawkins, Hulse and Hodson, 2004) have reported muscle strains as the most common type of injury. The assertion that growth-related injuries are sometimes mistakenly diagnosed as muscle injuries among younger players (DiFiori, Benjamin, Brenner, Gregory, Jayanthi, Landry et al., 2014) might be a contributing factor to the slight difference between studies.

Severity of injuries

The majority (46%) of injuries were 'moderate' (8 to 28 days lost), followed by 'mild' (4 to7 days lost), which is relatively different from most studies which reported minimal (i.e. 1 to 3 days lost) severity (Ekstrand, Hagglund and Walden, 2011; Read, Oliver, De Ste Croix, Myer and Lloyd, 2018; Gebert, Gerber, Pühse, Gassmann, Stamm and Lamprecht, 2019; López-Valenciano et al., 2020). The U18 age group had the most severe injuries, which is a slightly different finding from Lopez-Valenciano et al (2020) where the highest injury incidence was reported among U17 players.

New versus recurrent injuries

As expected, the new injuries incidence was higher than recurrent injuries rate (4.0 vs 0.5 injuries per 1 000 exposure hours). The majority of epidemiological studies on football corroborate this finding, although the incident rates may differ between studies (Cezarino, Grüninger and Scattone Silva, 2020; Hall et al., 2020; Krill, Borchers, Hoffman, Krill and Hewett, 2020; López-Valenciano et al., 2020; Raya-González et al., 2020; Materne et al., 2021; Wik, Lolli, Chamari, Materne, Di Salvo, Gregson et al., 2021; Tabben, Eirale, Singh, Al-Kuwari, Ekstrand, Chalabi et al., 2022). The U18s recorded the highest number of recurrent injuries suggesting that rehabilitation for U18s should be adequate in order to prevent premature return to play which is one of the main reasons for recurrent injuries (van der Horst, 2018).

5.2.3 Associated risk factors with injury incidence

Age and BMI

The present study found a negative association between age and overall injury incidence, as well as, match and training injury incidence. Younger players tend to sustain more injuries overall (during matches and training) which is corroborated by similar studies (Emery, Meeuwisse and Hartmann, 2005; Aoki, Kohno, Fujiya, Kato, Yatabe, Morikawa et al., 2010). However, higher injury rates have been associated with increasing age in some studies, citing rising levels of competition and body contact as underlying reasons (Faude, Rößler and Junge, 2013; Rössler, Junge, Chomiak, Němec, Dvorak, Lichtenstein et al., 2018). These studies' findings align with the current study that found that the U18s suffered from more severe injuries compared to U14 and 16 players. High amounts of force output occur from the muscular system having to expand in both length and size as a result of the skeletal systems' faster growth at younger ages causing increased injury rates (Sheehan et al., 2012).

Several studies have reported no significant association between BMI and injury incidence among football players. For instance, Hägglund et al. (2006) found that neither height, weight nor BMI was significantly associated with injury incidence among players. However, we found a negative association between BMI and overall injury incidence. Our findings suggest that football academies should be aware that smaller or lighter players are at a higher risk of injury, and that screening and training loads, as well as injury prevention techniques should be considered.

Previous Injury

Our study revealed that U18 players with previous injury in the last 12 months were at a higher risk of sustaining an injury during training than those without a history of injuries. The majority of risk factor studies corroborates our findings (Beynnon, Renström, Alosa, Baumhauer and Vacek, 2001; Kucera, Marshall, Kirkendall, Marchak and Garrett, 2005; Warsh, Pickett and Janssen, 2010; Bjorneboe, Bahr and Andersen, 2014; Onakunle et al., 2016; Manoel, Xixirry, Soeira, Saad and Riberto, 2020). Previous injury among the U18 age group was associated with overall injury incidence and training incidence. A possible reason for this finding is that about 79% of the players in our study had sustained an injury in the past 12 months prior to the study, most of which were U18s, who also sustained 71.4% of the recurrent injuries in the study. This discovery emphasises the necessity of thorough injury history reporting during the initial screening of players and follow-up observation of changes in movement patterns, following an injury.

Limb dominance

The literature is not clear whether limb dominance is risk factor for suffering more injuries, or specific types of injuries like an ankle sprain or ankle instability. The current study found no association between limb dominance and injury incidence among football players in Ghana which is corroborated by a few other investigations (Smpokos, Mourikis, Theos and Linardakis, 2019; Manoel et al., 2020). However, one main reason why limb dominance has been implicated as a risk factor is that most players place more stress on their dominant limb. Because players use their dominant more frequently, especially during high-demand activities, one would expect increased frequency and magnitude of load onthe ankle. The reasons for these findings are still speculative.

Functional Ankle Instability (FAI)

The present study found no association between FAI as measured by the SEBT and injury incidence. Interestingly, a statistically significant association between self-perceived FAI (CAIT) and injury was found which aligns with a study conducted among Portuguese athletes, where a statistically significant portion of the participants displayed indicators of self-perceived instability in their dominant limbs associated with injury rates (Mandorino, Figueiredo, Gjaka and Tessitore, 2023). Despite the paucity of studies on FAI, particularly in Africa, it is vital to appreciate the CAIT as an important marker of potential injury.

Ankle dorsiflexion range of motion

Our study found a negative association between left ankle DF ROM and training injury incidence for players above 17 years (senior team). Bradley and Porta's (2007) study supports our finding, where a relatively weak association was found between ankle DF ROM and ankle injury rates. No association was found between ankle DF ROM and injury incidence for the U14, U16 and U18 groups. The relatively smaller sample size of this study constitutes a limitation and a larger sample might have found more significant associations.

Player position

While a statistically significant association between goalkeeper position and match injury incidence was found, a strong association between U16 attacker position and overall injury incidence was also observed in this study. A possible explanation for this finding is that goalkeepers appear to be under higher expectations during matches, especially when their injuries can occasionally affect individual and team performance (Muracki, Klich, KawczyńSki and Boudreau, 2021). Contrary to these findings, some studies have reported no association between injury and player position (Aoki, O'Hata, Kohno, Morikawa and Seki, 2012; Ryynänen, Junge, Dvorak, Peterson, Kautiainen, Karlsson et al., 2013). Even with the most rigourousstudy design, it may be challenging to obtain findings due to the variety of playing styles and same players playing different positions in modern football (Della Villa, Mandelbaum and Lemak, 2018).

Exposure hours and national team membership

The current study found a negative association between exposure hours and injury incidence which means that players with less exposure hours reported higher injury rates. A potential reason for this discovery could be that experiencing low levels of physical exertion during games could play a role in the occurrence of injuries (Moreno-Perez, Paredes, Pastor et al., 2021). Moreno and colleagues (2021) found that players sustaining most muscle injuries typically displayed substantially less accumulated match playing exposure in a season, which corroborates this finding. Being a member of a national team was not associated with injury incidence in the study. Only nine out of 80 players were members of a national team in the current study. The small number of players who participated for their national teams may explain the fact that no association between the variables could be found. However, studies among female players found an association between players who were members of their national team and injury rates. The study attributed their finding to a possible higher exposure to football when being part of a national team as well as the level of competitiveness and the desire to stay in the national team.

4.3 LIMITATIONS

Despite the fact that the resident physiotherapists were trained on how to record on the SIS form, the researcher found some inconsistencies with recording during his monthly visits. For example, a player recorded initial injury of zero severity and later sustained a recurrent injury of 21 days severity, but the recurrent injury was recorded as a new injury. The resident physiotherapists were contacted to address inconsistencies after the data were evaluated monthly for completeness, correctness, and conformity with the definitions and categories. Furthermore, steps were taken to guarantee the consistency and completeness of the data. These steps included an initial meeting with physiotherapists from the academy to discuss the guidelines and procedures of the study and provide them with a detailed explanation of the research methodology.

Another limitation of the data collection was that the precise date for some of the players' final return to training or play could not be determined. Instead, an estimate was provided based on the clinical judgment of the physiotherapists regarding the general return to play period for each diagnosis. As a result, severity was evaluated more in terms of severity categories than mean days of absence/loss.

The self-reported data provided by players on their previous injury have the potential of recall bias. Researchers failed to find an association between factors and specific injuries such as hamstring injuries, ankle injuries or knee injuries. The researchers also acknowledge that not all possible risk factors associated with injury among academy players, including types of training, physical performance, playing surface, type of footwear and climate were explored.

The study was conducted in only one football academy in Ghana, hence, the findings cannot be generalised to other academies in Ghana or the African continent.

4.4 STRENGTHS

A strength of the study is the use of a prospective design and reporting injuries based on the IOC guidelines making it comparable to other international studies. The study, which describes the epidemiological and clinical features of injury among youth and adult academy football players, is probably the first of its kind in Ghana, as far as the researcher is aware. This study is also the first to examine the relationship between age, BMI, previous injuries, limb dominance, ankle DF ROM, FAI, playing position, exposure hours, and national team membership with injury incidence among academy football players in Ghana. Another strength of the study was recording individual player exposure hours during training and matches which allowed for accurate risk factor analysis. To keep track of injuries, the two resident physiotherapists were always present during training and matches. As a result, little time elapsed between the injury event and reporting of this injury to the physiotherapists for training and matches, therefore improving the accuracy of injury recording.

4.5 CLINICAL IMPLICATIONS

The relatively high injury incidence found in the current study implies the need for a screening and a prevention programme. This programme should focus on:

- Strategies to decrease match injuries, especially among younger players – e.g. strict education about the rules of the game, firm refereeing, wearing of protective clothing and football-specific conditioning to improve skills (Vasileiadis 2020).
- U16 with non-contact injury may benefit from multi-component programmes that includes core stability, balance, functional mobility and strength, as well as warm-up programmes (Pérez-Gómez, Adsuar, Alcaraz and Carlos-Vivas 2022).
- In order to reduce knee injuries, players should be encouraged to do strength training which may include running stairs to strengthen the muscles and ligaments that support the knees, as well as, ensure that cleats are correctly fitted to the foot and provide adequate support (Krutsch, Lehmann, Jansen, et al., 2020).

Regarding factors associated with injury incidence. The following clinical implications apply:

- Special attention should be given to the screening of younger and lighter players as well as, tailored training loads in order to reduce injuries.
- The correlation between injury incidence and players under the age of 18 in our study indicates that football academies should take into account implementing evidence-based screening procedures for previous injury and recurrent injury as a long-term investment in the career and health of their players.
- Previous injury of potential academy players must be assessed thoroughly to allow injury prevention strategies to be tailored to these players.
- Since FAI measured by CAIT was associated with injury incidence, screening self-perceived FAI, as well as objective FAI should be prioritised. Those with FAI, can then objectively be re-assured that the perception is not true.
- Goalkeepers and young attackers will benefit from special technical and skill training which would help in protecting themselves during matches.
- All players should get the opportunity of adequate playing hours to prevent under-loading which tend to be associated with injury incidence in this study.
- Players' injuries should be regularly and thoroughly recorded to allow for the identification of particular groups of players who are more susceptible to particular types of injuries than others.

4.6 CONCLUSION

Injuries among academy football players have not been well studied in Africa, especially in Ghana. This study provides novel information on the epidemiology and clinical characteristics of injury among both youth and adult academy football players. A total of 126 injuries were recorded with match injury incidence being almost 13 times higher than training injury incidence. Injury incidence was higher among the younger players compared to the adult players although relatively lower than other African youth players. Most injuries were caused by contact mechanisms, although some non-contact injuries represented a higher severity. Joint sprain and muscle strains were the most commonly reported injury pathology, mostly occurring at the knee, ankle or hip/groin. The majority of the injuries sustained were moderate in severity, which is different from most studies that reported minimal severity.

Risk factor analysis with respect to football injuries is also limited in Africa. The study identified a number of intrinsic and extrinsic factors associated with injury incidence. Age, BMI, previous injury, CAIT scores, goalkeepers and attackers, ankle DF ROM were associated with either overall injury incidence, match or training injury incidence.

The knowledge gained from the study about injuries among academy football players may assist medical professionals to develop and implement injury prevention programmes that are appropriate and tailored for their specific population.

The study's conclusions are significant for the Football Association of Ghana in terms of its health policy for young players in academies, particularly the need for every football academy to employ a physiotherapist.

4.7 RECOMMENDATIONS FOR FUTURE RESEARCH

According to the current study, the greatest concern is the high injury rate during matches, especially among younger players, and the high frequency of joint sprains and muscle strains. Other comparable studies in Africa and other parts of the world have shown similar risk factors (Age, BMI, previous injury, self-perceived FAI, ankle DF ROM, exposure hours) to be associated with injury incidence rates. To better understand the greater injury incidence among younger players compared to older players, more research is required. Further research should study more than one football academy at a time to obtain a larger sample size to prevent Type II errors. In addition, the relationship between training load and injuries in football in Ghana has to be explored further, as well as, investigating a threshold volume of training hours for injury.

Further studies should concentrate on the association between strength imbalances, fatigue, flexibility and specific injuries like hamstring strains, knee ankle sprains and ACL tears.

Additionally, studies should compare the relationship between biological and maturation age with injury prevalence and incidence.

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Appendix: 1 Ethics approval certificate Appendix

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences

Institution: The Research Ethics Committee, Faculty Health Sciences, University of Pretoria complies with ICH-GCP guidelines and has US Federal wide Assurance.

- FWA 00002567, Approved dd 22 May 2002 and Expires 03/20/2022.
- IORG #: IORG0001762 OMB No. 0990-0279 Approved for use through February 28, 2022 and Expires: 03/04/2023.

Faculty of Health Sciences **Research Ethics Committee**

1 July 2021

Approval Certificate
New Application

Dear Mr SK Kwakye

Ethics Reference No.: 268/2021
Title: The epidemiology, clinical characteristics and associated risk factors for injury among football players at an academy in Ghana

The **New Application** as supported by documents received between 2021-06-24 and 2021-06-30 for your research, was approved by the Faculty of Health Sciences Research Ethics Committee on 2021-06-30 as resolved by its quorate meeting.

Please note the following about your ethics approval:

- Ethics Approval is valid for 1 year and needs to be renewed annually by 2022-07-01.
- Please remember to use your protocol number (268/2021) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, monitor the conduct of your research, or suspend or withdraw ethics approval.

Ethics approval is subject to the following:

- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

We wish you the best with your research.

Yours sincerely

On behalf of the FHS REC, Professor Werdie (CW) Van Staden
MBChB, MMed(Psych), MD, FCPsych(SA), FTCL, UPLM
Chairperson: *Faculty of Health Sciences Research Ethics Committee*

The Faculty of Health Sciences Research Ethics Committee complies with the SA National Act 61 of 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 and 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes, Second Edition 2015 (Department of Health)

Research Ethics Committee
Room 4-60, Level 4, Tswelopele Building
University of Pretoria, Private Bag x323
Gezina 0031, South Africa
Tel +27 (0)12 356 3084
Email: deepeka.behari@up.ac.za
www.up.ac.za

Fakulteit Gesondheidswetenskappe
Lefapha la Disaense tša Maphelo

Institution: The Research Ethics Committee, Faculty Health Sciences, University of Pretoria complies with ICH-GCP guidelines and has US Federal wide Assurance.

- FWA 00002567, Approved dd 18 March 2022 and Expires 18 March 2027.
- IORG #: IORG0001762 OMB No. 0990-0278 Approved for use through August 31, 2023.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences

Faculty of Health Sciences **Research Ethics Committee**

15 June 2022

Approval Certificate
Annual Renewal

Dear Mr SK Kwakye,

Ethics Reference No.: 268/2021 – Line 1
Title: The epidemiology, clinical characteristics and associated risk factors for injury among football players at an academy in Ghana

The **Annual Renewal** as supported by documents received between 2022-05-18 and 2022-06-15 for your research, was approved by the Faculty of Health Sciences Research Ethics Committee on 2022-06-15 as resolved by its quorate meeting.

Please note the following about your ethics approval:

- Renewal of ethics approval is valid for 1 year, subsequent annual renewal will become due on 2023-06-15.
- Please remember to use your protocol number (268/2021) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, monitor the conduct of your research, or suspend or withdraw ethics approval.

Ethics approval is subject to the following:

- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

We wish you the best with your research.

Yours sincerely

On behalf of the FHS REC, Dr R Sommers
MBChB, MMed (Int), MPharmMed, PhD
***Deputy Chairperson** of the Faculty of Health Sciences Research Ethics Committee, University of Pretoria*

The Faculty of Health Sciences Research Ethics Committee complies with the SA National Act 61 of 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 and 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes, Second Edition 2015 (Department of Health)

Research Ethics Committee
Room 4-60, Level 4, Tswelopele Building
University of Pretoria, Private Bag x323
Gezina 0031, South Africa
Tel +27 (0)12 356 3084
Email: deepeka.behari@up.ac.za
www.up.ac.za

Fakulteit Gesondheidswetenskappe
Lefapha la Disaense tša Maphelo

Appendix 2: Data collection instrument – Standardised Injury Surveillance form

Date of report:

Form completed by: Name: Contact details:

Please report: All sport injuries of your athletes newly incurred, recurrent or an exacerbation of an underlying stable injury during the 2021/2022 season regardless of the consequences with respect to absence from competition or training. The information provided will be treated strictly confidential.

Demographics and Injury Definitions and codes (see below)

age	gender *male / female*	Previous Injury no / yes	Dominant limb Left / right	Member of a national team no / yes

Player position *GK / DF / MF / ATT*	Ankle DF ROM	Height	Weight	BMI

date of injury	Match / training	cod e	onset code	new code

injury mechanism	code	injured body region	cod e	injury type	code	time-loss *no / yes*	Retu rn date	Duration *days*

age	gender *male / female*	Previous Injury no / yes	Dominant limb left / right	Member of a national team no / yes

Player position *GK / DF / MF / ATT*	Ankle DF ROM	Height	Weight	BMI

date of injury	match / training	code	onset code	new code

injury mechanism	code	injured body region	cod e	injury type	code	time-loss *no / yes*	Retur n date	Duration *days*

age	gender *male / female*	Previous Injury no / yes	Dominant limb Left / right	Member of a national team no / yes

Player position *GK / DF / MF / ATT*	Ankle DF ROM	Height	Weight	BMI

Date of injury	Match/ training	code	onset code	New code

Injury mechanism	code	Injured body part	code	Injury type	code	Time-loss *No / yes*	Return date	Duration

age	gender *male / female*	Previous Injury no / yes	Dominant limb Left / right	Member of a national team no / yes

Player position *GK / DF / MF / ATT*	Ankle DF ROM	Height	Weight	BMI

Date of injury	Match/ training	code	onset code	New code

Injury mechanism	code	Injured body part	code	Injury type	code	Time-loss *No / yes*	Return date	Duration

New, recurrent or exacerbation

☐ new   recurrent after full recovery and return-to-sport   unknown, or not specified

☐ exacerbation of a stable (not recovered) condition

Date of full return to normal training and competition ______________(dd/mm/yy)

No return to sport possible: fatality   permanent disability   other reasons

Definitions and codes

For injuries (defined as any physical complaint sustained by a player, reported and diagnosed by a physiotherapist that resulted from a football match or football training and led to an absence from the next training session or match)

Competition or training

1 competition, please specify event

2 training

3 peri-competition activities (e.g. warm-up, cool-down)

Mode of onset

1 sudden after acute trauma

2 sudden but no acute trauma

3 gradual

4mixed

Injury mechanism

1 no identifiable single event (repetitive transfer of energy, overuse)

2 acute non-contact trauma

3 direct contact with another athlete

4 following contact with another athlete (e.g. fall after a push)

5 direct contact with an object (e.g. ball, wall, ground, i.e. slipped and fell)

6 following contact with an object

Injured body region

1 head / face

2 neck / cervical spine

3 chest (incl. chest organs)

4 thoracic spine / upper back

5 lumbar-sacral spine / buttock

6 abdomen (incl. abdominal organs)

7 shoulder

8 upper arm

9 elbow

10 forearm

11 wrist

12 hand

13 hip / groin

14 thigh

15 knee

16 lower leg / Achilles tendon

17 ankle

18 foot

Injury type

1 concussion / brain injury
2 spinal cord injury
3 peripheral nerve injury
4 bone fracture
5 bone stress injury
6 bone contusion
7 avascular necrosis
8 physis injury
9 cartilage injury
10 joint sprain / ligament tear
11 chronic instability
12 tendon rupture
13 tendinopathy
14 muscle strain / rupture / tear
15 muscle contusion
16 muscle compartment syndrome
17 laceration
18 abrasion
19 contusion / bruise (superficial)
20 arthritis
21 bursitis
22 synovitis
23 vascular damage
24 stump injury
25 internal organ trauma
26 unknown, or not specified

Appendix 3: Data collection instrument – Exposure form

Report the duration of training and match play for each player (in minutes)

Date									
Match/Training									
Player Code No.									

Appendix 4: Data collection instrument - Cumberland Ankle Instability Tool

Please tick the ONE statement in EACH question that BEST describes your ankles.

		Left	Right	Score
1.	**I have pain in my ankle**	◻	◻	5
	Never	◻	◻	4
	During sport	◻	◻	3
	Running on uneven surfaces	◻	◻	2
	Running on level surfaces	◻	◻	1
	Walking on uneven surfaces	◻	◻	0
2.	**My ankle feels UNSTABLE**			
	Never	◻	◻	4
	Sometimes during sport (not every time)	◻	◻	3
	Frequently during sport (every time)	◻	◻	2
	Sometimes during daily activity	◻	◻	1
	Frequently during daily activity	◻	◻	0

3. When I make SHARP turns, my ankle feels UNSTABLE	□	□	
Never	□	□	3
Sometimes during running	□	□	2
Often when running	□	□	1
When walking	□	□	0
4. When going down the stairs, my ankle feels UNSTABLE	□	□	
Never	□	□	3
If I go fast	□	□	2
Occasionally	□	□	1
Always	□	□	0
5. My ankle feels UNSTABLE when standing on ONE leg	□	□	
Never	□	□	2
On the ball of my foot	□	□	1
With my foot flat	□	□	0

6. My ankle feels UNSTABLE when	□	□	
Never	□	□	3
I hop from side to side	□	□	2
I hop on the spot	□	□	1
When I jump	□	□	0
7. My ankle feels UNSTABLE when	□	□	
Never	□	□	4
I run on uneven surfaces	□	□	3
I jog on uneven surfaces	□	□	2
I walk on uneven surfaces	□	□	1
I walk on a flat surface	□	□	0
8. TYPICALLY, when I start to roll over (or "twist") on my ankle, I can stop it	□	□	
Immediately	□	□	3
Often	□	□	2

Sometimes	□	□	1
Never	□	□	0
I have never rolled over on my ankle	□	□	3
9. After a TYPICAL incident of my ankle rolling over, my ankle returns to "normal"	□	□	
Almost immediately	□	□	3
Less than one day	□	□	2
1–2 days	□	□	1
More than 2 days	□	□	0
I have never rolled over on my ankle	□	□	3

Appendix 5: Letter of approval – Permission from the academy to conduct the study in the camp

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences

School of Health Care Sciences
Department of Physiotherapy
University of Pretoria,
Private Bag X20
Hatfield 0028, South Africa

Department of Physiotherapy
Samuel Koranteng Kwakye

Kwamed88@gmail.com
0544792730/ 0208037884

24/12/2020.

The CEO,
West African Football Academy
P. O. Box CT 5619
Accra-Ghana

Dear Mr. Brokken,

Masters study: THE EPIDEMIOLOGY, CLINICAL CHARACTERISTICS AND ASSOCIATED RISK FACTORS FOR INJURY AMONG FOOTBALL PLAYERS AT AN ACADEMY IN GHANA.

I hereby request permission to conduct the above-mentioned research study at your institution. I am currently enrolled in the MPhysio program at University of Pretoria (UP) in South Africa and am in the process of doing research for my Master's degree. The study is entitled '**The epidemiology, clinical characteristics and associated risk factors for injury among football players at an academy in Ghana'.** This project is conducted under the supervision of Prof. Karien Mostert (UP, South Africa) and Mr. Daniel Garnett (UP, South Africa).

I trust that the management will allow me to recruit all players enrolled at your academy to participate in the study. Interested players, who are over 17 years will be required to sign a consent form. Players who are below 17 years will be given assent forms which will be signed by their legal guardians and returned to the primary researcher before the study will commence.

If approved, participants will participate in a series of measurements (height, weight and ankle dorsiflexion range of motion) and tests (Cumberland ankle instability test and star excursion balance test) at the gymnasium during their free periods within the week. I, therefore, ask permission to use the academy's gymnasium, as well as, their free periods within the week to perform these measurements and tests. The process should take no longer than 20 minutes per participant. I will, therefore, use approximately 4 weeks to complete all measurements, doing 4 players a day for five days in a week. Information from individual participants will remain confidential and anonymous during reporting of the findings in all formats. Participants will be given unique codes to ensure this. No costs will be incurred by either your academy or the individual players. There is no foreseeable harm to any of the participants. Participation is voluntary and participants will be notified of their right to withdraw from the study at any time. Players who do not participate will not be punished nor their team selection, training or other element of being a member of the academy be affected

Attached find a copy of the research proposal which includes the data collection procedures and instruments, consent (Annexure C) and assent forms (Annexure D).

Your approval to conduct this study will be greatly appreciated. I will follow up with a telephone call and would be happy to answer any questions or concerns that you may have. You may contact me at kwamed88@gmail.com or 0544792730.

If you agree, kindly check the YES tick box and sign below and return the signed form.

Sincerely,

Samuel Koranteng Kwakye

Approved: Yes ☑ No☐

Approved by:

____

(Signature)

JULIET DODOO (MRS.)

(Name)

Appendix 6: Informed consent form for adult participants

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

PARTICIPANT'S INFORMATION and INFORMED CONSENT DOCUMENT

STUDY TITLE: The epidemiology, clinical characteristics and associated risk factors for time-loss injury among players at an academy in Ghana.

Principal Investigators: Samuel Koranteng Kwakye

Institution: University of Pretoria

DAYTIME AND AFTER HOURS TELEPHONE NUMBER(S):

Daytime number/s: 0544792730

After hours' number: 0544792730

DATE AND TIME OF FIRST INFORMED CONSENT DISCUSSION:

		2021
date	**month**	**year**

10 :00 GMT
Time

Dear Prospective Participant

1) INTRODUCTION

You are invited to volunteer for a research study. I am doing research for a master's degree purpose at the University of Pretoria. The information in this document is to help you to decide if you would like to participate. Before you agree to take part in this study you should fully understand what is involved. If you have any questions, which are not fully explained in this document, do not hesitate to ask the researcher. You should not agree to take part unless you are completely happy about all the procedures involved.

2) THE NATURE AND PURPOSE OF THIS STUDY

The aim of this study is to determine the epidemiology and clinical characteristics of injuries in male academy players and to determine the associations between selected factors and injuries over a season. By doing so we wish to learn more about intrinsic and extrinsic factors that are associated with football injuries among academy players and the clinical characteristics of the injuries sustained.

3) EXPLANATION OF PROCEDURES AND WHAT WILL BE EXPECTED FROM PARTICIPANTS.

This study involves answering some questions regarding your personal demographics, documenting injuries sustained over the season, weight and height measurements. We will also measure the ankle dorsiflexion range of motion. The weight-bearing lunge method will be used in measuring the ankle dorsiflexion range of motion.

4) POSSIBLE RISKS AND DISCOMFORTS INVOLVED

There are no medical risks associated with the study.

5) POSSIBLE BENEFITS OF THIS STUDY

Although you may not benefit directly. The study results may help us identify factors associated with football injuries which will help in the formulation of a more comprehensive and specific injury prevention programmes for football players in general. Further, reducing the incidences and prevalence of injuries among players which will consequently reduce financial implications.

6) COMPENSATION

You will not be paid to take part in the study. There are no costs involved for you to be part of the study.

7) YOUR RIGHTS AS A RESEARCH PARTICIPANT

Your participation in this trial is entirely voluntary and you can refuse to participate or stop at any time without stating any reason. Your withdrawal will not affect your access to other medical care.

8) ETHICS APPROVAL

This Protocol was submitted to the Faculty of Health Sciences Research Ethics Committee, University of Pretoria, telephone numbers 012 356 3084 / 012 356 3085 and written approval has been granted by that committee.

The study has been structured in accordance with the Declaration of Helsinki (last update: October 2013), which deals with the recommendations guiding doctors in biomedical research involving human/subjects. A copy of the Declaration may be obtained from the investigator should you wish to review it.

9) INFORMATION

If I have any questions concerning this study, I should contact:

Mr. Samuel Koranteng Kwakye Tel: +233544792730 or cell: +233208037884

10) CONFIDENTIALITY

All information obtained during the course of this study will be regarded as confidential. Each participant that is taking part will be provided with an alphanumeric coded number e.g. A001. This will ensure confidentiality of information so collected. Only the researcher and research assistants will be able to identify you as a participant. Results will be published or presented in such a fashion that participants remain unidentifiable. The hard copies of all your records will be kept in a locked facility at the physiotherapy department, The University of Pretoria.

11) CONSENT TO PARTICIPATE IN THIS STUDY

- I confirm that the person requesting my consent for my child to take part in this study has told me about the nature and process, any risks or discomforts, and the benefits of the study.
- I have also received, read and understood the above-written information about the study.
- I have had adequate time to ask questions and I have no objections to participate in this study.
- I am aware that the information obtained in the study, including personal details, will be anonymously processed and presented in the reporting of results.
- I understand that I will not be penalised in any way should I wish to discontinue with the study and that withdrawal will not affect my further treatments.
- I am participating willingly.
- I have received a signed copy of this informed consent agreement.

______________________________ ______________________

Participant’s name (Please print) Date

______________________________ ______________________

Participant’s signature Date

Samuel Koranteng Kwakye ______________________

Researcher’s name (Please print) Date

______________________________ ______________________

Researcher’s signature Date

Appendix 7: Assent form for participants under 18 years

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

INFORMATION AND ASSENT DOCUMENT FOR 7-17 YEARS

Study title: The epidemiology, clinical characteristics and associated risk factors for time-loss injury among players at an academy in Ghana.

Principal Investigator: Samuel Koranteng Kwakye

Supervisor: Prof. Karien Mostert

Institution: University of Pretoria

Daytime telephone number/s: 0544792730

Date and time of informed consent discussion:

		2021
date	**month**	**year**

:
Time

1) **INTRODUCTION**

My name is Samuel Koranteng Kwakye and my job is to do research on young and adult academy football players. We want to determine the epidemiology and clinical characteristics of injuries in male academy players and to determine the associations between selected factors and injuries over a season.

I am going to explain this research to you and invite you to be part of this research study. You can choose whether or not you want to participate in this study. We have discussed this research study with your legal guardian and they know that we are also asking for your permission. If you are going to be part of this research, your legal guardian also has to agree. But if you do not wish to participate, you do not have to.

You may discuss anything on this form with your legal guardian or friends. You can decide whether to participate or not after you have talked it over. You do not have to decide immediately.

There may be some words you don't understand or things that you want me to explain to you. Please ask me to stop at any time and I will explain.

2) WHAT IS RESEARCH?

Research is what we do to find new knowledge about subjects (and people). We use research studies to help us find more information about disease or illness. Research also helps us to find better ways of treating children who are sick or injured.

3) WHAT IS THIS RESEARCH PROJECT ALL ABOUT AND WHAT IS EXPECTED OF ME?

The study is to determine the epidemiology and clinical characteristics of injuries in academy players and to determine the associations between selected factors and injuries over a season.

We need information about height, weight, ankle dorsiflexion range of motion, injuries sustained and circumstances of the injuries over the season.

4) WHY HAVE I BEEN INVITED TO TAKE PART IN THIS RESEARCH PROJECT?

You are among the enrolled players in the academy and have been with the academy long enough.

5) WHO IS DOING THE RESEARCH?

We the researchers are mostly physiotherapists.

6) WHAT WILL HAPPEN TO ME IN THIS STUDY?

You are going to be weighed on a scale and your height measured. Your ankle dorsiflexion range of motion will also be measured. All injuries sustained in the course of the football season will be recorded on a standardised injury surveillance form by your physiotherapist.

7) CAN ANYTHING BAD HAPPEN TO ME?

We do not foresee that anything bad will happen to you because of this research study.

8) CAN ANYTHING GOOD HAPPEN TO ME?

The researcher will give you information on your injury in case of any and will refer you to relevant practitioners for appropriate treatment.

9) ETHICS APPROVAL

This Protocol was submitted to the Faculty of Health Sciences Research Ethics Committee, University of Pretoria, Medical Campus, Tswelopele Building, Level 4-59, Telephone numbers 012 356 3084 / 012 356 3085 and written approval has been granted by that committee.

10) WILL ANYONE KNOW I AM IN THE STUDY?

Only the researchers will know that you are participating in the study.

11) Who can I talk to about the study?

Samuel Koranteng Kwakye the primary researcher on 0544792730

12) WHAT IF I DO NOT WANT TO DO THIS?

You do not have to participate in the study, even if legal guardians have signed consent that you can participate. You can also withdraw from the study at any time without getting in trouble.

13) CONSENT TO PARTICIPATE IN THIS STUDY

Do you understand this research study and are you willing to participate in it?

YES	NO

Do you understand that your height, weight and ankle dorsiflexion range of motion will be measured?

YES	NO

Has the researcher answered all your questions?

YES	NO

Do you understand that you can pull out of the study at any time without any consequences?

YES	NO

You don't have to give us your answer now, take your time and read the rest of this form before you decide.

If you sign at the bottom it will mean that you have read this paper, and that you would like to be in this study.

	Your Name	Person Obtaining Consent	Parent / Guardian / Witness
Name Please Print			
Signatur e			
Date			

Appendix 8: Letter of statistical support

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Denkleiers • Leading Minds • Dikgopolo tša Dihlalefi

DEPARTMENT OF STATISTICS

LETTER OF STATISTICAL SUPPORT

Date: ***04/02/2021***

This letter is to confirm that **Mr. S.K. Kwakye** studying at the University of Pretoria discussed the project with the title "**THE EPIDEMIOLOGY, CLINICAL CHARACTERISTICS AND ASSOCIATED RISK FACTORS FOR INJURY AMONG FOOTBALL PLAYERS AT AN ACADEMY IN GHANA**" with me.

I hereby confirm that I am aware of the project and undertake to assist with the statistical analysis of the data generated from the project.

The SPSS IBM Statistics version 26 software will be used to perform the analysis. The data analysis will consist of the descriptive statistics (means, median and standard deviations) for continuous variables and frequency tables (counts and percentages) for categorical variables to describe characteristics of the population. The same measurements will be used to determine the incidence of football injuries and weekly prevalence of injury.

To describe the clinical characteristics (the type of injury, anatomical region injured, the severity of the injury, mechanism of injury, tissue type and pathology type, frequency tables (counts and percentages) will be used. The Pearson chi-square test will be performed to determine if the intrinsic factors and the extrinsic factors are associated with football injuries and to test if there is an association between clinical characteristics of injuries among age groups. If the number of counts is < 5 within cells, the Fisher exact test will be performed.

The total population sampling method will be used, where the sample will consist of approximately 80 males, youth, and adult academy football players.

NAME:

A. Masenge

Mr. Andries Masenge
Department of Statistics
Internal Consultation Service
Tel 012 420 3645

Appendix 9: Confirmation letter of submitted manuscript in press at British Journal of Sports and Exercise Medicine

6/26/23, 5:00 PM Gmail - bmjsem-2022-001519.R1 - Decision on Manuscript

Gmail samuel koranteng kwakye <kwamed88@gmail.com>

bmjsem-2022-001519.R1 - Decision on Manuscript
3 messages

BMJ Open Sport & Exercise Medicine <onbehalfof@manuscriptcentral.com> Tue, Jun 20, 2023 at 5:52 AM
Reply-To: info.bmjsem@bmj.com
To: danielphysio@gmail.com

20-Jun-2023

bmjsem-2022-001519.R1 - "Epidemiology and clinical characteristics of football injuries among academy players in Ghana"

Dear Dr. Garnett,

Following review of your article to BMJ Open Sport & Exercise Medicine, we invite you to submit a minor revision.

The review comments can be found at the end of this email.

I have also made some of my own final suggested edits in the attached word file. There is no need to respond to these individually. Simply accept or reject these suggestions as you see fit.

Nice work!!

Evert

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Please submit your revised article by 05-Jul-2023. If we have not received it by this date, the opportunity to submit a revision will expire and your article may be treated as a new submission. If you need to request an extension, please contact the Editorial Office as soon as possible.

Thank you for submitting your article to BMJ Open Sport & Exercise Medicine; we look forward to receiving your revision.

If you have any queries, please contact the Editorial Office at info.bmjsem@bmj.com.

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Appendix 10: Confirmation of published manuscript in Scientific reports

Gmail samuel koranteng kwakye <kwamed88@gmail.com>

Scientific Reports: Decision on your manuscript

1 message

Scientific Reports <srep@nature.com> Tue, May 9, 2023 at 4:19 AM
To: kwamed88@gmail.com

Ref: Submission ID 2b048b47-96a0-4eec-9544-94d03e8a61ff

Dear Dr Kwakye,

Re: "Risk factors associated with football injury among male players from a specific academy in Ghana: a pilot study"

We're delighted to let you know your manuscript has now been accepted for publication in Scientific Reports.

Editor comments
I am pleased to report that the authors have revised the manuscript based on the reviewers' suggestions. The manuscript is now ready for publication in Scientific Reports.

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Kind regards,

Marco Gervasi
Editorial Board Member
Scientific Reports

Reviewer Comments:

Reviewer 2
The authors have made the necessary revisions to the manuscript according to the suggestions by the reviewers. I have no further comments.

P.S. If appropriate, you may also consider uploading any protocols used in this manuscript to the protocol exchange, part of our online web resource, https://protocolexchange.researchsquare.com. By participating, you are enabling researchers to reproduce or adapt your methodology. The protocol exchange is fully searchable, providing your protocols and paper with increased utility and visibility. Protocols can also be easily updated via versioning. Please submit your protocol to https://protocolexchange.researchsquare.com/submission. You may need to create a new Research Square account. Please provide details of this article in the associated publications section. You'll find more information at: https://protocolexchange.researchsquare.com

Annexure 1: Summary of studies investigating the incidence of injury among youth and adult European football.

Author (year)	**Country**	**Number of players (youth or adult)**	**Methodology**	**Level of injury incidence by type of exposure**		
				Training	Match	Total
Kurittu, E., Vasankari, T., Brinck, T., Parkkari, J., Heinonen, O. J., Kannus, P., ... and Leppänen, M. (2021)	**Finland**	236 first team players of Finnish football league	The study was a one-season prospective follow-up Study collecting data via injury reports from the medical staff and directly from the players using the Oslo Sports Trauma Research Centre Health Questionnaire.	3.4 injuries per 1 000 hours	30.6 injuries per 1 000 hours	8.6 injuries per 1 000 hours

Raya-González, J., Suárez-Arrones, L., Navandar, A., Balsalobre-Fernández, C., and de Villarreal, E. S. (2019)	Spain	309 youth male football players between the ages of 12 and 24 years.	A prospective study in elite male young football players during four consecutive seasons (2014/2015 to 2017/2018).	2.10 injuries per 1 000 hours	10.16 injuries per 1 000 hours	2.93 injuries per 1 000 hours
Jaber, A., Weishorn, J., Berrsche, G., Ott H. and Bangert Y. (2021)	Germany	138 male football players aged between 12 and 19 years.	A prospective study among academy players during one football season.	0.7 injuries per 1 000 hours	6.9 injuries per 1 000 hours	Total?
Jones, A., G. Jones, G., Greig, N., Bower, P., Brown, J., Hind, K., et al. (2019)	England	243 male professional football players	The study prospectively recorded injuries in football players during the 2015-2016 competitive football season.	6.84 injuries per 1 000 hours	24.29 injuries per 1 000 hours	9.11 injuries per 1 000 hours

Nogueira, M., Laiginhas, R., Ramos, J., and Costa, O. (2017)	Portugal	529 Under-17 and Under-19 male football players.	A prospective study of a follow-up of six months (26 weeks) of one season.	2.06 injuries per 1 000 hours.	15.22 injuries per 1 000 hours.	3.87 injuries per 1 000 hours.
Nilsson, T., Östenberg, A. H., and Alricsson, M. (2016)	Sweden	43 young elite male football players, aged between 15 to 19 years	A prospective study among elite male youth soccer players in a Swedish first league during two seasons.	5.6 injuries per 1 000 hours respectively.	15.5 injuries per 1 000 hours	6.8 injuries per 1 000 hours.
Shalaj, I., Tishukaj, F., Bachl, N., Tschan, H., Wessner, B., and Csapo, R. (2016)	Kosovo	143 adult male professional football players	A prospective study among players in Kosovo's top division during the 2013/14 season	3.16 per 1 000 hours.	35.37 injuries per 1 000 hours	7.37 injuries per 1 000 hours
Bianco, A., Spedicato, M., Petrucci, M., Messina, G., Thomas, E., Nese Sahin, F., Paoli, A.,	Italy	80 young male football players	A prospective cohort study among players grouped into two age groups of 13 to 16 and 17	1.15 injuries per 1 000 hours	2.84 injuries per 1 000 hours	1.28 injuries per 1 000 hours

and Palma, A. (2016)			to 19 years.			
Stubbe, J. H., van Beijsterveldt, A. M. M., van der Knaap, S., Stege, J., Verhagen, E. A., Van Mechelen, W., and Backx, F. J. (2015)	Netherlands	217 adult professional football players	Players participating in the Dutch premier football league were prospectively followed during the 2009–2010 competitive season.	2.8 injuries per 1 000 hours	32.8 injuries per 1 000 hours	6.2 injuries per 1 000 hours
Javier Noya Salces, Pedro M. Gómez-Carmona, Luis Gracia-Marco, Diego Moliner-Urdiales and Manuel Sillero-Quintana (2014)	Spain	427 adult male professional players	A prospective study using a specific web-based survey during the 2008/2009 season among 16 first division clubs.	3.55 per 1 000 hours	43.5 injuries per 1 000 hours	5.5 injuries per 1 000 hours

Annexure 2: Brief review of relevant articles investigating the incidence and prevalence of injury in African football.

Author (year)	Country	Number of players (youth or adult)	Methodology	Level of injury incidence by type of exposure			Injury prevalence
				Training	Match	Overall	
Nuhu A and Kutz M (2017)	East Africa	240 adult male players	A prospective study conducted among players during a two-week tournament	Not reported	82.25 injuries per 1 000 hours	Not reported	Not reported
Owoeye, O. B. A., Aiyegbusi, A. I., Fapojuwo, O. A., Badru, O. A., and Babalola, A. R. (2017)	Nigeria	756 players (356 males and 300 females) between the ages of 18 and 32 years	A prospective cohort design was conducted among players in a National Football Tournament	Not reported	15.6 hours per 1 000 hours	113.4 injuries per 1 000 hours	Not reported
Onakunle, T. O., Owoeye, O. B., Ajepe, T. O., Akodu, A. K., and Akinbo, S. R.	Nigeria	266 registered adult male players	The study involved the use of self-administered questionnaires to collect data on	Not reported	Not reported	Not reported	30% and 16.7% injury prevalence rates for Football Federation's Professional and National Leagues respectively

(2016).			injuries sustained and sociodemographic characteristics				
Calligeris T, Burgess T and Lambert M. (2015)	South Africa	32 adult male players	The study was a retrospective cohort design conducted among active male professional football players who played for first and reserve team.	6.6 injuries per1 000 hours	88.9 injuries per 1 000 hours	13.4 injuries per 1 000 hours	Not reported
Mughogho A (2012)	Malawi	200 adult football players	A concurrent mixed method study design was used to collect data. A self-administered questionnaire was used to collect quantitative data from football players. Qualitative data was collected through in-	Not reported	Not reported	Not reported	Overall injury prevalence was 68.9% with 64% of injuries during matches and 37% during training.

			depth interviews from team doctors and coaches respectively.				
Nshimiyimana J. B. and Frantz J. M. (2012)	Rwanda	360 high school soccer players. between the ages of 11 to 26 years.	A cross-sectional study which utilised a validated closed-ended questionnaire to collect data from players.	Not reported	Not reported	Not reported	Overall prevalence of 75%
Bailey R, Erasmus l, Lüttich L, Theron N and Joubert G (2009)	South Africa	16 adult first team players	A prospective cohort descriptive study was conducted among adult male players actively participating in matches during the 2007/2008 season	Not reported	Not reported	39.5 injuries per 1 000 hours	Not reported
Azubuike, S. O., and Okojie, O. H. (2009)	Nigeria	196 players	Seven clubs from the premiership, professional, national	Not reported	Not reported	Not reported	Overall injury rates of 81.6% with 46.1% during matches and 36.8% during training.

			and state amateur clubs were studied using a descriptive cross-sectional study design.				
Naidoo, M. A. (2007)	South Africa	26 male football players ranging from 17-39 years	The study utilised a questionnaire in which the team physiotherapist collected data on injuries sustained	Not reported	Not reported	Not reported	Overall injury prevalence was 58%

Annexure 3: Summary of relevant articles investigating the objective tests used to evaluate ankle dorsiflexion range of motion by year, content and feasibility.

Author (s) and study title	Year	Type of test and rigour
Konor, M. M., Morton, S., Eckerson, J. M., and Grindstaff, T. L. Reliability of three measures of ankle dorsiflexion range of motion	2012	weight-bearing lunge position with 1. Tape measure: ICC, right = 0.98, left = 0.99, SEM=0.4 to 0.6 cm, MDC = 1.1 to 1.5 cm 2. Digital inclinometer: ICC, right = 0.96; left = 0.97, SEM= 1.3 to1.4°, MDC = 3.7 to 3.8°. 3. Standard goniometer (ICC, right= 0.85; left=0.96, SEM= 1.8 to 2.8°, MDC = 5.0 to 7.7°.
Chisholm, M.D., Birmingham, T.B., Brown, J., Macdermid, J., Chesworth, B.M. Reliability and validity of a weight-bearing measure of ankle dorsiflexion range of motion.	2012	Weight-bearing Lunge Test, Lower Extremity Functional Scale (LEFS) and American Academy of Orthopedic Surgeons Global Foot and Ankle Scale (GFAS) All of the ICC values > 0.90, SEM = 4.0 to 5.7 mm, and MDC =9.4 to 13.3 mm.
Cipriani, D., Pera, D., Pomerantz, A., Reid, A., Brown, T. A proposed modification to the ankle dorsiflexion lunge measure in weight bearing: Clinical application with reliability and validity.	2020	modified Weight-bearing Lunge Test (mWBLT): Tape measure and goniometer: ICC > 0.90, SEM = 0.70, MDC= 1.95 and sufficient goniometer correlation (r > 0.60), all of which were equivalent to the standard WBLT.

Annexure 4: Brief summary of relevant articles investigating the objective tests used to evaluate Functional Ankle Instability (FAI)

Author(s) and Study title	**Year**	**Type of test and rigour**
Gribble, P. A., Kelly, S. E., Refshauge, K. M., and Hiller, C. E. Interrater reliability of the star excursion balance test.	2013	Assessing SEBT's inter-rater reliability ICC (non-normalised) = 0.89 to0.94). ICC (normalised) = 0.89 to 0.92
Hertel, J., Braham, R. A., Hale, S. A., and Olmsted-Kramer, L. C. Simplifying the star excursion balance test: analyses of subjects with and without chronic ankle instability.	2006	Using factor analysis to reduce the number of SEBT components The anterior, posteromedial, and posterolateral reach directions were found to be the most useful in diagnosing functional problems.
Hiller, C. E., Refshauge, K. M., Bundy, A. C., Herbert, R. D., and Kilbreath, S. L. The Cumberland ankle instability tool: a report of validity and reliability testing.	2006	The Cumberland Ankle Instability Tool (CAIT) Sensitivity = 82.9 % Specificity = 74.7 %. ICC = 0.96.
Arnold, B. L., Wright, C. J., Linens, S. W., and Ross, S. E. Recalibration of the CAIT cut-off score for chronic ankle instability.	2011	Re-verification and recalibration of the CAIT cut-off score. The maximum Youden index was 0.951, which corresponded to a cut-off score of 25.5, indicating chronic ankle instability.