THE UNITED KINGDOM & IRELAND BASKETBALL INJURY PREVENTION STUDY

(UKIBIPS)

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Dedication

For my parents, Thomas and Elizabeth Lynch

Abstract

The programme of research presented in this study aimed to understand the injury profile of basketball players in Ireland and the UK and, in turn, provide data that can support the introduction of testing strategies for the identification of players at a higher risk of injury. The overriding focus was on the development of a practical, robust and comprehensive electronic injury surveillance system that was accessible to players, non-medically qualified personnel and other professional team staff.

The first study (Chapter 1) reviewed injury risk factors in basketball and other sports. From this, a total of 32 risk factors were identified and could be classed as intrinsic or extrinsic in nature. Some of the risk factors like training load, shoe type and weight are modifiable, while others like player contact and level of competition are not. The identification of these modifiable risk factors provided the framework for the design of the assessment phase to identify players at increased injury risk.

The second study (Chapter 2) established the extent of electronic injury surveillance systems used for different sports around the world. While they are commonplace in professional sport, there is a notable lack of use at the amateur level. None of the systems were available for this study due to geographical and licensing restrictions. However, they demonstrated a simultaneous commonality and disparity of identifiable risk factors used to underpin the data collected. The study established that the underlying injury definitions of some of these systems were medically exclusive and injury data was only included if medically assessed. The injury definitions were restrictive in what constituted an injury, so a more inclusive definition was proposed to be accessible and help capture data that may be lost in a self-reporting system. The injury definition established for this study was factored in as an integral part of the bespoke surveillance system developed and described in Chapters 3 and 4.

Preparticipation assessment is an important part of data collection for injury prevention. Using the framework of tests available for identified modifiable risk factors, Chapter 5 describes the pre-season testing carried out as baseline preparation for a competitive season in which athletes would report on incidence of injury using the bespoke system. Injury data is presented in Chapter 6 and is in line with other studies where the most frequent injury was to the lower extremity, in particular the ankle.

Statistical models (logistic regression and cluster analysis) were fitted to the two data sets gathered in Chapters 5 and 6 to model the relationships between risk factors and injury outcome. The resulting models demonstrated the circular relationship between injury, risk factor and tests that can identify a potential weakness in an athlete that may contribute to an injury. The cluster analysis (Chapter 5) established the similarities between the tests used for various risk factors, thus allowing a judicious selection of tests to be used by the practitioner for both pre-participation and in-season testing.

Overall, this work presents a new robust Injury Surveillance System, previously unknown information on basketball injury in Ireland and the UK, and data on PPE testing which may be used to identify basketball players at increased risk of injury. This data collection tool can also be used by a variety of sports-based researchers and the resultant data can assist in providing answers to their specific research questions.

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"There is no time in youth that the mature person can look back on with as much happiness and gratitude as the time which they spent on the sports field."

Author unknown

Preface

This dissertation has come together as a result of a lifelong relationship with the sport of basketball that has spanned over four decades as player, head coach, physiotherapist and strength & conditioning coach from schools' leagues to international level. One's own academic journey may not be signposted, but life experience often guides you. The sport of basketball is a beautiful game to play and to watch as a spectator. However, as a team sport, research has shown that more injuries occur in basketball relative to any other team sports. As a player, it was to be an injury which forced my premature retirement from the game. It is devastating for any athlete to hear that they can't play anymore and it can be an even more difficult and longer journey to reach acceptance of the fact.

In my professional capacity as a physiotherapist, I have treated athletes for a range of injuries, from the very minor to the most complex, up to and including those which have ended playing careers. Healthcare professionals can address the injured athlete post-trauma and guide them through their recovery and return to sport. This is not enough! Injury prevention for modifiable, non-contact injuries can be achieved. The question verbalised in the old adage concerning "an ounce of prevention" remained unanswered in the sport of basketball in the UK and Ireland. Could some injuries be prevented or maybe reduced in severity?

Basketball has one of the highest participation rates in sport in Ireland and the UK. However, there was a lack of data available on injury rates, types and mechanisms which could inform any prevention strategies and policies developed or supported by governing bodies. To help address this gap in our knowledge, I undertook this research to contribute to academic debate and provide new knowledge that may assist in reducing injury within the sport of basketball in Ireland and the UK.

With the assistance and permission of the national governing bodies for basketball in the UK and Ireland, this research was carried out to record injury-related data across two competitive seasons in all four nations. The target population was u14, u16, u18, u20 and senior level for both male and female players. Participating players competed in amateur, professional and international teams. This population provided the context and landscape for the injury data collection upon which this study is based.

In order to collect the data, a bespoke electronic injury surveillance system was designed and developed to gather and store information on injury occurrence as well as data on injury risk variables in the game. In the amateur game, it was important that the data collection was done at source through the players and non-medical staff. A pre-participation team assessment provided data for the first time on modifiable non-contact injuries.

While the research study has been difficult, it has been worthwhile and, more importantly, has provided the sport with a new injury surveillance tool suitable for the amateur landscape and original analysis on test variables which have the potential to reduce injury in players identified as being at greater risk.

Acknowledgements

Firstly, from the University of Glasgow, I wish to acknowledge Dr John MacLean for encouraging me to take up this research study and for his valuable advice during the field testing phase of this research. To Dr Martin McBride and Dr David Preiss from ICAMS, thank you for the academic debate and guidance during my PGR sessions. A big thank you also goes to Mrs Dorothy Rooney for her administrative support throughout the process.

I would like to thank my supervisor, Professor Jason Gill, for his guidance and support through this process. He helped form my initial ideas into a meaningful and enjoyable research project. I have benefited greatly from his expertise and it has been a pleasure to have had the opportunity to work with and learn so much from him.

The development of the systems used in my research allowed me to work with talented software developers. From GMIT, I wish to acknowledge the work of Ms Angela Forde and Mr Damien McGuinn for their work on the initial phase of injury surveillance system development. Mr Paulius Peldzius provided his expertise, talent and patience to translate my ideas to code.

To Mr Damien Costello, thank you for your support and expertise throughout this journey. For the endless enthusiasm you have shown in my work from concept to completion, I am forever grateful for your friendship.

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Thanks to the field testing team of Anthony Flanagan, Des O Meara, Niamh Ebbs and Judy McInerney.

To my coaches, Fr. Sean Manning, Joe King and Ciaran Murphy, thank you for introducing me to basketball and educating and inspiring me to play to my full potential and in doing so ensuring a life-long love of this game.

I would like to thank the following governing bodies – Basketball Ireland, Basketball Scotland, Basketball Wales, England Basketball and the British Basketball League for their permission and support in carrying out this research. A huge debt of gratitude is due to the players and coaches who participated in this study and provided me with the opportunity to carry out my research. Specific clubs I wish to thank for their assistance are:

IRELAND

Titans BC	Belfast Star BC	Brunell BC	WIT Wildcats
Templeogue BC	Oblate Dynamos BC	Moycullen BC	Killester BC
Meteors BC	Liffey Celtics BC	UCD Marian BC	UL Eagles BC
Neptune BC	DCU St Vincent’s BC	Letterkenny Blaze BC	Sligo All-Stars BC
DCU Mercy BC	Tralee Imperials BC	Tolka Rovers BC	Ulster Elks BC
Malahide BC	NUIG Mystics BC	Drogheda Bullets BC	St Anthony’s BC
Fr Matthews BC	St Mary's Castleisland BC	TCD BC	Kilkenny Stars BC
Glanmire BC			

SCOTLAND

City of Edinburgh Kool Kats BC	St Mirren BC	Stirling Knights BC
Glasgow Lady Rocks BC	Glasgow Rocks BC	West Lothian Wolves BC
City of Edinburgh Kings BC		

ENGLAND

Cheshire Panthers BC	London Phoenicians BC	Sefton Stars BC
Bristol Academy Flyers BC	Loughborough Riders BC	Northants BC
Plymouth Raiders BC	Leeds Force BC	Reading Rockets BC
Nene Valley Venom BC		

WALES

Barry Huskies BC	Cardiff City BC	Vale Vipers BC
Cardiff Archers BC	Swansea Storm BC	Vale of Glamorgan BC
Cougars BC	Tonyrefail Tigers BC	

To the international teams of Scotland, Ireland and Wales who participated, thank you.

To Patrick and Mary, thanks for listening and the encouragement always. I would like to thank my wife Judy for her support, sacrifice and encouragement. To you, I am forever indebted.

The road to completing a PhD can be a rollercoaster of emotions, trials and tribulations. Academically, I have grown and look forward to continuing to research. During this research study, I have also suffered the loss of both of my parents, Thomas and Elizabeth Lynch. They worked so hard and selflessly to support and encourage me in whatever goals I had.

Chapter 1 – Introduction

1.1. Introduction

Sports injury prevention is important for any athlete at any level. If we can prevent injury, it will be of great benefit reducing time off work and associated cost burden. In the sport of basketball, there are 213 national basketball federations which boast over 480 million players registered worldwide (FIBA 2019). The Federation Internationale de Basketball Amateur (FIBA) organisation, or more commonly known now as the International Basketball Federation, is made up of five regional offices around the globe: Africa, Americas, Asia, Europe and Oceania. Basketball has one of the highest incidence of injury of all non-contact sports (3-6 injuries per 1000 hours of play with a conservative estimated annual cost of €500 million per year in European basketball) (Luig *et al.*, 2010). While there is extensive data available on injuries occurring in the game of basketball in America, there is a lack of research data available on basketball injuries occurring in Ireland and the UK.

There is limited evidence about the types and rates of injury in Ireland and the UK. To understand what is happening we need to gather evidence and in order to do this we need to survey what is happening with injuries in basketball in Ireland and the UK.

There are a number of factors that make it difficult to generalise between injury rates and risk factors when we compare the sport played between the United States and Europe. Basketball rules are global, but European competitions have rule variations compared to American. Basketball court dimensions differ between FIBA European and the American NBA and NCAA divisions (see Table 1-1).

The 3-point line made its first appearance in 1961 in the American Basketball League and only lasted 1.5 seasons. This was the end of the 3-point line until it was reintroduced in 1979 to the NBA, with the NCAA implementing it in 1986. Players are becoming more efficient at shooting and while size was a crucial factor in match-ups in the past, the 3-point line has given smaller teams a more even playing field. The 3-point line has changed the way the game is played. For a smaller team, it allows them to shoot more from the perimeter and avoid going into the key area where many of the taller players are defending the basket and there is a greater possibility of player contact. The 3-point shot requires the player to have good shooting form, strength and accuracy. This shot is not the first choice shot in younger age players who prefer to drive to the basket to try and score a higher percentage shot. While there are some very good 3-point shooters in the UK and Ireland, many teams still focus on a fast break game and inside plays in the key area where the highest numbers of injuries occur. The narrower key size in the European basketball court compared to the American key may also contribute to the increased incidents of injury, with players having less space to manoeuvre and land safely than their counterparts in America.

Table 1-1: International Basketball Court Dimension Variations (imperial)

Rules	FIBA Europe	Australian Basketball League	NBA (Men)	WNBA (Women)	NCCAA & NAIA
Court Dimensions	91’ 10” x 49’ 2.5”	91’ 10” x 49’ 2.5”	94’ x 50’	94’ x 50’	94’ x 50’
3-Point Line Distance	20’	20’	23’	20’	Men 22’ Women 20’
Key Size	19’ x 13’ 12.5”	19’ x 13’ 12.5”	19’ x 16’	19’ x 16’	18’ x 12’

In addition, while there are specific playing positions in the sport of basketball, the physical characteristics of the players playing in those positions may also be different between America and the UK and Ireland. The three playing positions in basketball are Forwards, Centers and Guards. These positions can be further described in more specific roles as Point Guard, Shooting Guard, Small Forward, Power forward and Center. The Center and Power Forward players are usually the tallest and the heaviest players on court as the position requires a player with greater mass to play in the low or middle-post positions due to the high level of contact when boxing out, setting picks and rebounding. The point guard and shooting guards players are smaller and slimmer. There is more emphasis on skill levels for this position for shooting, guarding the ball or playmaking. These players need to be quick and therefore there is less emphasis on upper body strength (Ben Abdelkrim *et al.*, 2010).

A term often used in basketball is “match-up” – where players strategically match-up against one another. Mis-matches present strategic opportunities to be exploited during the course of play. For example, where a taller player is being marked by a smaller player, the team will try to get the ball to them and then with the weight and height difference capitalise on the match-up to score and even get a “and one” (term used for a free throw when you are fouled after a score). In NBA and NCAA College games, most teams are able to match-up against each other. The average heights per position in the NBA and NCAA divisions are shown in Table 1-2 and Table 1-3 for male and female players respectively. Also included in the table are the heights per position from players in Ireland and the UK participants of a study in 2014-2015 season.

Table 1-2: Male Player Heights (cm) in US, Irish and UK Leagues

Year	Country	League	Average Height	Point Guard Height	Power Forward Height	Center Height
2019 - 2020	America	NBA	Mean 202cm	Mean 190.5cm	Mean 207.87cm	Mean 209cm
2019 - 2020	America	NCAA	Mean 195.98cm	Mean 187.96cm	Mean 200cm	Mean 205.74cm
2014 –2015	Ireland and UK	National leagues	Mean 181.18cm Range 142cm – 208cm	Mean 169.85cm Range 142cm – 185cm	Mean 190.12cm Range 180cm – 206cm	Mean 192cm Range 155cm – 208cm

Table 1-3: Female Player Heights (cm) in US, Irish and UK Leagues

Year	Country	League	Average Height	Point Guard Height	Power Forward Height	Center Height
2019 - 2020	America	WNBA	Mean 185.42cm	Mean 172.72cm	Mean 187.96cm	Mean 195.98cm
2019 – 2020	America	NCAA	Mean 182.88cm	Mean 172.72cm	Mean 182.88cm	Mean 187.96cm
2014 –2015	Ireland and the UK	National leagues	Mean 173.92cm Range 140cm – 191cm	Mean 169.11cm Range 163cm – 178cm	Mean 177.95cm Range 160cm – 191cm	Mean 184.71cm Range 175cm – 191cm

Many countries have the luxury of picking players for specific positions based on height. However, in Ireland, playing positions are often filled by the players that are available at a given time to a team. In reality, a point guard from one team may match the height of a centre from another team. This becomes apparent in European competition level. For instance, in the 2019 U20 Men's European Championships, Ireland had the two smallest point guards in the tournament. Both players were 5’9" compared to the Dutch point guard who was 6’ 4”. The physicality of the games can lead to injury with these types of mis-matches. In the same tournament a 6’3” Irish forward could mark a 6’10” Russian forward. As basketball has a lot of physical contact, players who are large for their position are often of a better standard in close quarter marking (Sallet *et al.*, 2005).

So when we look at injury in relation to a player's position we are not comparing players with similar physiological characteristics between countries such as Ireland, UK and America. Before any injury prevention strategies can be effectively implemented in a sport, it is first necessary to fully understand the nature and scope of the problem in Ireland and the UK. To do this effectively, we cannot just rely on data from America. No study has ever done this systematically in the UK and Ireland and this gap in our knowledge highlights the need for this particular study.

1.2. Sports Injury Definitions

Centre to sports injury surveillance research is the definition of a sports injury itself. There are a variety of sports injury definitions used in different sports injury research. See Table 1-4. One of the broad injury definitions employed by researchers describes an injury as "any muscular-skeletal complaint newly incurred due to competition and/or training that received medical attention regardless of absence from competition or training" (Junge *et al*., 2008). The advantage of using a definition like this is that it allows for the possibility to assess a broad spectrum of injuries from contusions to fractures and not only those injuries which result in time lost from playing, training or indeed work. However, for most researchers their definition will include time lost from sport in their sports injury definition.

A reportable injury in the National Collegiate Athletic Association - Injury Surveillance System (NCAA- ISS) is defined as an injury that a) occurred as a result of participation in an organised intercollegiate practice or competition, b) required attention from an Athletic Trainer or physician, and c) resulted in restriction of the student/athlete's participation for one or more days beyond the day of injury (Kerr *et al.*, 2014).

Table 1-4: Sports Injury Definitions

Author	Sport	Sports Injury Definition
Junge et al 2008	*Multi Sport*	*Any muscular-skeletal complaint newly incurred due to competition and/or training that received medical attention regardless of absence from competition or training.*
Kerr et al 2014	*Multi Sport*	*An injury that (1) occurred as a result of participation in an organized intercollegiate practice or competition, (2) required attention from an AT or restriction of the student–athlete's participation for 1 or more days beyond the day of injury.*
Verhagen et al 2004	*Basketball*	*A basketball accident with a sudden, direct cause/onset, which required at least minimum (medical) care including, e.g. ice, tape, etc. and which caused the injured player to miss out on at least 1 training or game session*
Hainline et al 2017	*Multi Sport*	*A new or recurring musculoskeletal complaint incurred during competition or training that require medical attention, regardless of the potential absence from competition or training*
Swenson et al 2009	*Multi Sport*	*A sports injury should require restricted activity for at least 1 day*
Junge and Dvorak 2013 (Junge and Dvorak, 2013)	*Football*	*Any musculoskeletal complaint (including concussion) incurred during a match that received medical attention from the team physician regardless of the consequences with respect to absence from the match or training.*
Targett 1998	*Rugby*	*Something that prevented a player from taking part in two training sessions, from playing the next week, or something requiring special medical treatment (suturing or special investigations). An injury was "significant" if it prevented the player from being able to play one week after sustaining it (that is, if it made the player miss the next match).*
FIBA Medical Commission 2017	*Basketball*	*Any musculoskeletal complaint newly occurred due to competition and /or training that received medical attention regardless of absence from competition or training. This definition covers injuries ranging from mild contusion to severe complicated musculoskeletal injury.*

In a study by Cumps *et al.*, they defined an acute injury as being "a basketball accident with a sudden, direct cause/onset, which required at least minimum [medical] care, including e.g. ice, tape, etc., and which caused the injured player to miss out on at least one training or game session" (Cumps, Verhagen and Meeusen, 2007). The IOC has defined sports injury as "a new or recurring musculoskeletal complaint, incurred during competition or training that required medical attention, regardless of the potential absence from competition or training" (Engebretsen *et al.*, 2013). In another study by Swenson, they suggested that a definition of sports injury should require restricted activity for at least one day (Swenson *et al.*, 2009).

In a consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries, an injury was defined as "any musculoskeletal complaint (including concussion) incurred during a match that received medical attention from the team physician regardless of the consequences with respect to absence from the match or training" (Fuller *et al.*, 2006).

In Targett's study into rugby injuries, an "injury" was defined as something that prevented a player from taking part in 2 training sessions, from playing the next week, or something requiring special medical treatment (suturing or special investigations). An injury was "significant" if it prevented the player from being able to play one week after sustaining it (that is, if it made the player miss the next match) (Targett, 1998). FIBA, in their medical resource for basketball team physicians, offer a broad definition of an injury as "any muscular-skeletal complaint newly incurred due to competition and /or training that received medical attention regardless of absence from competition or training". The report states that the definition covers injuries ranging from mild contusions to more severe complicated musculoskeletal injuries (Commission, 2017).

When considering the variety of definitions, it must be ascertained whether or not the injury definitions in use limit or restrict the researcher from capturing important data. Data collection on injury in professional sport is usually carried out by members of the medical team, who are best positioned to monitor players on a daily basis. Detailed medical records are at hand and assist the medical and management staff when designing programmes to keep their players healthy. There is also a buy-in from the players as they see this type of monitoring of data is in their best interests and an investment in prolonging their career as professional athletes.

However, problems may occur when the player is self-reporting and, whether through lack of understanding of the definition of an injury or the individual's perception of "what is an injury", important data may be lost. Some of the injury definitions used in studies can be based on whether a medical professional made an injury diagnosis, time missed from the onset of injury to return to training and, if treatment was required at the time of injury. However, what about the self-reporting amateur athlete who suffers an injury, and who does not attend a doctor, has not had a diagnosis and who shows up to training still suffering the effect of an injury? Players may not record the incident during training or competition as a specific injury and this will be a limitation in the data collected. There are limitations associated with injury definitions and comparability between same-sport research and competition**.** Therefore there is a need to select a sports injury definition and include appropriate questions to allow the researcher to capture as much data on injury as possible.

1.3. Injury Classification and Coding Systems

Sports medicine researchers use injury and illness classifications systems to:

A. Accurately classify and group diagnoses for research and reporting allowing easy grouping into parent classifications for summary, so that injury and illness trends can be monitored over time.

B. Compare injury or illness incidence or prevalence between groups (e.g. different teams, leagues, sports and sexes).

C. Create databases from which cases can be extracted for in-depth research on specific types of injuries and illnesses.

D. Facilitate comparative studies between different research projects with the use of common coding systems (Orchard *et al.*, 2020).

There have been many difficulties when comparing sports injuries epidemiological studies and deciding what systems to use for one's own specific area of research. Whatever system is engaged by the researcher, it needs to be easily comparable with other studies. When looking at the International Classification of Diseases (ICD) there are many specific sports medicine diagnosis absent from their injury collection (Rae *et al.*, 2005).

The Sports Medicine Diagnostic Coding System (SMDCS) was developed in 1991 and was used in the Canadian Intercollegiate Sports Injury Register (CISIR). It was later used in the Canadian Athletic monitoring program, the National Hockey League and the National College Athletic Association (NCAA) for the injury surveillance system. Another coding system was developed in 1992 called the Orchard Sports Injury Classification System (OSICS). It was developed initially for use in Australian Rules football but is used now on a wider variety of sports including tennis, rugby union, cricket and soccer. It has gone through many developmental changes and is now in its 10th edition.

A meeting of the IOC in 2019 was convened with the purpose of updating recommendations for sports epidemiological research to provide guidance to researchers on how to plan and conduct data collection and, subsequently, how to report this data to encourage consistency in comparable research studies (Bahr *et al.*, 2020). These recommendations can provide the detail on injury codes which may be integrated into a specifically designed system to collect data on injuries occurring in basketball in Ireland and the UK.

In the FIBA medical resource pack, injuries are classified under the general terms of Acute and Chronic/Overuse injuries. They describe an acute injury as one where they know the mechanism of injury (how it happened) as this is obvious at the time of injury. When the injury occurs, the force exerted on the specific musculoskeletal tissues is greater than the tensile strength of the structure, resulting to damage of the tissue itself. The most common injuries that present acutely are ligament sprains, muscle strains, contusions and tendon injuries. Injuries such as concussions, fractures, and brain trauma also occur but to a lesser extent (Commission, 2017).

In the FIBA medical resource for physicians, an overuse/chronic injury is referred to as “an injury resulting from repetitive microtrauma without an identifiable triggering event”. In this case overuse injuries commonly affect tendons and bones resulting in tendonopathy or sometimes stress fractures. Factors causing overuse injuries are generally categorised as intrinsic and extrinsic factors.

Injury questionnaires may include different terminology for the person who is inputting the data. Some of the terminologies which may be included are – contact Vs non-contact injury, acute or chronic injury, reoccurring injury, previous injury, overuse injury and gradual or sudden injury. The medical and management team who are aware of and understand this terminology can gain information through interviewing the player. However, this level of instruction or information is not available to the self-reporting athlete and may also result in poor or loss of important data collected at the time of injury.

Sports medicine professionals utilise injury classification codes when recording injury-related data with players. Data on injuries such as acute v chronic, repeat injury, gradual onset or sudden onset of injury are easily captured through interview and easily analysed. However, the self-reporting player or amateur team who do not have this expertise may not understand the nature of the injury and may choose to avoid recording data on the injury as they may be confused. For this reason, questions on injuries need to be in simple language format, with the Primary Investigator being responsible for creating questions that are presented in a logical manner to capture important injury-related data. Therefore, this research study is important and can address gaps in other research which uses self-reporting participants.

1.4. Rates of Injury

The fundamental unit of injury measurement is rate. To calculate a valid injury rate, the number of injuries experienced (numerator data) is linked to a suitable denominator measure of the amount of athletic exposure to the risk of injury. Thus a rate consists of a denominator and a numerator over a period of time. Denominator data can be a number of different things including the number of athletes in a club or team, the number of games played, the number of minutes played, or the number of player appearances. The choice of the denominator affects the numerical value of the derived data and also their interpretation (Schootman, Powell and Torner, 1994). For example, injuries can be expressed as the number of injuries per game or training, an injury per many minutes of play, or the number of injuries per (*x*) player appearances. Other injury rates expression may be by 1000 hours of exposure, weeks of exposure or per season. Researchers may also be confronted with the situation of lower participation numbers, so we must be aware that the decision on how to express the rate of injury may have been associated with limitations in the data which was collected by the research team.

In order to successfully compare expressions of injury rate, the current mechanisms of measurement need to be identified. Will a player be asked to include time spent at all training types, both team and on an individual level? Is game participation enough, or are the actual minutes played more important? Is participation in other/different sporting activity a factor to include? Understanding how other researchers are expressing rates of injury informs the information we need to collect in order to be able to express them in an appropriate way for analysis and comparability.

The way in which incidence is expressed has also been shown to affect the calculation and interpretation of incidence rates. Increasingly, incidence rates in all sports are being expressed as rates per 1000 hours. This is a good approach and allows some comparison across sports. However, a further refinement of the calculation of incidence rates is to measure the actual exposure time at risk. Thus expected injuries are calculated using player exposure/risk hours. These risk hours should ideally include training time as well as competitive participation (Phillips, Standen and Batt, 1998).

Here is an example of how exposure/risk hours are calculated in rugby league, a team sport. There are 13 players per team on the field at any one time. The duration of the game is 80 minutes (1.33 hours). Thus there are 17.33 player exposure/risk hours per team per game of rugby league (13 × 1.33). Over an average season of 30 games, there may be 520 player exposure/risk hours (13 × 1.33 × 30) (Phillips, 2000). To calculate the incidence in relation to these exposure hours, the total number of injuries recorded over a period is divided by the total exposure for that period, and the result multiplied by 1000 to obtain the rate per 1000 hours. This period could be one game, several games, or a whole season or number of seasons. To see if there are significant differences across games or seasons, observed and expected injuries can be used.

Therefore, it is important that the United Kingdom and Ireland Basketball Injury Prevention Study – Injury Surveillance System (UKIBIPS-ISS) has a questionnaire that allows the collection of detailed information on player exposure rates to training and games in order to establish injury rates in Ireland and the UK in an appropriate way for comparison with other research.

1.5. Risk Factors in Basketball

The sport is classified as a non-contact sport which may lead many to believe that the sport is relatively safe with a low incidence of injury. However, in a 2007 study by Cumps *et al.*, where they observed one hundred and sixty-nine players over a full season, they stated that with such a high injury incidence of 9.8/1000 hours (of which 62% of acute injuries were caused by contact), basketball can no longer be considered a safe, non-contact sport. Meeuwisse, in a 2003 study, observed 318 Canadian college basketball players over two full seasons. One hundred and forty-two players sustained two hundred and fifteen injuries, with more contact injuries than non-contact injuries (a 4:3 ratio). Player contact accounted for 79.8% of all contact injuries and 34.9% of total injuries. Basketball has been identified as having one of the highest overall injury rates of non-contact sports rate of injury, of all non-contact sports (Cumps, Verhagen and Meeusen, 2007), (Conn JM, 2003), (Meeuwisse, Sellmer and Hagel, 2003) and (Yde and Nielsen, 1990).

Difficulties when trying to compare basketball injury research studies are similar to that often experienced with other sports injury-related research. Problems can occur when comparing statistics on injuries across sports because of factors such as numbers of participants, time played and varied injury definitions. Another possible weakness can be trying to make comparisons with other research studies that have not used the same injury coding or methodology (Phillips, 2000).

There is a general consensus from epidemiological studies that risk factors can be classified into two groups, extrinsic and intrinsic factors (Lysens *et al.*, 1984). The extrinsic factors are the type of sport, the rules, playing time, position on the team and the level of competition. The intrinsic factors are person's age, somatotype, physical fitness, previous injuries, muscular tightness, joint instability and malalignment of the lower extremities. In the same study, Lysens also highlighted the influence of other external factors like the playing environment and the equipment used. 32 different types of risk factors for basketball injuries have been identified in basketball injury research studies (see Table 1-5).

Table 1-5: Identified Extrinsic and Intrinsic Risk Factors for Injury in Basketball

Extrinsic Factors		Intrinsic Factors	
Player Position	Seasons Played	Age	Weight
Level of Competition		Height	Gender
		Race	
Footwear Choice	Age of Footwear	Flexibility	Previous Injury
Protective Gear		Laxity	Limb Alignment
		Strength	Hormonal Differences
Games	Warm-up	Balance	Fitness
Not Stretching	Training		
Player Contact	Court Location	Skill Level	
Length of Season	Time of Injury		
Landing	Rebounding		
	Pre-season Training		
Facilities			

As part of this literature review, the main extrinsic and intrinsic risk factors for injury in basketball were identified from 20 studies spanning 30 years. This allowed the Principal Investigator to develop a bespoke questionnaire to capture the necessary data that was easily comparable with other sports injuries studies. While a summary is provided in Table 1-5 above, the full listing of the studies, their year of publication and their pertinent risk factors is included in Appendix 1. The identification of these risk factors also provided the framework for the design of the assessment phase of the current study for injury risk prediction. While risk factors may be the same, rates have not been established in UK and Irish Basketball and, as discussed earlier ,rules and regulations differ between Europe and America along with player characteristics. Therefore, this research is important to add to previous bodies of work in this area.

1.5.1. Player Position and Injury Risk

Meeuwisse (Meeuwisse, Sellmer and Hagel, 2003) highlights a player's position on court as a major risk factor for injury. Player position has also been cited as an injury risk factor in other previous research (Cumps, Verhagen and Meeusen, 2007), (Kofotolis and Kellis, 2007) and (Leanderson, Wykman and Eriksson, 1993). Point guards and Shooting guards are required by position to cover a large area of the court at a high speed. In contrast, Forwards and Centers are more often exposed to more aggressive contact in the confined area of the “key” or “zone” under the basket. The Center position has the highest rate of injury followed by Guards and Forwards (Meeuwisse, Sellmer and Hagel, 2003). For contact injuries, Forwards had 29 injuries for 6687 exposures to either training or game time and a rate of 4.43 per exposure. Guards had 38 injuries for 7911 exposures and a rate of 4.80. Centers had 15 injuries for 553 exposures and a rate of 27.12. For non-contact injuries, Forwards had 18 injuries for 6687 exposures and a rate of 2.69, Guards had 25 injuries for 7911 exposures and a rate of 3.16, and Centers had 20 injuries for 553 exposures and a rate of 36.16.

Kofotolis carried out a two-year study of eighteen teams (204 female players) in the Greek leagues – there were fifty ankle injuries which included thirty-two ankle sprains. With regard to player position and injury, Centers had the highest rate of injury and Small Forwards had the lowest. Rates per position were as follows: Centers had 9 injuries for 1707.8 exposures and at rate of 5.26, Guards had 13 injuries for 10,881.8 exposures and at rate of 1.19, Point Guards had 4 injuries for 11,507.6 exposures and at rate of 0.34, Small Forwards had 2 injuries for 7994.6 exposures and at rate of 0.25 and Power Forwards/Centers had 4 injuries for 3602.2 exposures and at rate of 1.11 (Kofotolis and Kellis, 2007).

Cumps in her 2007 study found no statistical difference for ankle injury in relation to player position. However, anterior knee pain divided among players showed that Forwards had the lowest prevalence (12%), followed by Guards (20%) and Centers (26%). Significant differences between the prevalence of anterior knee pain was found only between Forward and Center players (OR=0.5[95%CI: 0.2-0.9]) with Forward players being at a lower risk (Cumps, Verhagen and Meeusen, 2007).

1.5.2. Gender and Injury Risk

The risk of injury associated with gender has been examined by a number of studies (Deitch *et al.*, 2006) (Hosea, Carey and Harrer, 2000; Fuller and Drawer, 2004; Hickey, Fricker and McDonald, 1997; Emery *et al.*, 2007; Murphy, Connolly and Beynnon, 2003; Hewett, 2000; Zelisko, Noble and Porter, 1982) and (Malone, 1993). In a study by Zelisko, (Zelisko, Noble and Porter, 1982) they identified a 60% greater risk of injury for female players than men. Hosea (Hosea, Carey and Harrer, 2000) carried out a two-year intercollegiate study with eleven thousand seven hundred and eighty athletes (6840m/4940f). In total there were one thousand and fifty-two ankles injuries, with female players having a 25% greater risk of sustaining a grade 1 ankle injury than their male counterparts and finally Deitch in the National Basketball Association (NBA) and Women's National Basketball association (WNBA) injury study identified women players as having a higher risk of game associated injuries than the male players. WNBA players were more likely to suffer a sprain (10.1 per 1000 Athlete Exposures (AE) [95% CI 8.8-11.3]) in a game than their male NBA counterparts (7.2 per 1000 AE [95% CI]) and also that the WNBA players suffered a higher incidence of knee injuries than the men. The female players game-related ACL injury rate was 4 times that of the NBA players and overall, experienced a rate 1.6 times that of their NBA counterparts (Deitch *et al.*, 2006).

One basketball study which contradicts the finding of this and the other studies mentioned is that by Messina *et al.* who in their study of high school basketball players found that 973 male players reported a total of 543 injuries which resulted in an injury rate of 0.56 per athlete per season while in the girls study there were 890 participants with a total of 436 injuries reported for an injury rate of 0.46 per athlete per season. The rate of knee injuries was significantly higher in females (p 0.0001). The incidence of knee injuries was 0.71 knee injuries per 1000 player-hours exposure for girls and 0.31 knee injuries per 1000 player-hours for boys. Thus, the risk of knee injury in girls was 2.29 times greater than in boys (P, 0.001) (Messina, Farney and DeLee, 1999).

1.5.3. Game vs. Training Risk Factor

There is also an increased risk of injury in games over practice sessions according to studies by (Meeuwisse, Sellmer and Hagel, 2003), (Murphy, Connolly and Beynnon, 2003), (Messina, Farney and DeLee, 1999), (Agel *et al.*, 2007a), (Borowski *et al.*, 2008) and (Dick *et al.*, 2007a). Meeuwisse stated that injuries occurred 3.7 times more in games than during training. Agel's sixteen year study between 1988 – 2004 identified that the rate of injury in games was almost 2 times higher than that at training (7.68 versus 3.99 injuries per 1000 AE, rate ratio = 1.9, 95% confidence interval = 1.9, 2.0). There was also a difference noted between pre-season training and regular season training with pre-season injury rates more than twice as high as regular practice rates (6.75 versus 2.84 injuries per 1000 AE, rate ratio = 2.4, 95% confidence interval = 2.2, 2.4).

In Borowski's high school study he states that there were 1518 injuries during 780,651 (m 423,239/f 357,412) player exposures for an injury rate of 1.94 per 100 AE. The injury rate per 1000 player exposures was greater during games (3.27) than training (1.40; rate ratio, 2.23; 95% CI, 2.10-2.57) and was greater among girls (2.08) than among boys (1.83; rate ratio, 1.14; 95% confidence interval, 1.03-1.26). In Dick's sixteen-year men's collegiate basketball study between 1988 – 2004 he stated that the overall rate of injury was 9.9 per 1000 player exposures for games and 4.3 per 1000 player exposures for training.

1.5.4. Basketball Court Area Risk Factor

Specific areas on the basketball court have been identified as having greater risk of injury over others, in particular the key area, as cited in studies by Meeuwisse (Meeuwisse, Sellmer and Hagel, 2003) and (Kofotolis and Kellis, 2007). Meeuwisse, in his 2003 study, stated the greatest number of injury events occurred in the key area and accounted for 44.7% of all injuries at a rate of 2.21 injuries per 1000 player exposures. In Kofotolis's Greek basketball study they also identified the key area as the location of the highest amount of injuries accounting for 56.3% (P= .007) of all ankle sprains at a rate of 0.45 per 1000 hours of exposure (Kofotolis and Kellis, 2007).

1.5.5. Previous Injury as a Risk Factor

Previous injury in a player is a well-documented risk factor for injury. This specific risk factor can be seen in studies by (Meeuwisse, Sellmer and Hagel, 2003), (McKay *et al.*, 2001b), (Agel *et al.*, 2007a), (Murphy, Connolly and Beynnon, 2003), (Kofotolis and Kellis, 2007) and (Cumps, Verhagen and Meeusen, 2007). Kofotolis stated that 67% (n=138) of the study's participants had suffered a previous ankle injury and of these players 17.39% (n=24) sustained a new ankle injury. McKay stated that a player with a previous history of an ankle injury was almost 5 times more likely to sustain an ankle injury (OR) 4.94 or 95% with a confidence interval (CI) 1.95 to 12.48. Agel stated that 30% of ankle ligament sprains were identified as recurrent sprains.

1.5.6. Landing as a Risk Factor

Landing from either shooting, blocking or rebounding is seen as a risk factor for injury in studies by (McKay *et al.*, 2001b), (Agel *et al.*, 2007a), (Borowski *et al.*, 2008) and (Cumps, Verhagen and Meeusen, 2007). McKay stated that 45% of all ankle injuries were incurred while landing. He further stated that 50% of these injuries were sustained by landing on another player's foot and the other 50% were due to landing on the court surface. Agel states that of the ligamental injuries reported in the NCAA 45% occurred from landing on another player. Borowski stated that jumping/landing accounted for 17.5% of all injuries and that 29.4% of all ligament sprains were caused as a result of jumping/landing (Borowski *et al.*, 2008).

1.5.7. Shoe Selection as a Risk Factor

Shoe selection by players is cited by McKay *et al.* (one of the largest basketball studies carried out) in their 2001 study as being one of the three major risk factors for ankle sprains, specifically shoes which contain an air cell sole (McKay *et al.*, 2001b). McKay stated that wearing shoes with air cells in the heel were 4.3 times more likely to injure an ankle than those wearing shoes without (OR 4.34, 95% CI 1.51 to 12.40). Previous studies by (Jenkins and Raedeke, 2006), (Curtis *et al.*, 2008), (Cumps, Verhagen and Meeusen, 2007) and (Barrett *et al.*, 1993) found no significant risk factor in shoe selection. The use of a high top basketball shoe is still one of the best means for protecting the ankle from inversion sprains. NBA players choose a wide variety of shoe gear styles to play in: 68% of the players utilise a high top shoe, 15% utilise a 3/4 top shoe, and only 10% will use a low top basketball shoe for regular play (Lowe, 2012).

Dr Michael Lowe, Team Podiatrist of the Utah Jazz of the NBA, stated that a high school basketball player can greatly decrease his/her incidence of overuse injury by simply replacing his/her basketball shoes frequently. Lowe presented a study which showed that the average high school basketball player will utilise only one pair of new basketball shoes per season. His recommendation is that the basketball shoes be changed monthly during the season. This has been found to greatly decrease the rate of injury to professional players, to the point that they will often replace shoe gear every two to three days or games (Lowe, 2012).

The use of proper shoe gear has a strong relationship to the performance and stability of foot function within the shoe. Those shoes which complement foot requirements for stability, flexibility and shock absorption, can greatly aid in the dissemination of stress to foot and leg structure. The amount of stress applied to the shoe gear before replacement with a new shoe also has a profound influence on protecting the athlete.

Dr Lowe stated that the average high school or collegiate athlete will work out easily 72 hours per month. Basketball shoes are now being made from materials types such as Eva or polyurethane midsole and a harder outer sole material. These materials all have a fatigue factor which greatly influences function of foot and stress delivered to bone and soft tissue structures. Players in the NBA will rarely use a basketball shoe for longer than 7-10 days before replacing it with a new pair of shoes.

A positive secondary by-product of frequent shoe change is that of a protective influence of shoe gear to foot and ankle stability to external forces. As the shoe is worn over hours of use, the leather uppers slowly begin to stretch to the rotational forces applied. Also, the midsole material slowly deforms or compresses to repetitive ballistic starting and stopping of play. As these external changes to the shoe continue, the rotational movement of the foot within the shoe slowly increases in range of motion. Therefore, it can be seen that with newer shoe usage, there will be fewer inversion injuries as compared to injuries due to the lack of support from worn and stretched shoe gear materials which lack the integrity to decelerate foot rotational movement beyond normal positioning. Amateur players may not have the luxury of changing shoes frequently during the season due to costs and therefore may be governed in their shoe selection by cost and not protection.

1.5.8. Flexibility as a Risk Factor

A player not stretching is a risk factor for injury in the conclusions of McKay (McKay *et al.*, 2001b). McKay stated that players who did not stretch before a game were 2.6 times more likely to injure an ankle than those who did (OR 2.62, 95% CI 1.01 to 6.34). In their study, both elite and recreational basketball competitions were observed prospectively to identify injuries prospectively. At the end of a game, players were asked if they sustained an injury and if they had, they were asked to fill out a questionnaire. A control group was obtained by administering a questionnaire to entire teams of players who were not injured on a particular day but had competed in the same competition as the injured players. Stretching was considered included if players had incorporated a general stretching routine as part of their warm up. McKay's study documented 276 injuries, 14% involved ankle sprains. Of the ankle sprain group, there was a trend towards more ankle sprains occurring in the non-stretching group (59%) than the stretching group (41%) (McKay *et al.*, 2001b).

Lysens *et al.* suggested that there was a relationship shown between tightness of the calf muscles and ankle injuries. This suggested that tightness of the calf muscle may be responsible for ground contact of the feet in the supinated position, with a high risk of an ankle sprain (Lysens *et al.*, 1989). McKay also recommends that an appropriate stretching programme be taught to basketball players, particularly those with a history of ankle injuries (McKay *et al.*, 2001a).

1.5.9. Player Contact

Player contact has been described in the research work of (Meeuwisse, Sellmer and Hagel, 2003), (Agel *et al.*, 2007a), (Kofotolis and Kellis, 2007) and (Dick *et al.*, 2007b) as another risk factor for injury. Meeuwisse stated that the most common mechanism of injury was contact with another player, and further grouped these contact injuries into those resulting in players missing less than seven sessions (63 injuries at a rate of 1.45 per 1000 player exposures) or missing more than seven sessions (12 injuries at a rate of 0.28 per 1000 player exposures) (Meeuwisse, Sellmer and Hagel, 2003). Agel stated that 46% of all game injuries resulted from player contact (Agel *et al.*, 2007a). Kofotolis also stated that the most common mechanism of injury was contact with another player, and also categorised them into two groups: contact injury causing the player to miss less than seven sessions (17 injuries at a rate of 0.47 per 1000 player exposures) or to miss more than seven sessions (1 injuries at a rate of 0.03 per 1000 player exposures) (Kofotolis and Kellis, 2007). Dick stated that most game (52.3%) and training (43.6%) injuries resulted from player contact (Dick *et al.*, 2007a).

1.5.10. Other Risk Factors

To a lesser extent, the following researchers have identified some other risk factors such as race, BMI and posture. Trojian's 2006 study into anterior cruciate ligament (ACL) injuries in women's professional basketball stated that the ACL tear rate for white European and American players was 0.45 per 1000 hours of player exposures, whereas for non-white (black, African American, Hispanic and Asian) European players, the rate was 0.07. The odds ratio (OR) for ACL tears in white vs. non-white European players was 6.55 (95% CI, 1.35-31.73). The study concluded that white European players have more than 6 times the ACL tear rate than other ethnic groups combined (Trojian and Collins, 2006).

A study by Yeh *et al.* looked at the incidence of meniscal tear injuries over a twenty-year period in the NBA. They identified 129 meniscal injuries and looked at the relationship between BMI and these meniscal injuries. Their findings concluded that players with a BMI greater than 25.0 had a statistically significant higher risk of injury (2.18 per 100 player seasons than those players who had a BMI of less than 25.0 (IRR, 1.65; 95% CI, 1.2-2.3; P < .05) (Yeh *et al.*, 2011). McGuine collected data over two seasons on 210 players over the first two weeks of their season. Players with a higher postural sway score suffered increased ankle sprain injury rates (p=001). They concluded that players with poor balance (high sway scores) had almost 7 times as many ankle sprains as players with good balance (low sway scores) (P=0.0002), (McGuine *et al.*, 2000).

There has not been much research into the time of injury during a game or practice. A study of knee injuries in high school female basketball players found that most injuries occurred in the first half of the season (Wirtz, 1982). Fatigue as a possible risk factor has been cited by Gutgesell (Gutgesell, 1991), who stated that 40.7% of all injuries in a YMCA basketball programme occurred in the last quarter of the game. A 1995-1997 injury surveillance overview of high school basketball players found that 59% of injuries in boys games and 63% in girls games came in the second half (Association and (NATA), 2004).

Dick in his NCAA study into men's basketball injuries during uncontrolled game situations stated that injuries to the head and face had increased substantially over the course of the 16-year study, with an average increase of 6.2% (P=.01) (Dick *et al.*, 2007a).

A study of high school and collegiate basketball players stated that injury rates were 2.73 times higher in college players (4.96 for 1000 player exposures) than in high school players (1.82 for 1000 player exposures). A reason for this may be different levels of intensity and competition in the college game (Clifton *et al.*, 2018).

Agel *et al.* reported that pre-season training injury rates were more than twice as high as regular season training (6.75 versus 2.84 injuries per 1000 hours of player exposures, rate ratio= 2.4, 95% CI=2.2-2.4) (Agel *et al*., 2007b). Dick *et al.* in the 16-year college basketball review stated that across all divisions in the NCAA, pre-season training injury rates were almost 3 times higher than in season practice rates (7.5 versus 2.8 per 1000 player exposures, rate ratio 2.7,95% CI 2.6, 2.8, P<.01) (Dick *et al*., 2007).

Gaps in the risk factor questionnaires used for Injury Surveillance Systems need to be identified to inform the research team's design of a more complete data collection mechanism. There may be differences between geographical leagues and between the levels of competition being played.

1.5.11. Body Location and Injury

Basketball requires repetitive jumping interspersed with running and rapid change of direction, and this pattern is indicated in the lower limb being more affected by injury than the upper limb. With regard to the distribution of injuries by body region, the **Lower limb** accounted for the highest percentage of injuries in the following studies:

- (Agel *et al.*, 2007a) 68%
- (Crawford, 1990) 66%
- (Dick *et al.*, 2007a) 57.9%
- (Deitch *et al.*, 2006) 65%
- (Meeuwisse, Sellmer and Hagel, 2003) 67.4%
- (McKay *et al.*, 2001b) 46.8%
- (Starkey, 2000) 46.4%

Head and neck injuries were distributed as:

- (McKay *et al.*, 2001b) 23.7%
- (Agel *et al.*, 2007a) 14.7%
- (Dick *et al.*, 2007a) 13.9%
- (Meeuwisse, Sellmer and Hagel, 2003) 10.2%
- (Crawford, 1990) 9.6%
- (Starkey, 2000) 8.5 %

Upper limb injuries were distributed as:

- (McKay *et al.*, 2001a) 23.2%
- (Agel *et al.*, 2007a) 14.1%
- (Meeuwisse, Sellmer and Hagel, 2003) 13.5%

- (Starkey, 2000) 12.1%
- (Crawford, 1990) 5.6%

The **Spine and Pelvic** injuries were distributed as:

- (Crawford, 1990) 14.9%
- (Dick *et al.*, 2007a) 11.4%
- (Starkey, 2000) 9.5%
- (Agel *et al.*, 2007a) 7.4%
- (Meeuwisse, Sellmer and Hagel, 2003) 6.65%
- (McKay *et al.*, 2001a) 6.3%

Other injuries in each of the studies were distributed as follows:

- (Starkey, 2000) 23.5%
- (Agel *et al.*, 2007a) 3%
- (Dick *et al.*, 2007a) 2.7%
- (Meeuwisse, Sellmer and Hagel, 2003) 2.3%
- (Crawford, 1990) 2.2%

In a basketball injuries study review by Andreoli *et al.*, they reviewed 11 studies which had more than 12,000 basketball injuries. Their results showed that there were more injuries to the lower limbs 63.7%, regardless of gender (Male 65.2%; Female 68.4%) or level of competition (Professional 64.7%, Masters, 74.5% and Children and Adolescence 62.5%).

With regard to a specific anatomical region, the largest proportion of injuries occurred in the ankle (2832 injuries, 21.9%) followed by the knee (2305 injuries, 17.8%), (Andreoli *et al.*, 2018). Many authors have reported that the ankle is the most common site injured (Messina, Farney and DeLee, 1999), (Powell and Barber-Foss, 1999), (Dick *et al.*, 2007a), (Agel *et al.*, 2007a), (Starkey, 2000) and (Zelisko, Noble and Porter, 1982).

With the knowledge that the lower limb suffers a higher rate of injury than other body parts in basketball players, a pre-participation screening assessment focusing on the lower extremity would be indicated as part of the UKIBIPS research study.

1.6. Pre-Participation assessment testing in sport

The Risk Management Framework model described by Fuller and Drawer identifies the need to establish, in the first case, the intrinsic and extrinsic risk factors for injury in any sport (Fuller and Drawer, 2004). Meeuwisse *et al.* state that understanding the causes and risk factors of sports injury are prerequisites for injury prevention (Meeuwisse *et al.*, 2007). The 1992 four stage injury prevention model (Figure 1-1), described by Van Mechelen *et al.* establishes the identification of injury risk factors as the first stage in their model for injury prevention (Van Mechelen, Hlobil and Kemper, 1992).

Figure 1-1: Van Mechelen Injury Prevention Model

Pre-season evaluation represents one of the most important steps prior to resuming formal team-based sports practice; it allows us to positively influence athletes' performance and injury risk. Apart from the identification of life-threatening conditions, this screening is extremely relevant for the planning of the season as it will highlight players' individual needs in terms of strength, flexibility, agility and motor control that can be further addressed in order to avoid injury and improve performance. Pre-participation screening tests should gather relevant information to create a profile of every athlete, relying on tests relevant to performance and also be evidence-based (Ferreira *et al.*, 2017).

Pre-participation screening as part of injury prevention programmes for teams may be expensive, especially in the amateur game where they may not have qualified personal involved with their teams to carry out testing. Professional teams often have dedicated medical staff and athletic trainers who perform these tests as part of their programmes. However, in the amateur game it can be very difficult to arrange times to test all players outside of prearranged team training schedules due to a lack of resources. Testing during training is frowned upon by many coaches as it reduces their contact time with players.

The importance of injury prevention takes a back seat to training. There has been no research to date on pre-participation screening for basketball players in Ireland or the UK. When selecting tests to use in assessments it is of paramount importance take into consideration the physical demands in basketball such as balance, flexibility, strength and functional movements when trying to develop injury prevention programmes. Within an individual sport the playing position of the player must be considered due to the different physical demands associated with each role. In the absence of injury-related data in Ireland and the UK it is difficult to attempt to implement injury prevention strategies. We therefore need to review pre-participation screening tests that would be suitable for us to use in testing in the sport.

1.6.1. Functional Movement Screen (FMS)

The Functional Movement Screen (FMS) is used as part of programmes for the prevention of musculoskeletal injuries in professional and amateur sports as well as in the military. The Functional Movement Screening test (FMS) is a 7-point movement screen designed to identify dysfunctional movement patterns and asymmetries within the body. The FMS test is a ranking and grading system that documents movement patterns that are key to normal function. By screening these patterns, the FMS test readily identifies functional limitations and asymmetries. These are issues that can reduce the effects of functional training and physical conditioning and distort body awareness. The FMS generates the Functional Movement Screen Score, which is used to target problems and track progress. There are seven test stations which are scored between 0 and 3. The max score is 21 while the minimum is 0. The FMS is one of the most universally used screening test tools and as such has provided reliable normative data across many sports (Mokha, Sprague and Gatens, 2016), (Fox, 2014), (Chorba *et al.*, 2010), age groups (Schneiders *et al.*, 2011), (Abraham, Sannasi and Nair, 2015) and professional sports (Tee *et al.*, 2016) and (Kiesel, Plisky and Voight, 2007).

A system review and meta-analysis was carried out by Bonazza *et al.* who hypothesised that the FMS demonstrates good inter-rater and intra-rater reliability and validity and has predictive value for musculoskeletal injuries. Their results showed that the Intraclass Correlation Coefficient (ICC) for intra-rater reliability was 0.81 (95% CI, 0.69-0.92) and for inter-rater reliability was 0.81 (95% CI, 0.70-0.92). The odds of sustaining an injury were 2.74 times with an FMS score of ≤14 (95% CI, 1.70-4.43).

They concluded that the FMS has excellent inter-rater and intra-rater reliability. Participants with composite scores of ≤14 had a significantly higher likelihood of an injury compared with those with higher scores, demonstrating the injury predictive value of the test (Bonazza *et al.*, 2016).

In a study by Gulgin *et al.*, they looked at the inter-rater reliability between raters of varied experience. This article found that a majority of the individual tests had a strong agreement despite the various level of experience of the raters scoring the Functional Movement Screen. Additionally, the level of experience of the rater scoring the FMS should be considered, as it appears that the expert rater was more critical than novice raters in the interpretation of the scoring criteria (Gulgin and Hoogenboom, 2014).

A research study by Saki investigated the reliability of the Functional Movement Screen (FMS) test. The purpose of the study was to compare the FMS scoring between the beginner level and expert raters using video records. The study subjects comprised 15 elite juvenile male basketball players. The subjects were randomly selected and each of them completed FMS tests. Three examiners (two beginners and one expert) watched the recorded video separately and scored the tests. The test-retest reliability was assessed using Intra-Class Correlation Coefficients (ICCs). Also, the inter-tester reliability of each test was computed using Fleiss' kappa test. Their results showed the mean (SD) total FMS score for rater 1, rater 2, and rater 3 were 14.17(1.26), 14.17(1.94), and 13.67(1.67), respectively. There was no significant difference between examiners with respect to total FMS score (P=0.136). Half of the individual FMS components had perfect agreement, and the rest were categorised as moderate to substantial agreement. The high and moderate values of ICC as 0.88~0.99 and 0.71~0.91 were observed for intra-rater and inter-rater reliability, respectively. The examiners reported FMS total scores similarly. The inter-rater reliability for the test components had strong agreement. Their findings suggested that FMS can be used in the evaluation of the abnormal movement patterns of basketball players (Saki, 2017) with a high degree of confidence.

Having been utilised in previous basketball injury research and identified as being reliable in identifying abnormal movement patterns which can contribute to injury, the FMS has been selected for inclusion as part of the pre-season screening assessment component of the UKIBIPS research study.

1.6.2. Y-Balance Test

The Y-balance Test kit is used to test a person's risk for injury as well as demonstrate functional symmetry. It allows the assessor to measure and quantify a person’s motor control and, while testing how the athlete’s core and each limb work under bodyweight loads, to look at the body in four parts: left versus right and upper versus lower body. The Y-Balance Test Protocol was developed after years of research in lower extremity injury prevention using the Star Excursion Balance Test (SEBT) (Plisky *et al.*, 2009).

In a 2006 study, Plisky *et al.* carried our research to determine if the Star Excursion Balance Test (SEBT) reach distance was associated with risk of lower extremity injury among high school basketball players. Prior to the 2004 basketball season, the anterior, posteromedial, and posterolateral SEBT reach distances and limb lengths of 235 high school basketball players were measured bilaterally. After normalising for lower limb length, each reach distance, right/left reach distance difference, and composite reach distance were examined using odds ratio and logistic regression analyses. The research study found that the reliability of the SEBT components ranged from 0.82 to 0.87 (ICC3, 1) and was 0.99 for the measurement of limb length. Logistic regression models indicated that players with an anterior right/left reach distance difference greater than 4 cm were 2.5 times more likely to sustain a lower extremity injury (P<.05). Girls with a composite reach distance less than 94.0% of their limb length were 6.5 times more likely to have a lower extremity injury (P.05). They concluded that components of the SEBT were reliable and predictive measures of lower extremity injury in high school basketball players, and suggested that the SEBT can be incorporated into pre-participation physical examinations to identify basketball players who are at increased risk for injury.

The Y-Balance test in its simplest form is an instrumented version of components used in SEBT. It was developed to improve the repeatability of measurement and standardise performance of the test. The device utilises the anterior, posteromedial and posterolateral components of the SEBT. In a study with soccer players by Plisky *et al.*, they used the Y-Balance Kit to measure single limb excursion distances. Intraclass Correlation Coefficients (ICC) were used to determine the reliability of the test. The ICC for intra-rater reliability ranged from 0.85 to 0.91 and for inter-rater reliability ranged from 0.99 to 1.00. The composite reach score reliability was 0.91 for intra-rater and 0.99 for inter-rater reliability. This new device and protocol are highly accurate and can be used for measuring pre and post rehabilitation performance, improvement after performance enhancement programmes, dynamic balance for fitness programmes, and return to sport readiness (Plisky *et al.*, 2009).

Bird and Markwick stated that the SEBT/YBT appear to be valuable musculoskeletal screens that contribute to the identification of movement dysfunction in basketball players (Bird and Markwick, 2016). Bressel *et al.* reported that NCAA Division I female basketball players display both inferior static balance compared with gymnasts and impaired dynamic balance compared with soccer players as determined by the SEBT/YBT (Bressel *et al.*, 2007). Bird and Markwick stated that the practical relevance of the SEBT/YBT for physical therapists, athletic trainers and rehabilitation professionals' centres on its potential application as a prediction tool to identify functional deficits related to the trunk and lower extremity (Bird and Markwick, 2016).

Bird *et al.* have discussed the influence of force interplay characteristics on postural demands during basketball game-play situations that frequently involve high intensity change of directions (Bird and Stuart, 2012). Dynamic tests that challenge postural control and balance allow identification of movement limitations in basketball athletes compared to isolated assessments of muscle function (Bird and Markwick, 2016). The Y-Balance assessment test has been identified as one of the musculoskeletal screens and functional tests that may allow easy identification of inefficient and/or compensatory movement tendencies in athletes and provide an inexpensive yet practical means in determining athletes that may be at risk.

The Move2Perform analysis software is a movement and analysis tool that identifies deficits and the risk of injury. It is a computer software application that has been designed to synthesise results from tests such as the FMS test and Y-Balance test. It is used to calculate the individual's musculoskeletal status specific to their age gender and sports activity. It uses a proprietary algorithm based on published research. When the results of the Y-Balance test are entered into the Move2Perform software, we can establish the personalised injury risk and peer performance measure according to age, gender, and sport/activity (Plisky *et al.*, 2009).

In a 2013 study by Lehr *et al*. looking at field expedient screening and injury risk algorithm as a predictor of non-contact lower extremity injury, they found that athletes who were identified as high risk (n=63) were at a greater risk of non-contact injury to the lower extremity (27/63) during the season [RR: 3.4, 95% CI 2.0 to 6.0]. They concluded "that an injury prediction algorithm composed of performance on efficient, low cost field ready tests can help identify athletes at an elevated risk of non-contact lower extremity" (Lehr *et al.*, 2013).

The Y-balance test has been selected for inclusion as part of the pre-season screening assessment component of the UKIBIPS research study. The move2perform analysis tool will also be included to analyse data collected from the FMS and Y-Balance tools in the research study.

1.6.3. Fitness Test

The Bleep test, also known as the multi-stage fitness test or shuttle run test, is used by sports coaches and trainers to estimate an athlete's maximum oxygen uptake, better known as VO2 Max. The recording is typically structured into 23 'levels', each of which lasts 60 seconds. Usually, the interval of bleeps is calculated to require a speed at the start of 8.5 km/h, which increases by 0.5 km/h with each level. The progression from one level to the next is signalled by 3 rapid beeps. The highest level attained before failing to keep up is recorded as the score for that test. The procedure is designed to measure the maximum endurance of an individual (Léger and Lambert, 1982). There are many variations of the Bleep test and it is important to select which tests are most suitable to measure fitness in relation to the demands and movements of a basketball player during a game.

A study by Castanga *et al.* in 2008 was carried out to examine the physiological correlates of the Yo–Yo intermittent recovery test level 1 (Yo–Yo IR1) in basketball players. Anaerobic-capacity was assessed using 15 m shuttle running sprint (15 mSR) and line drill (LD), respectively. The same tests were replicated after an experimental basketball game in order to assess selective effect of fatigue on physical performance. Pre to post-game 15 mSR (5.80 ±0.25 versus 5.77 ±0.22 s) performances were not significantly different ($p > 0.05$). Line Drill performance decreased significantly post-game (from 26.7 ±1.3 to 27.7 ±2.7 s, $p < 0.001$). Yo–Yo IR1 performances (m) were significantly related to VO_{2max} ($r = 0.77$, $p = 0.0001$), speed at VO_{2max} ($r = 0.71$, $p = 0.0001$) and $\%VO_{2max}$ at VT ($r = -0.60$, $p = 0.04$). Yo–Yo IR1 performance was significantly correlated to post-game LD decrements ($r = -0.52$, $p = 0.02$). These findings show that Yo–Yo IR1 may be considered as a valid basketball-specific test for the assessment of aerobic fitness and game-related endurance (Castagna *et al.*, 2008).

In a study by Berdejo-del-Fresno *et al.*, they looked at the 20-meter shuttle run test (Bleep test) and the Yo-Yo test in two high-level British female basketball teams to evaluate and compare both tests. The results showed statistical differences were found between the VO2max values of the two teams obtained in the 20-meter shuttle run (p=0.000), and between the VO2max calculated by Yo-Yo IR1 and the VO2max calculated by 20-meter shuttle run without taking into account the age (p=0.002). Berdejo-del-Fresno *et al.* stated that there are no differences when it comes to the use of the Bleep test or the Yo-Yo test in order to calculate the maximum oxygen uptake through an indirect method. A further important finding in their research was that British basketball players showed cardiorespiratory levels (VO2max) lower than high-level female basketball players from countries where basketball is more popular and better developed (Berdejo-del-Fresno and Gonzalez Rave, 2013).

Schools, colleges and club teams have used the Bleep test to measure fitness in their athletes. Players are familiar with the test and its procedure. Having reviewed the literature, previous research findings support the inclusion of the Bleep test as part of the pre-season screening assessment component of the UKIBIPS research study.

1.6.4. Single Leg Balance Test

The Single Leg Balance Test (SLBT) has been identified as a reliable test for predicting ankle sprains in high school and intercollegiate athletes in a study by Trojian and McKeag (Trojian and McKeag, 2006). Two Hundred and thirty athletes were observed in this study. The SLB Test was defined as standing on one foot without shoes with the contralateral knee bent and not touching the weight bearing leg; the hips were level to the ground; the eyes were open and fixed on a spot marked on the wall; and then the eyes were closed for 10 seconds. Both legs were tested.

A SLB Test was considered positive if the athlete was unable to carry out the test on either or both legs. They found excellent agreement between the physician and the ATC in reproducibility testing, with a high κ statistic of 0.898 (SE=0.07, T score=5.709, $p<0.01$). This is important for verification of the generalisability of the SLB Test to other settings and testers. Their findings support the excellent reliability of the SLB Test. Their results demonstrated prospectively an association between ankle sprains and a positive SLB Test (common odds ratio=2.54 (95% CI, 1.02 to 6.03) ($p<0.05$). The association between a positive SLB Test and ankle sprains was significant ($\chi^2=5.833$, df=1, p=0.016). The relative risk (RR) for an ankle sprain with a positive SLB Test during the PPE was 2.43 (95% CI, 1.15 to 5.14.).

Leanderson *et al.* reported that proprioceptive deficits could predict ankle injury susceptibility in basketball players. In their study, which looked at three teams playing in the Swedish basketball league, they also stated that basketball players with a previously sprained ankle demonstrated significantly increased postural sway in comparison with normal controls and uninjured players (Leanderson, Wykman and Eriksson, 1993).

McGuine *et al.* showed that in high school basketball players, the pre-season measurement of balance predicted susceptibility to ankle sprain injury. The pre-season COMP balance scores for subjects who sustained ankle sprains was significantly higher (p = 0.001) than the COMP balance scores for subjects who did not sustain an ankle injury. Their results indicated that in this cohort of high school basketball players, pre-season measures of balance as quantified by postural sway, predicted susceptibility to ankle sprain injury. The study also indicated that poor balance (postural sway deficits) appears to be present in certain individuals prior to injury and may actually predispose these individuals to injury. The SLB Test has been shown to be a valid test for use in the basketball population with balance deficits and as such has been selected for inclusion as a pre-season screening assessment component of the UKIBIPS research study (McGuine *et al.*, 2000).

1.6.5. Ankle Dorsiflexion Test

In sports such as basketball, poor landing technique has been linked to both initial injury and re-injury (Louw and Grimmer, 2006). Low ankle dorsiflexion range is a risk factor for developing injury in basketball players. In the studied material, an ankle dorsiflexion range of 36.5° or less was found to be the most appropriate cut-off point for prognostic screening (Backman and Danielson, 2011). In their study, 90 junior elite basketball players were examined for different characteristics and potential risk factors for Patella Tendonopathy (PT), including ankle dorsiflexion range in the dominant and non-dominant leg. Data were collected over a 1-year period and follow-up, including re-examination, was made at the end of the year. Seventy-five players met the inclusion criteria. At the follow-up, 12 players (16.0%) had developed unilateral PT. These players were found to have had a significantly lower mean ankle dorsiflexion range at baseline than the healthy players, with a mean difference of –4.7 (P = .038) for the dominant limb and –5.1 (P = .024) for the non-dominant limb. Complementary statistical analysis showed that players with dorsiflexion range less than 36.5° had a risk of 18.5% to 29.4% of developing PT within a year, as compared with 1.8% to 2.1% for players with dorsiflexion range greater than 36.5°. They concluded that the test may provide information that can be used in identifying at-risk individuals in basketball teams and enabling preventive actions (Backman and Danielson, 2011).

In McKay's 2001 study, their results found that basketball players lacking adequate ankle dorsiflexion ROM are nearly five times more likely to reinjure an ankle after a prior ankle injury (McKay *et al.*, 2001a). In a study by Bennell *et al.*, they showed that in healthy subjects, distance and angle measurements of a DF lunge test can be reliably performed by the same therapist as well as by different therapists with varying clinical experience. This study provides evidence to support the use of a DF lunge as an objective measurement tool in physiotherapy practice (Bennell *et al.*, 1998).

The Dorsiflexion Lunge test has been shown to be a valid test for use in the basketball population with restricted ankle movement and as such has been selected for inclusion as a pre-season screening assessment component of the UKIBIPS research study.

1.6.6. Muscle Testing

Manual muscle testing is regularly used by clinicians and sports medical team staff. Muscle testing when used in conjunction with other tests can provide the practitioner with information to make evidence-based decisions when working with an athlete. There are many factors which can contribute to an athlete's dysfunctional movement patterns – muscle tightness, muscle weakness, ligament laxity, neurological dysfunction, joint shape, previous injury and training methods.

Muscle tightness may protect a joint, but research has shown that muscle tightness may also contribute to injury. Krivickas *et al.* in their study on lower extremity injuries looked at the relationship between muscle tightness and ligament laxity to see if they had any influence on injury in athletes. In their testing they assessed the following muscle groups for tightness: Iliopsoas, Rectus Femoris, Gastrocnemius, Hamstrings and the Tensor Fasciae Latae (TFL)/Iliotibial Band (IT Band). In male athletes tested, they found significant relationships between muscle tightness and an increased overall injury rate (95% CI for differences between injured and uninjured men =0.2 to 1.8 tight units; p=.04). The iliopsoas tightness was also related to knee injuries (95% CI=1-9 degrees of hip flexion contracture p=.02). Krivickas *et al.* suggested that detection of muscle tightness during pre-season coupled with a correct stretching and rehabilitation programme may reduce injury and is a costless way to carry out screening in large numbers (Krivickas and Feinberg, 1996).

In Kreckel's study (Kreckel, 2004) into soccer injuries, they used Janda's "muscle function diagnostic testing". The participating football players showed extensive muscle tightness which was seen as a risk factor for injury, and they recommended Janda's muscle function testing (Janda, 1983) as an assessment method suitable to use when screening players for soccer injury. Gabbe *et al.* looked at the reliability of common lower extremity musculoskeletal screening tests. Gabbe concluded that simple, commonly used muscle and range of motion testing are reliable, and these tests are recommended as part of pre-season or pre-participation protocols for sports participants (Gabbe *et al.*, 2004).

Ferber *et al.* (Ferber, Kendall and McElroy, 2010) provided normative data for the testing of Psoas and the IT band. Subjective assessments and instrument measurements were combined to establish normative values and critical criteria for tissue flexibility for the modified Ober and Thomas test. Two clinicians were used to test a random sample of 100 players who were classified subjectively as either negative or positive for iliotibial band and iliopsoas tightness. Percentage of agreement indicated inter-rater reliability for the subjective assessment. They concluded that the clinician can now compare a participant's resting muscle length to make evidence-based decisions (Ferber, Kendall and McElroy, 2010).

Lower extremity normative data on muscle testing was also provided by Corkery *et al.* in their 2007 study. Having tested the iliopsoas, rectus femoris, hamstrings and gastrocnemius with a goniometer, they concluded that the normative data they acquired could be used to identify patients at risk of injury due to decreased flexibility as a result of muscle tightness (Corkery *et al.*, 2007).

South African Rugby released a musculoskeletal assessment form in 2009 (Gray, 2009) with the aim of providing medical team staff and clinicians a screening protocol with reliable and, where possible, valid clinic tests. The assessment form (see Appendix 2) included testing for iliopsoas muscle, rectus femoris, hamstrings and ankle dorsiflexion tests. The other aim of their questionnaire was to feedback risk factor findings collected for use by medical staff and trainers with a view to providing a resource to help in developing injury prevention strategies. Having this data available allows the clinician to select tests which have a high reliability when identifying injury. As an example, the Straight Leg Raise (SLR) used in their screening assessment form is used to test hamstring flexibility. In one study, the mean correlation coefficient between tests conducted on day 1 and day 3 for the different variables of the SLR was 0.97, indicating excellent reliability (Lombard, 2004).

Studies by Witvrouw *et al*. and Jönhagen *et al*. indicated that less than 90° on a straight leg raise test was considered a risk factor for primary or first-time hamstring strains (Witvrouw *et al.*, 2003, Jönhagen, Németh and Eriksson, 1994). The design of the South African Rugby document was similar to other countries such as New Zealand and Australia. There is no data collected on muscle testing, in either individuals or team basketball research in Ireland or the UK. As a simple cost effective test, it is worthwhile to be included and as such has been selected for inclusion as a pre-season screening assessment component of the UKIBIPS research study.

For sports management teams, identifying players at risk of injury should be paramount. It is important that these professionals have access to valid and reliable pre-participation musculoskeletal screening and functional testing protocols (Werner, 2010). Having identified tests which may be relevant to identifying lower extremity injuries in basketball, we need to carry out a pilot study in Ireland and the UK which includes pre-season player assessment. Using the data collected during testing along with the data collected through the Injury Surveillance System, we may be able to offer important data which could be used to facilitate strategies used by the governing bodies which may lead to the reduction of injury in the sport.

1.7. Injury Surveillance

In the past, injury surveillance has been defined as the "the ongoing and systematic collection of injury data" (Dick *et al.*, 2007a, Macarthur and Pless, 1999). Finch *et al.* defined an injury surveillance system as "the full set of processes and procedures set in place to facilitate the collection of injury data" (Finch and Mitchell, 2002). Injury studies are driving an iterative revision of aspects of sport. This constant evolution necessitates that the injury surveillance practice also develops. For example, the charge circle was introduced following observation of a pattern of injury in a specific location on court over significant time.

Both long and short term injury surveillance are important. During specific events, one might observe elite athletes performing over a concentrated period with higher than usual demands on the body. This short term study provides valuable preparatory information for future events. Finch *et al.* state that short term injury surveillance is also important and go as far to recommend that the planning of injury surveillance activities should be a core element during the general organisation of sporting events, and funding for injury surveillance activities should be included in the budget for any sporting event. They also recommend that their injury report forms can be used by organisers of other sporting events or medical coverage services for injury surveillance activities, usually with minimal modification (Finch, Valuri and Ozanne-Smith, 1999).

Long term injury surveillance allows researchers to observe the changes that occur through the development of the sport, such as changes in rules, indoor and outdoor playing surfaces, increased demands of a physical nature and the narrowing of the gap between the amateur and the professional athlete in some sports over time. Sports injury research must be based on the analysis of reliable and comparable data. Central to any investigative research is the questionnaire, which in its simplest form acts as a data collecting tool.

A major element of any injury surveillance study is the method of data collection employed by the research team. While there is an increasing trend in gathering data through electronic injury surveillance questionnaires, data collection through hard copies is still the most common medium used. There are advantages and disadvantages for both methods, but the responsibility remains with the research design team to 1) make the questionnaire user friendly and time efficient, and 2) maintain a high level of compliance and reliability in the data collected. One advantage of the paper questionnaire is that it requires no computer skills for the research team to design and no computer skills for the study participant to complete. A disadvantage is the cost of carrying out large studies and collecting the documents at the end of the research. Postal questionnaires have the inherent problem of transcription accuracy, due to the need to input the data manually for analysis, whereas data collected through an electronic system may be exported directly from a system to whatever platform is being used for analysis.

Problems can arise when there is no control by the researchers over the order in which questions are answered and no check on incomplete responses, on incomplete questionnaires, or the passing of questionnaires to other people to complete (Jones, 2008). Using an electronic questionnaire system demands a great deal of time in its development, and the researchers often have to employ technical expertise to collaborate on the development of the software, which may be seen as a disadvantage as it can be an expensive and time consuming process. An electronic system facilitates use with a larger group due to the reduced workload in transcription and the centralised nature of the data collected. Examples of injury surveillance questionnaires previously used are described in the following section.

1.8. Sports Injury Surveillance Questionnaires

McKay *et al.* carried out a study into the rates and risk factors for ankle injuries in basketball players (McKay *et al.*, 2001a). They used a two-part questionnaire, one for all players and the second part for those who suffered an injury (see Table 1-6).

Table 1-6: McKay Paper-Based Questionnaire Topics

Questionnaires for all Players	Additional questions for players with injuries
Personal characteristics: for example, age, sex, weight, height	Site of injury
Position on court: guard, forward, centre	Mechanism of injury
Standard of competition played: elite, recreational	Type of injury
Protective gear worn: for example, ankle or knee tape/brace, mouth guard	When injury occurred 1^{st} , 2^{nd} , 3^{rd} or 4^{th} quarter second
Shoe type: (a) Cut: low, mid, high cut (b) Condition: good, fair, poor	
Age of shoes: months	
Warm up undertaken: including amount (time) and type (stretch, run, ball skills)	
History of ankle or knee injury	

Kofotoils *et al.* (Kofotolis and Kellis, 2007) carried out a prospective cohort study into ankle sprain injuries in professional Greek female athletes whose injuries were monitored prospectively for 2 years from August 2003 to August 2005. A player injury audit questionnaire was designed in this study with data on injuries collected and inputted by physiotherapists and/or medical doctors. Before the study, full-time medical staff from each club attended a course regarding the project methods and received specific guidelines regarding the completion of the questionnaire. Before each season, athletes were required to give written consent. They recorded basic medical information and anthropometric age, height, mass, training experience, body mass index and player position (see Table 1-7). Injuries were divided and noted on a weekly exposure sheet. They were put into 2 categories based on severity – injuries resulting in loss of participation for fewer than 7 sessions and injuries resulting in loss of participation for 7 or more sessions.

Table 1-7: Kofotoils Injury Audit Questionnaire Topics

Physical Therapist Week by Week Data Documented from Questionnaires
Hours of exposure to injury game and practice
Anatomical location of injury
Session type game or practice
Player position
Date of injury
Mechanism of injury – contact/non-contact
Previous ankle injury
Use of external joint support – taping or joint support
Court Location of injury

The court location of injury as presented by Kofotolis is given in Figure 1-2 below.

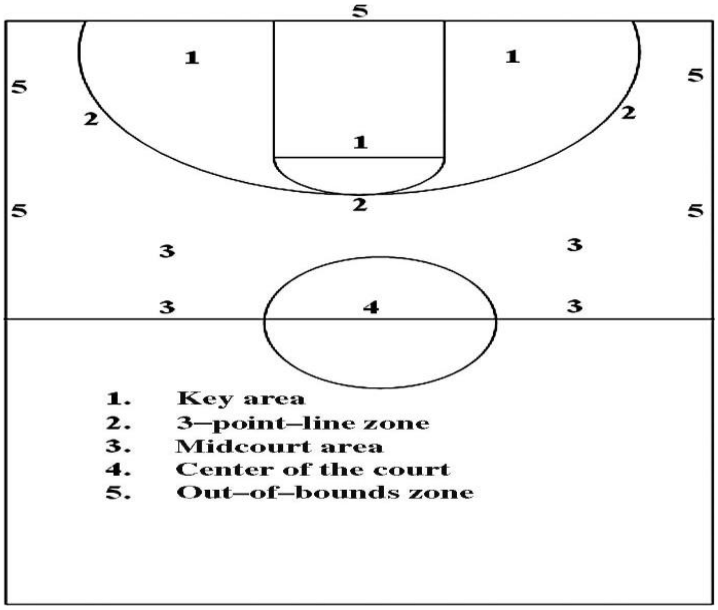


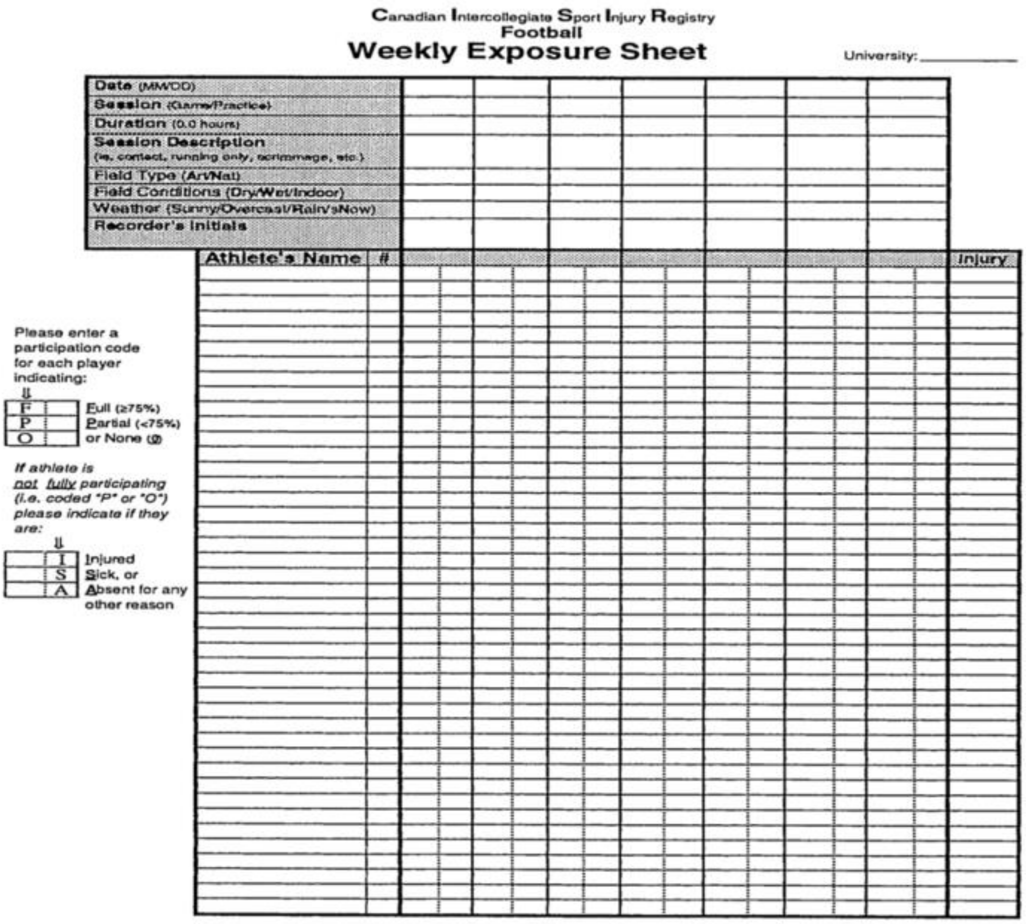
Figure 1-2: Kofotolis Court Area Location for Injury Occurrence

Elke Cumps *et al.* (Cumps, Verhagen and Meeusen, 2007) carried out a prospective epidemiological study of basketball injuries during a competitive season. All information for this study was collected through questionnaires. A standard questionnaire, used to collect the demographic information at baseline (e.g. playing position, years of basketball experience, etc.), was completed by each player. The information about acute and overuse injuries was gathered through an injury registration form, with different questions for acute and overuse injuries because of their intrinsic differences. Each form consisted of three parts:

1. Concerning the circumstances involved in the injury, filled out by the player.
2. Collecting the medical diagnosis in cases where a doctor was consulted.
3. Containing questions on time loss, completed by the injured player.

Meeuwisse (Meeuwisse, Sellmer and Hagel, 2003) collected data through the Canadian Intercollegiate Sports Injury Register or CISIR system which spanned 2 years of participation in the Canada West Division of Canadian Intercollegiate Athletic Union men's basketball. The CISIR prospectively tracked injury and participation (exposure). Before each season, all participating athletes gave written consent and provided baseline medical information.

In a previous study by Meeuwisse (Meeuwisse and Love, 1998), he concluded that there was a high degree of validity for many elements of the CISIR model. Meeuwisse also stated that with the suggested revisions, the CISIR system represented the current standard in athletic injury reporting in terms of individual injury risk assessment. It was agreed that this system would be used in the future to explore the prediction and prevention of sports injuries. The weekly exposure sheet for teams is provided in Figure 1-3 and the injury report form is shown in Figure 1-4.



Canadian Intercollegiate Sport Injury Registry
Football
Weekly Exposure Sheet

University: ____________

Date (MM/DD)
Session (Game/Practice)
Duration (0.0 hours)
Session Description (ie, contact, running only, scrimmage, etc.)
Field Type (Art/Nat)
Field Conditions (Dry/Wet/Indoor)
Weather (Sunny/Overcast/Rain/sNow)
Recorder's Initials

Athlete's Name | # | Injury

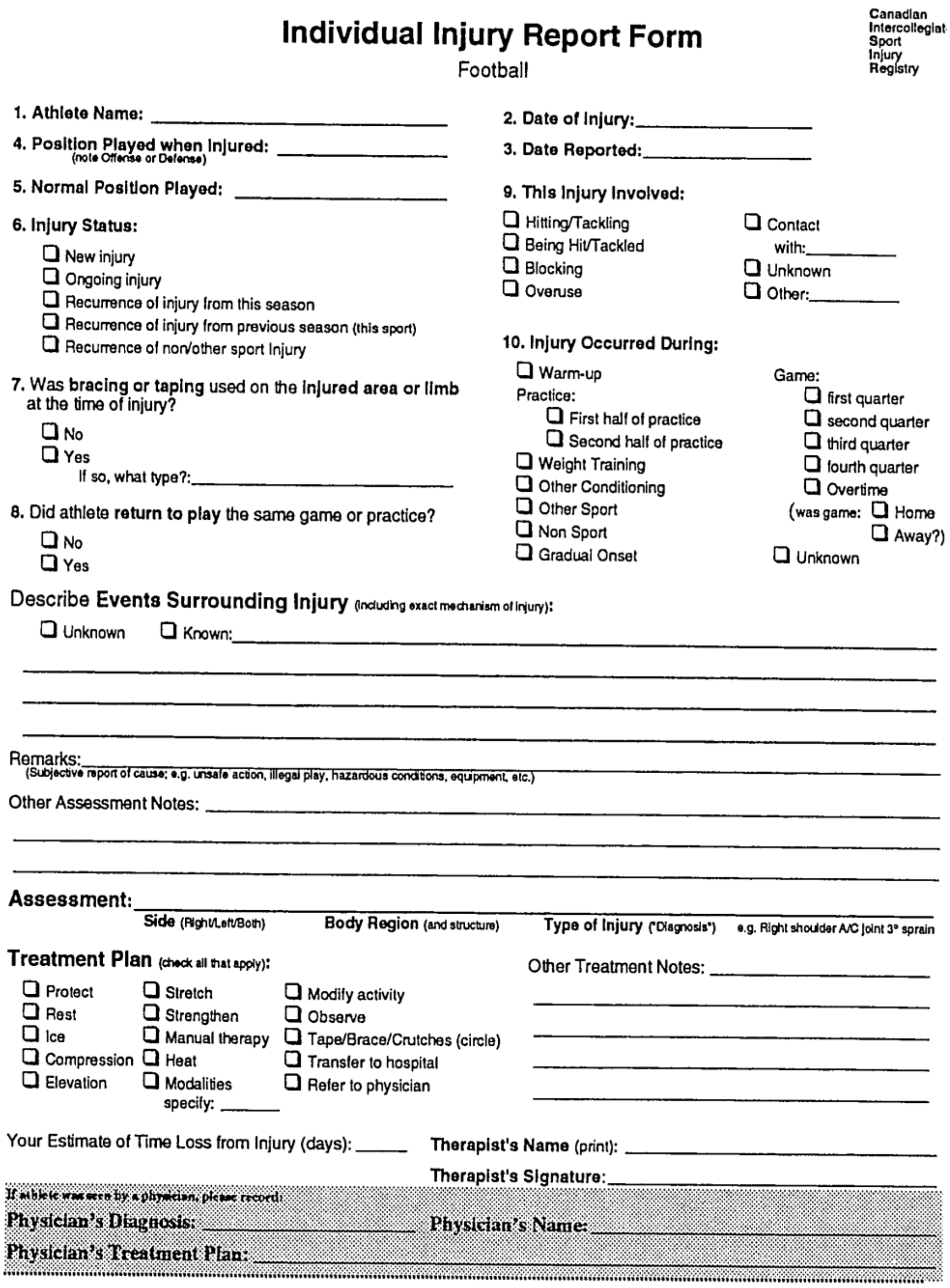
Please enter a participation code for each player indicating:

F — Full (≥75%)
P — Partial (<75%)
O — or None (Ø)

If athlete is not fully participating (i.e. coded "P" or "O") please indicate if they are:

I — Injured
S — Sick, or
A — Absent for any other reason

Figure 1-3: CISIR Weekly Exposure Sheet



Individual Injury Report Form
Football

Canadian Intercollegiat Sport Injury Registry

1. **Athlete Name:** ____________
2. **Date of Injury:** ____________
3. **Date Reported:** ____________
4. **Position Played when Injured:** ____________ (note Offense or Defense)
5. **Normal Position Played:** ____________
6. **Injury Status:**
   - ☐ New injury
   - ☐ Ongoing injury
   - ☐ Recurrence of injury from this season
   - ☐ Recurrence of injury from previous season (this sport)
   - ☐ Recurrence of non/other sport Injury
7. Was **bracing or taping** used on the **injured area or limb** at the time of injury?
   - ☐ No
   - ☐ Yes
     If so, what type?: ____________
8. Did athlete **return to play** the same game or practice?
   - ☐ No
   - ☐ Yes
9. **This Injury Involved:**
   - ☐ Hitting/Tackling
   - ☐ Being Hit/Tackled
   - ☐ Blocking
   - ☐ Overuse
   - ☐ Contact with: ________
   - ☐ Unknown
   - ☐ Other: ________
10. **Injury Occurred During:**
    - ☐ Warm-up
    - Practice:
      - ☐ First half of practice
      - ☐ Second half of practice
    - ☐ Weight Training
    - ☐ Other Conditioning
    - ☐ Other Sport
    - ☐ Non Sport
    - ☐ Gradual Onset
    - Game:
      - ☐ first quarter
      - ☐ second quarter
      - ☐ third quarter
      - ☐ fourth quarter
      - ☐ Overtime
      - (was game: ☐ Home ☐ Away?)
    - ☐ Unknown

Describe **Events Surrounding Injury** (including exact mechanism of injury):
☐ Unknown ☐ Known: ____________

Remarks: ____________
(Subjective report of cause; e.g. unsafe action, illegal play, hazardous conditions, equipment, etc.)

Other Assessment Notes: ____________

Assessment: ____________
Side (Right/Left/Both) **Body Region** (and structure) **Type of Injury** ("Diagnosis") e.g. Right shoulder A/C joint 3° sprain

Treatment Plan (check all that apply):

☐ Protect	☐ Stretch	☐ Modify activity
☐ Rest	☐ Strengthen	☐ Observe
☐ Ice	☐ Manual therapy	☐ Tape/Brace/Crutches (circle)
☐ Compression	☐ Heat	☐ Transfer to hospital
☐ Elevation	☐ Modalities specify: ______	☐ Refer to physician

Other Treatment Notes: ____________

Your Estimate of Time Loss from Injury (days): ______

Therapist's Name (print): ____________

Therapist's Signature: ____________

If athlete was seen by a physician, please record:
Physician's Diagnosis: ____________ **Physician's Name:** ____________
Physician's Treatment Plan: ____________

White - Therapist Copy *Yellow - C.I.S.I.R. Copy* *Pink - Physician Copy*

FIG. 3. Current (revised) individual injury report form.

Figure 1-4: Canadian Intercollegiate Sports Injury Player Registration Form

The Australian Sports Injury Data Dictionary was developed to provide guidelines for injury data collection and classification for the prevention and control of injury in sport and recreation. The dictionary was written to assist sporting and recreation organisations, researchers, sports medicine professionals, first aiders and individual clubs collect information on sports injury. There are sports-specific forms available, but a researcher or sports organisation can choose to create a customised form for data collection. The dictionary was prescriptive in the use of data categories and options within those categories. The Primary Investigator felt this was necessary if the advantages of comparability and consistency were to be gained. (See Figure 1-5 for example of basketball injury questionnaire).

Name: ______________ Initials: ____ Position: ____________ **Circle** Player/Referee/Coach/Spectator

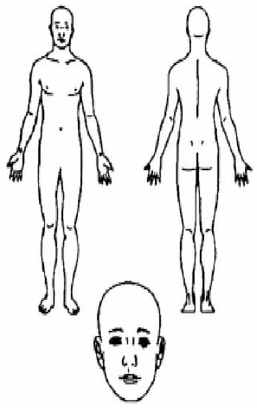
Team : ____________ Grade: ______ DOB: _/_/_ Gender: M ☐ F ☐ Venue/area at which injury occurred: __________

Date of Injury _/_/_

Type of activity at time of injury
☐ training/practice
☐ competition
☐ other ____________

Reason for Presentation
☐ new injury
☐ exacerbated/aggravated injury
☐ recurrent injury
☐ illness
☐ other ____________

Body Region Injured
Tick or circle body part/s injured & name



Body part/s
____
____

Nature of Injury/Illness
☐ abrasion/graze
☐ sprain eg ligament tear
☐ strain eg muscle tear
☐ open wound/laceration/cut
☐ bruise/contusion
☐ inflammation/swelling
☐ fracture (including suspected)
☐ dislocation/subluxation
☐ overuse injury to muscle or tendon
☐ blisters
☐ concussion
☐ cardiac problem
☐ respiratory problem
☐ loss of consciousness
☐ unspecified medical condition
☐ other ____________

Provisional diagnosis/es ____________
____
____

CAUSE OF INJURY
Mechanism of Injury
☐ struck by other player
☐ struck by ball or object
☐ collision with other player/referee
☐ collision with fixed object
☐ fall/stumble on same level
☐ jumping to shoot, defend/rebound
☐ fall from height/awkward landing
☐ overexertion (eg muscle tear)
☐ overuse
☐ slip/trip
☐ temperature related eg heat stress
☐ other ____________

Explain exactly how the incident occurred
____

Were there any contributing factors to the incident, unsuitable footwear, playing surface, equipment, foul play?
____

Protective Equipment
Was protective equipment worn on the injured body part? ☐ yes ☐ no

If yes, what type eg mouthguard, ankle brace, taping.
____

Initial Treatment
☐ none given (not required)
☐ RICER ☐ dressing
☐ sling, splint ☐ crutches
☐ massage ☐ manual therapy
☐ CPR ☐ stretch/exercises
☐ strapping/taping only
☐ none given - referred elsewhere
☐ other ____________

Advice Given
☐ immediate return unrestricted activity
☐ able to return with restriction
☐ unable to return at present time

Referral
☐ no referral
☐ medical practitioner
☐ physiotherapist
☐ chiropractor or other professional
☐ ambulance transport
☐ hospital
☐ other ____________

Provisional severity assessment
☐ mild (1-7 days modified activity)
☐ moderate (8-21 days modified activity)
☐ severe (>21 days modified or lost)

Treating person
☐ medical practitioner
☐ physiotherapist
☐ nurse
☐ sports trainer
☐ other ____________

Signature of treating person
____

Today's Date: _/_/_

Figure 1-5: Australian Sports Injury Dictionary Basketball Injury Form

Dr A Junge (Junge *et al.*, 2008) presented standards for injury surveillance during major competitions, specifically to provide the methodology that would be applied during the 2008 Olympic Games in Beijing. The IOC injury surveillance system for multi-sports events is based on an injury-reporting system well-established for top level international football (Junge and Dvorak, 2013), (Yoon, Chai and Shin, 2004) and handball (Langevoort *et al.*, 2007) tournaments. These were used for all team sports tournaments during the Olympic Games in Athens in 2004. During all tournaments at the Athens Olympic Games, compliance with the procedure was excellent with a response rate greater than 90%. This injury-reporting system developed for team sports tournaments was modified to be applicable for both individual and team sports. The key modifications are presented in Table 1-8.

Table 1-8: IOC Injury Surveillance - Key Modifications

Headings	*Team sports events	†Multi sports events
Sports events included	Team sports	Individual and Team Sports
What is reported	Match injuries	Injuries due to competition or training
Who reports the injury	Team Physician	Physician of the national team (and doctors of the medical centre or polyclinic)
When is the injury reported	After each match	Daily
Injury report form	Additional information on consequence of injury	Additional information about sport event

*2004 Olympic games †2008 Olympic games

While modifying the injury-reporting system, the most important principles and advantages of the established system were preserved. These included the consensus definition of injury, injury report by the physician responsible for the athlete, report related to a time period independent of whether or not an injury occurred, and one report form per team (not per injury). The modified injury surveillance system was implemented and proven feasible during the 2007 World Championships of the International Association of Athletics Federations (IAAF) in Osaka.

The Center for Research and Prevention of Injuries among the Young, in view of the 2004 Olympics, looked at sports injuries in European countries. The information was collected using the questionnaires provided in Figure 1-6 and Figure 1-7. The final report was compiled by Eleni Petridou, Center for Research and Prevention of Injuries among the Young (CE.RE.PR.I).

SPORTS INJURIES SPORTS INJURIES SURVEILLANCE QUESTIONNAIRE

ADDRESSED TO ATHLETES

ID |__|__|__| Informer………………………… Interviewer………………………………

Name…………………………………………………………………………………………….

Residence……………………………………………………………………………………..

Tel |__|__|__|__|__|__|__|__|__|__|__|__| Sex |_________| Age |__|__|

Mother's education………………………………….. Father's education…………………………….

Education………………………………………... Profession……………………………………

Sport…………………………………………. Professional Amateur

Athletic club……………………………………………………………………..

Hours of training per week: personally ………………….with team……………………..…

Days participating in games: per month………………… per year………………………………

How many hours you exercising in a performance day………………………………………………

Injury lead to absence from training or competition for a day at least. Serious injury lead to absence for a week, at least.

Number of injuries

1998: in training ……………………..in games……………………….. serious ones…………………..

1999: in training……………………. in games……………………….. serious ones…………………..

2000: in training……………………. in games……………………….. serious ones..…………………

Were you ever injured during training?

How many times this happened: in the start………………. in the middle………. in the end…………

How many times this happened: with the presence of trainer………… without trainer……………..

Were you ever injured in a game?

How many times this happened: in the start………………. in the middle………. in the end…………

Your opinion for prevention of injury in the sport you exercise

…………………………………………………………………………………………………

…………………………………………………………………………………………………

Date of injury…………………………… Time of injury………………………..

Treatment: Public hospital Private Health institution Private practice

By whom you were accompanied?…………………………………

Insurance: Public Personal Both

Treatment: Surgery Medical

Place that the accident happened…………………………………………………………………………

Injured body part

1…………………………………………………………………………………………………

2….………………………………………………………………………………………………...

3…………………………………………………………………………………………………

Type of injury

1…………………………………………………………………………………………………

2….………………………………………………………………………………………………...

3…………………………………………………………………………………………………

Mechanism of accident………………………………………………………………………………..

Mechanism of injury……………………………………………………………………………………

Time of rehabilitation ……………………………………………………………………………..

Time of re-entry in competition……………………………………………………………………...

First aid was provided by……………………………………………………………………………….

What do you think caused this injury?…………………………………………………………………..

Figure 1-6: Center for Research and Prevention for Injuries in the Young – Questionnaire for Athletes

SPORTS INJURIES SURVEILLANCE QUESTIONNAIRE ADDRESSED TO TRAINERS

ID |__|__|__|

Name……………………………………………………………………………………………………….

Tel |__|__|__|__|__|__|__|__|__|__|__|__| Sex |_________| Age |__|__|

Education………………………………………... Profession……………………………………

Sport…………………………………………. Professional Amateur

Number of persons you trained………………………………………………….

Hours of training per week:……………………………………………………..

Ages of athletes…………………………….Sex of athletes Male:……….. Female………………

Is there in your club: Doctor………… Physiotherapist………………

Injury lead to absence from training or competition for a day at least. Serious injury lead to absence for a week, at least.

Number of injuries

1998: in training ……………………..in games……………………….. serious ones…………………..

1999: in training…………………… in games……………………….. serious ones…………………..

2000: in training…………………… in games……………………….. serious ones...…………………

Did your athletes ever get injured during training?

How many times this happened: in the start……………… in the middle………. in the end…………

How many times this happened: with the presence of trainer………… without trainer……………..

Were they ever injured in a game

How many times this happened: in the start……………… in the middle………. in the end…………

Your opinion for prevention of injury in the sport you are specialised

……

……

How soon these injuries were treated…………………………………………………………………….

Usual time of recovery…………………………………………………………………………………

Usual time of warming up……………………………………………………………………………..

Usual time of training………………………………………………………………………………….

Treatment: Public hospital Private Health institution Private practice

Treatment: Surgery Medical

Who covered the cost?……………………………………………………………………………………

Place that accidents usually happen……………………..…………………………………

Injured body part (the 3 most common)

1……

2…..………………………………………………………………………………………………………...

3……

Type of injury (the 3 most common)

1……

2…..………………………………………………………………………………………………………...

3……

Usual mechanism of accidents……..…………………………………….…………………………..

Usual mechanism of injury…………………………….……………………….………………………

What do you think caused this injury …...……………………………………………………………

Mean time of rehabilitation ………………………………………………………………………

Place and equipment that are used……………………………………………………………………...

Are the place and the equipment safe?…………………………………………………………………..

What proportion of the athletes follow the safety measures……………………………………………..

Absence of safety measures result in what proportion of injuries? ……………………………………..

SPORTS INJURIES SPORTS INJURIES SURVEILLANCE QUESTIONNAIRE

Figure 1-7: Sports Injury Questionnaire Addressed to Trainers

The previous discussion identifies the merits and failings of the traditional paper-based system. The evolution in technology has placed a means of data collection in the hands of every athlete participating in sport. It makes sense then to try and take advantage of this proliferation of handheld devices and engage the players in a guided, well-constructed electronic questionnaire to provide consistent, accurate and more complete data to form the basis of an injury prevention study.

Consequently, the aims of the UKIBIPS are:

1. Identify (Scope Review) existing injury surveillance systems and describe their characteristics, and establish what factors may be appropriate to use in this research study.
2. Develop a basketball Injury surveillance system for use in Ireland and the UK.
3. Undertake a pilot study to understand how this system could be used to:
    a. Monitor Injury Incidence.
    b. Understand Risk factors for injury which exist in Ireland and the UK which may contribute to further research on injury prevention strategies.

Chapter 2 – Scope Review of Injury Surveillance Systems

2.1. Introduction

In order to develop effective strategies for injury prevention in sport, it is first necessary to collect detailed information on the incidence, risk factors and mechanisms of injury. Research into these factors in basketball in the UK and Ireland has been limited to date, and a key limitation has been the lack of a framework for the collection of the relevant data. Understanding the approaches used for data collection on injuries in other sports can help inform the development of a fit-for-purpose data collection system for basketball. There are a variety of methods employed to collect sports injury-related data in other sports, including paper report forms, online report forms, electronic medical report systems (EMR) and bespoke electronic injury surveillance systems.

Sports injury surveillance has well been established for team sports in countries such as Australia, Canada and the United States, initially using paper-based systems and subsequently leading the development of electronic injury surveillance systems. In order to establish the characteristics of existing interventions currently in operation for team ball sports, and to determine if there were existing gaps in these systems which needed to be addressed in the proposed UKIBIPS-ISS, it was decided to carry out a scoping review of existing injury surveillance systems.

As there is no universally accepted injury reporting system, there are many inconsistencies in the way injury data is collected and reported. In the absence of an available ISS in UK and Irish basketball, the UKIBIPS study is ideally positioned to identify sports injury surveillance systems already in use and evaluate the similarities and differences in the questioning and reporting which may limit the analysis of injury in the sport. Consequently, the characteristics appropriate to this study can be identified and handled.

This review is concerned with establishing a pathway which provides a platform for the development of a system that can provide high-quality, robust data which can in turn be used as a tool to design and evaluate sports injury prevention programmes. While injury definitions have been discussed in the previous chapter, this chapter aims to identify a suitable injury definition to use in the UKIBIPS that would be accessible for both medical team staff and/or the self-reporting player in order to collect as much relevant data as possible.

2.2. Summary of Aims

- To identify existing injury surveillance systems and describe their characteristics and establish what factors may be appropriate to use in this research study or if there is a need for a bespoke system to be developed.
- To identify a suitable injury definition to use in the UKIBIPS that would be accessible for both medical and non-medical team staff and/or the self-reporting player in order to collect as much player data as possible.

2.3. Methodology

Team ball sports have been selected for this review as athletes are likely to suffer similar types of injuries, have similar team structures and have similar data collected. There are parallels that are relevant to consider. The team ball sports selected for review include American Football, Australian Rules Football, Baseball, Basketball, Cricket, Soccer, Rugby and Volleyball. These ball sports are played globally, have large numbers engaged in play, have professional status and have been included in sports-specific research studies.

Where possible, available electronic systems will be trialled to assess the user experience and, if available, the data stored will be reviewed in order to determine how the variables listed above are handled by each system and how accessible the system is to potential users.

Professional teams are best placed to offer their elite players access to top medical staff and strength and conditioning coaches. They can also offer their players the most up-to-date training and injury prevention techniques based on the latest research to keep their players on the court or field.

Governing bodies of the 8 selected sports were contacted by email to establish if an injury surveillance system existed within their sport in their country. The top professional league/division in each sport and country, along with their professional players' associations were also identified and contacted by email to establish if injury surveillance was occurring in their sport. The email query (Appendix 3) contained the following key questions:

- Is injury surveillance carried out by the governing body/senior professional league in your sport?

- Is data collected through paper reports or through an electronic medium?

- What are the variables/queries included in your system?

- Who records the data and how often?

- How is data collected on injury expressed when analysed, i.e. athletic exposure or per 1000 hours?

An excel sheet was used to register the name of the system, its country of origin, the population under surveillance and the process of their data collection. Once the injury surveillance systems were identified, information relevant to this review was extracted which included:

- Who records data – Team Doctor, AT, S/C Coach, Coach, Player or other?

- How often is data collected?

- Is the system integrated or an online questionnaire?

- Is it required to export data for analysis or has the system the capability?

- Player demographics?

- How is athletic exposure expressed - per game, game and training, season, competition?

- Is data collected on both injured and non-injured players?

- Are both training and game data recorded?

- Is there a pre-season assessment?

- Training description – individual and team?

- What game data is reported?

- Injury definition?

- What injury variables have been observed – site, type, previous injury mechanism of injury, injury diagnosis, injury treatment?
- Time loss – return to sport, fitness test?
- Is injury recorded which was sustained outside of the sport being observed?
- How are injury rates calculated and expressed in reports?
- How is data analysed and by whom?
- Is the system linked with external data sources?

A review of the characteristics of each system was carried out to identify similarities and differences between them. When there were no responses to emails by any of the groups contacted, further searches were conducted to find additional grey literature on any identified sports injury surveillance carried out in these leagues that may offer new or additional information on variables, definitions and recordings not documented elsewhere. In addition to the review of the professional teams in the 8 sports, the NCAA-ISP (multiple sports) and the HS RIO (multiple sports) systems were also included in this review when any of the 8 sports were included in their programmes. The decision to include these systems was taken as both of these systems are well-established and have a large injury database. The NCAA-ISP collects data on approximately 88,000 athletes per year.

The search methodology stages were as follows:

- Identify the governing bodies and the top professional leagues in the following sports – Australian Football, American Football, Baseball, Basketball, Cricket, Rugby, Soccer and Volleyball.
- Establish any injury surveillance system being used in each of the 8 team sports and identify and include details of the surveillance system (e.g. name of system, country of origin, population under surveillance, process of data collection.
- Review and compare the relevant characteristics and injury variables from each system through the information that is available publicly.

- Conduct Google searches to find additional grey literature on identified sports injury surveillance systems with no associated peer-reviewed publications, using the name of the surveillance system as the search term.

- Where no information is available publicly, each governing body or system provider will be contacted for permission to gather information on what is collected in the back end of their systems and how data is reported.

2.4. Results

A total of forty governing bodies were identified in 8 different sports from 18 countries. Forty nine professional leagues (m39m/10f) were identified within the review. All governing bodies, professional leagues and players' associations were contacted. In total, 42 emails were sent and there were 6 responses. Emails returned per sports were Rugby (World Rugby, Scotland Rugby), Baseball (Major League Baseball MLB), and Basketball (National Basketball Association NBA), Multi-Sports (National Collegiate Athletic Association (NCAA) and Multi-Sports (High School Reporting Information Online HS RIO). A grey literature search on injury surveillance systems was carried out in parallel to contacting the governing bodies. See Figure 2-1 for a summary of inquiries and searches carried out for the scope review.

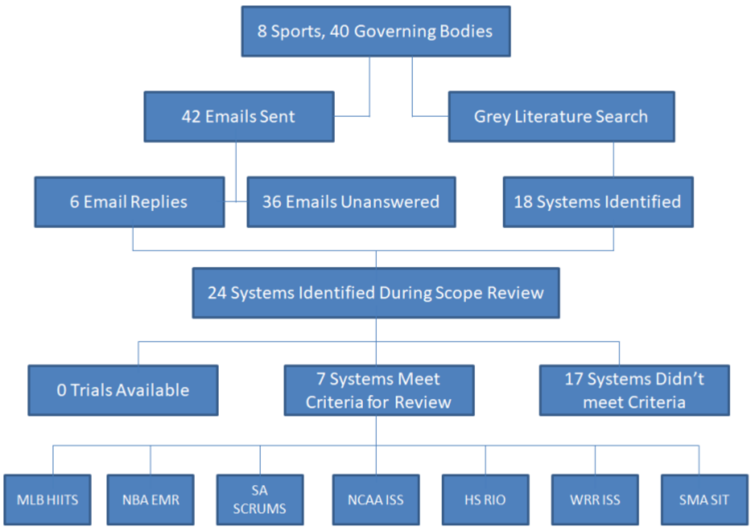


Figure 2-1: Searches carried out for the Scope Review

Following email inquiries and grey literature searches, a total of 24 injury surveillance systems were identified. Six were through replies to the initial email sent and eighteen through the grey literature search (Goggle search). Of these 24 systems, there were no trials available to the Primary Investigator. Only 7 (named) offered enough relevant information to evaluate their collection and treatment of data. The remaining 17 did not provide an avenue to extract similar information for comparison in this review. The NCAA-ISP uses 8 independent companies with compatible emergency record systems. The NCAA-ISP provides surveillance in 6 sports reviewed, two of which are male only (Rugby/American Football). The *Sports Office Company* provides Injury surveillance for four different Rugby and soccer teams, (male - cricket, rugby and soccer: female - soccer).

Data collected from the primary search include the following: (1) Sport's governing body, (2) Country of origin, (3) Gender, (4) Professional, Semi Professional or Amateur status of top sports leagues, (5) Injury Surveillance in governing body or league and (6) Type of Injury Surveillance System. High-level overview results can be seen in Table 2-1 through Table 2-8 under these headings.

Table 2-1: Injury Surveillance Systems in American Football – High Level Overview

Sport	Governing Body Country	Players Male (M) Female (F) Both (M/F)	Level Professional (P) Semi Professional (SP) Amateur (A)	Injury Surveillance System Used	Data Collection Method
American Football	National Football League (NFL) USA	M	P	Yes	NFL Electronic Health Record System
American Football	Canadian Football League (CFL) Canada	M	P	Yes	CFL Injury Surveillance Database Electronic Record For medical Teams
American Football	European League Football Europe	M	P	No	No
American Football	National College Athletic Association (NCAA) USA	M	A	The Injury Surveillance Program ISP	**Compatible EMR Systems** Athletic Trainer System CSMI Solutions SportsWare Online HealthyRoster Presagia Sports PyraMED Smartabase (by Fusion Sport) Vivature NExTT

Table 2-2: Injury Surveillance Systems in Baseball – High Level Overview

Sport	Governing Body Country	Players Male (M) Female (F) Both (M/F)	Level Professional (P) Semi Professional (SP) Amateur (A)	Injury Surveillance Databases	Data Collection Method
Baseball	Major League Baseball (MLB) USA	M	P	Yes	Health and Injury Tracking System (HITS)
Baseball	Australian Baseball League Australia	M	P	No	No
Baseball	Chinese Professional Baseball League Taiwan	M	P	No	No
Baseball	Korean Baseball League (KBO) South Korea	M	P	No	No
Baseball	Mexican Baseball League Mexico	M	P	No	No
Baseball	Nippon Professional Baseball Japan	M	P	No	No
Baseball	National College Athletic Association (NCAA) USA	M	A	The Injury Surveillance Program ISP	**Compatible ElMR Systems** Athletic Trainer System CSMI Solutions SportsWare Online HealthyRoster Presagia Sports PyraMED Smartabase (by Fusion Sport) Vivature / NExTT

Table 2-3: Injury Surveillance Systems in Rugby – High Level Overview

Sport	Governing Body Country	Players Male (M) Female (F) Both (M/F)	Level Professional (P) Semi Professional (SP) Amateur (A)	Injury Surveillance Databases	Data Collection Method
Rugby	Major League Rugby (MLR) USA	M	P	No	No
Rugby	Super Rugby Australia New Zeeland Fiji Pacific Islands	M	P	Yes	National Data Based Software used by ARU Franchises
Rugby	Japan Rugby Football Union (JRFU) Japan	M	P	No	No
Rugby	Irish Rugby Football Union (IRFU) Ireland	M	P	Irish Rugby Injury Surveillance (IRIS) Project	IRIS system EMR – The Sports Office
Rugby	Rugby Football Union (RFU) England	M	P	England Professional Rugby Injury Surveillance Project (PRISP)	Orchard Sports Injury Classification System (OSICS) The Sports Office
Rugby	Scottish Rugby Union (SRU) Scotland	M	P	Yes	Scottish Rugby Union management System SCRUMS
Rugby	Welsh Rugby Union (WRU) Wales	M	P	Welsh Rugby Union Injury Surveillance Program	Paper-Based
Rugby	National College Athletic Association (NCAA) USA	M	A	The Injury Surveillance Program ISP	**Compatible EMR Systems** Athletic Trainer System CSMI Solutions SportsWare Online HealthyRoster Presagia Sports PyraMED Smartabase (by Fusion Sport) Vivature , NExTT

Table 2-4: Injury Surveillance Systems in Basketball – High Level Overview

Sport	Governing Body Country	Players Male (M) Female (F) Both (M/F)	Level Professional (P) Semi Professional (SP) Amateur (A)	Injury Surveillance Databases	Data Collection Method
Basketball	National Basketball Association (NBA) USA	M	P	National Basketball Association Player Injury and Illness Database	NBA EMR
Basketball	Women's National Basketball Association (WNBA) USA	F	P	No	No
Basketball	Australian National Basketball League Australia	M	P	No	No
Basketball	Women's Australian National Basketball League Australia	F	P	No	No
Basketball	Canadian Elite Basketball League (CEBL) Canada	M	P	Kinduct AMS	EMR
Basketball	Basketball Ireland (BI) Ireland	M + F	SP + A	No	No
Basketball	British Basketball League (BBL) Great Britain	M	P	No	No

Basketball	Women's British Basketball League (WBBL) Great Britain	F	P	No	No
Basketball	National College Athletic Association (NCAA) USA	M + F	A	The Injury Surveillance Program ISP	**Compatible EMR Systems** Athletic Trainer System CSMI Solutions SportsWare Online HealthyRoster Presagia Sports PyraMED Smartabase (by Fusion Sport) Vivature NExTT

Table 2-5: Injury Surveillance Systems in Cricket – High Level Overview

Sport	Governing Body Country	Players Male (M) Female (F) Both (M/F)	Level Professional (P) Semi Professional (SP) Amateur (A)	Injury Surveillance Databases	Data Collection Method
Cricket	Major League Cricket USA	M	P	No	No
Cricket	Cricket Australia Australia	M + F	P	Yes	Cricket Australia injury surveillance system Athlete Management System
Cricket	The Board of Control for Cricket in India (BCCI) India	M	P	No	Surveillance Report Paper-Based Retrospective
Cricket	England and Wales Cricket Board England And Wales	M	P	Yes	Profiler (2010–2016 inclusive) Cricket Squad, The Sports Office, UK (2017–2018 inclusive)

Table 2-6: Injury Surveillance Systems in Soccer – High Level Overview

Sport	Governing Body Country	Players Male (M) Female (F) Both (M/F)	Level Professional (P) Semi Professional (SP) Amateur (A)	Injury Surveillance Databases	Data Collection Method
Soccer	Major League Soccer (MLS) USA	M	P	Yes	"Heal the Athlete" Electronic Health record
Soccer	National Women's Soccer League (NWSL) USA	F	P	No	No
Soccer	Football Australia Australia	M	P	Yes	Football Federation Australia Injury Surveillance spreadsheet
Soccer	Football Australia Australia	F	P	No	No
Soccer	Canadian Soccer League Canada	M	P	Yes	Kinduct's Athlete Management System Electronic Medical Record System
Soccer	Football Association of Ireland (FAI) Ireland	M	P	No	No
Soccer	English Football Association (FA) England	M + F	P	Yes	Sports Office Athlete Management System

Soccer	Scottish Football Association Scotland	M	P	Yes	Sports Office Athlete Management System
Soccer	Cymru Football Wales	M	P SP	No	No
Soccer	National College Athletic Association (NCAA) USA	M + F	A	The Injury Surveillance Program ISP	**Compatible Electronic Medical record Systems** Athletic Trainer System CSMI Solutions SportsWare Online HealthyRoster Presagia Sports PyraMED Smartabase (by Fusion Sport) Vivature NExTT

Table 2-7: Injury Surveillance Systems in Volleyball – High Level Overview

Sport	Governing Body Country	Players Male (M) Female (F) Both (M/F)	Level Professional (P) Semi Professional (SP) Amateur (A)	Injury Surveillance Databases	Data Collection Method
Volleyball	Italian Volleyball Federation Italy	M	P	No	No
Volleyball	Brazilian Volleyball Confederation Brazil	M + F	P	No	No
Volleyball	Polska Liga Siatkowki (PLS SA) Poland	M	P	No	No
Volleyball	Turkish Volleyball Federation Turkey	M + F	P	No	No
Volleyball	Russian volleyball Federation Russia	M + F	P	No	No
Volleyball	NCAA United States	M + F	A	The Injury Surveillance Program ISP	**Compatible EMR Systems** Athletic Trainer System CSMI Solutions SportsWare Online HealthyRoster Presagia Sports PyraMED Smartabase (by Fusion Sport) Vivature NExTT

Table 2-8: Injury Surveillance Systems in Australian Football – High Level Overview

Sport	Governing Body Country	Players Male (M) Female (F) Both (M/F)	Level Professional (P) Semi Professional (SP) Amateur (A)	Injury Surveillance Databases	Data Collection Method
Australian Football	AFL Commission Australia	M	P	Yes	Sports Injury Tracker Online ISS
Australian Football	AFL Commission Australia	F	P	No	No

The injury surveillance systems providing characteristics and variables for review are:

- National Colligate Athletic Association – Injury Surveillance Program (NCAA-ISP)
- National Basketball Association Electronic Medical Record – (NBA EMR)
- Major League Baseball – Health and Injury Tracking System (HITS)
- High School Reporting Information Online – (HS RIO)
- World Rugby Research – Injury Surveillance System (WRR ISS)
- Sports Medical Australia – Sports Injury Tracker (SMA SIT)
- Scotland Rugby – SCRUMS

The data that was extracted from these systems for comparison and evaluation are presented in Table 2-9 through Table 2-12. These data address the initial questions presented, including who enters the data, what types of injury are recorded and how is the data analysed and by whom? For comparative purposes, the UKIBIPS was included in these tables as well.

Table 2-9: Data Entry and System Use

Injury Surveillance System	Data Collected Prospectively (P) or Retrospective (R)	Compulsory (C) or Voluntary (V) Participation	Player Demographic Details	Data Inputted by Doctor (D), Physio (P), S/C Coach(C) (Teacher(T)	Data Inputted by Athletic Trainer (AT), Medical Team (MT)	Data Inputted by Player
UKIBIPS	P	V	Y	D, P, S/C	AT, MT	Y
NCAA – ISP	P	C	Y	No	AT	N
NBA EMR	P	C	Y	D	AT	N
MLB HITS	P	C	Y	No	AT	N
HS RIO	P	C	Y	No	AT	N
WRR ISS	P	C	N	D, *SC	MT	N
SMA SIT	P	Unspecified	N	No	MT	N
SA SCRUMS	p	V	N	C, T, P	N	N

Table 2-10: Exposure Variables

Injury Surveillance System	Data Collected on All (A) or injured (I) player	Session Type Training (T), Game (G)	Training Time Duration	Training Type Selection available	Game Time Minutes played	Exposure rate Per 1000 hrs of play (P/1000Hr) or Athlete Exposure (AE)	Exposure rate Per Game (G), Week (W) or Season (S)
UKIBIPS	A	T, G	Y	Yes	Yes	P/1000Hr	G, W, S
NCAA – ISP	A	T, G	?	Yes	Yes	AE	G, W, S
NBA EMR	A	T, G	N	N	Y	P/1000Hr , AE ~Other	G, W, S
MBL HITS	A	G	?	N	N	AE	G
HS RIO	I	T,G	N	N	N	AE	S
WRR ISS	A	G	N	N	Y	P/1000 Hr Training and Game	G
SMA SIT	I	T, G	N	N	N	Unknown	S
SA SCRUMS	A	N	N	N	N	P/1000 Hr Training and Game	G

Table 2-11: Injury Data Type

Injury Surveillance System	Injury Site	Injury Type	Mechanism of injury	Contact injury	Non-contact Injury	Gradual / overuse injury	Previous injury	Injury due to player violation
UKIBIPS	Y	Y	Y	Y	Y	Y	Y	Y
NCAA – ISP	Y	Y	Y	Y	Y	Y	Y	Y
NBA EMR	Y	Y	Y	Y	Y	Y	N	N
MBL HITS	Y	Y	Y	Y	Y	N	Y	N
HS RIO	Y	Y	Y	T	Y	Y	N	N
WRR ISS	Y	Y	Y	Y	Y	Y	Y	N
SMA SIT	Y	Y	Y	Y	Y	Y	N	Y
SA SCRUMS	Y	Y	Y	Y	Y	N	N	Y

Table 2-12: Time and Treatment of Injury

Injury Surveillance System	Time of Injury during game	Field / Court area where Injury occurred	Diagnosis of injury	Injury Treatment	Injury with absence from game or training	Return to sport fitness test	Illness recorded	Illness Report produced	Time Lost through injury	Fitness test after illness
UKIBIPS	Y	Y	Y	Y	Y	Y	Y	N	Y	Y
NCAA – ISP	Y	Y	Y	Y	Y	N	Y	N	Y	N
NBA EMR	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
MBL HITS	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
HS RIO	Y	Y	Y	N	Y	N	N	N	N	N
WRR ISS	Y	N	Y	N	Y	Y	Y	N	Y	Y
SMA SIT	Y	N	N	Y	N	Y	N	N	N	N
SA SCRUMS	Y	N	Y	Y	N	N	N	N	N	N

Professional leagues such as the England Professional Rugby Union (Brooks *et al.*, 2005; Steering and Group, 2015), Major League Baseball (MLB) (Ahmad *et al.*, 2014), the US National Football League (NFL) (Henderson, 2012; Elliott *et al.*, 2011), Australian Football League (AFL) (Orchard, Seward and Orchard, 2013) and the Union of European Football Association UEFA (Hägglund *et al.*, 2005) have all had injury surveillance research carried out in their sports using an electronic injury surveillance system to collect data. Paper-based injury surveillance research has been carried out by organisations such as FIFA (Junge *et al.*, 2004), Norwegian Football (Bjørneboe *et al.*, 2011), the International Olympic Committee (IOC) (Engebretsen *et al.*, 2013) and the International Association of Athletics Federations (IAAF) (Alonso *et al.*, 2009).

The National Collegiate Athletic Association (NCAA) (Kerr *et al.*, 2014), MLB (Ahmad *et al.*, 2014) and High School Reporting Information Online (HS RIO) (Comstock RD, 2014) systems have injury-related data uploaded by athletic trainers while injury surveillance in professional English Rugby, NFL, AFL Olympics, FIFA, UEFA and Norwegian Football all require data to be uploaded by medical team staff such as doctors and physiotherapists. It is important to consider the benefits of making an injury surveillance system available which has the potential to record data and can be used by organisations, coaches and players who compete outside of the well-funded professional bodies and leagues.

2.5. Overview of Selected Injury Surveillance Systems

World Rugby Research Injury Surveillance System

The World Rugby Union research team collects data on their injury surveillance system which accords with the consensus statement on injury definitions and data collection procedures for studies of injuries in rugby union. Injury, illness, and exposure data records are collected prospectively by team medical staff attached to participating teams. For each tournament, there is a defined period of time in which a surveillance study will operate. Typically, this will begin when each team arrives for a tournament until their involvement in the tournament concludes. World Rugby use independent consultants that will liaise with team medical staff on an ongoing basis to answer queries and quality assure the collected data prior to analysis. Data are compiled, quality assured and analysed by the independent consultants. Findings from each competition are written up as a tournament report. Participation in injury surveillance research is a condition that teams participating in World Rugby competitions sign-up to. Consequently, all participating teams in World Rugby competitions will use the system to facilitate injury surveillance data collection. These competitions are listed below:

a. Rugby World Cup (Men’s and Women’s)

b. Sevens World Series / Olympic Games / Commonwealth Games / Rugby World Cup Sevens (Men’s and Women’s)

c. U20 Competitions (Championship and Trophy)

As well as World Rugby competitions, they have also made the system available to other Unions or Competition Organisers to facilitate injury surveillance research. At present, the system is being used by Rugby Europe for their Championship competition and also the Super Liga Americana de Rugby in South America. In addition, the system is also being used in an injury surveillance project ongoing in the Leinster Boys Schools competitions in Ireland.

Note: *The world rugby research team advised they cannot provide access to their live system; however, we were given access to a basic demo system that allowed the Primary Investigatory to view the injury / illness and exposure data collection process.*

The Professional Rugby Injury Surveillance and Prevention Project (PRISP)

The PRISP was first commissioned by the Rugby Football Union (RFU) and Premiership Rugby in 2012. The PRISP monitors injury incidence, injury severity and injury burden (incidence x severity) in English Premiership clubs and the England senior team.

The main objectives of PRISP are to accurately report the risk of injury in the professional game and to highlight any patterns or trends over time, allowing for the targeted investigation of specific areas of injury risk and the development of evidence-based strategies to reduce injury risk. The medical staff from each of the participating teams, including the English senior team, reports the details of injuries and illnesses sustained by a player at their club/team. Injury details are recorded using an online medical record-keeping system. Strength and conditioning coaches record the team’s weekly training schedules and exposure on a password protected online system. The injury surveillance for the project is used in conjunction with the World Rugby Research Injury Surveillance System. The English RFU also carry out research work on the following projects:

- Community Rugby Injury Surveillance and Prevention (CRISP) Project
- Women's Rugby Injury Surveillance and Prevention Project (WRISP)
- BUCS Injury Surveillance Project (BUCS ISP)

Scottish Rugby Injury Surveillance System (SCRUMS)

Injury Surveillance in Scottish rugby is carried out by their governing body – Scotland Rugby. Data is collected electronically using SCRUMS. SCRUMS was developed in 2018 by Scotland Rugby to provide a modern, integrated set-up to record member information for those involved with rugby in Scotland, including youth players (under the age of 18). Data may be collected by a variety of individuals at a club/school (coaches, teachers, team managers, physios) and they can be given the necessary access to complete injury reports for their players via SCRUMS.

NCAA Injury Surveillance System (Datalys Center for Injury Surveillance)

The American National College Athletic Association (NCAA) Datalys Center for Injury Surveillance was established in 1982 and has been an innovative leader in the use of electronic data collection software. The injury surveillance was carried out using paper-based forms by the Athletic Trainers for each team from 1982 through to 2005, before data was collected by a web-based system from 2004 – 2009 and updated in 2009 through to 2014. The NCAA has approved three software vending companies, Athletic Training Systems (A.T.S), Vivature NExTT, and Security Information Management Systems (SIMS), for use by the athletic trainers in all divisions. These systems allow the trainers to upload to the Datalys Center which in turn performs a sample analysis of the data for each sport and when compiled is presented to the NCAA medical committees who may in turn implement injury prevention protocols based on the evidence. The average fee for the use of one of these systems, for example the ATS (see ATS pricing list in Appendix 4), is a $300 annual fee plus a first-time purchase fee of $695 for a single user totalling $995. Even then, there is a limit on usage for researchers and the number of players/participants.

All college teams in all sports and in all divisions utilise the system and it is compulsory for coaches or athletic trainers to use and complete. This has become the largest collegiate sports injuries database in the world. Today, the NCAA Sports Science Institute partners with the Datalys Center to manage the injury surveillance program and to help inform injury prevention policies and practices in college sports (link to The Datalys Center for Injury Surveillance).

High School Reporting Information Online - HS RIO™

In 2005, the High School Reporting Information Online (HS RIO) system was introduced to capture data on high school athletes and modelled after the NCAA-ISP. Relevant data are shared with the NCAA and high school sport and policy committees to develop evidence-based rules and programmes that help protect the health and safety of student-athletes (Kerr *et al.*, 2014). The HS RIO is a web-based sports injury surveillance system that was launched to capture data on athletes from a national random sample of US high schools

The HS RIO program software was developed under the direction of Dr Dawn Comstock of Research Information Services. Research Information Services is the information technology support service for The Research Institute at Nationwide Children's Hospital.

Sports Medicine Australia – Sports Injury Tracker

In 2010, the Sports Injury Tracker (SIT) was the first online sports injury surveillance system developed for community sport by Sports Medicine Australia (SMA) (Ekegren *et al.*, 2014). It enabled sports injuries data to be recorded, stored safely and analysed to assist community sporting organisations in developing strategies addressing their sports injury issues. Sports Injury Tracker is free and easy to use. However, it is geographically restricted to those with a postcode in Australia. The "Sport InjurEdata Project" created the first electronic sports injury surveillance and reporting system of its kind. Using RecordPro software, this system collects data on sports injuries during events and provides immediate modelling of trends and occurrence rates of injury across sports and venues. SMA-ACT Sports Trainers use this system to log injury and treatment data in real-time on site via a menu prompt system to maximise the quality of data recorded.

Sports Medicine Australia, ACT Branch (SMA-ACT), launched new software designed to record and collate data about injuries, as well as monitoring concussion rates across the Australian Territories. The new software built on the InjurEdata Project was rolled out in 2012 and has been supported by funding of $29,200 through the Sport and Recreation Grants Program. The electronic data collection and referral process improves the ability to detect balance problems in athletes who are concussed, resulting in improved care for these athletes, and preventing potentially catastrophic side-effects of returning a concussed athlete to training or competition too early (Territory, 2015).

Major League Baseball Health and Injury Tracking System (HITS)

In 2010, Major League Baseball and the Major League Baseball Players' Association reached an agreement regarding the development and implementation of an electronic medical record system and a new league-wide injury surveillance system (Pollack *et al.*, 2016).

The Major League Baseball (MLB) Electronic Medical Record system (EMR) was built with the purpose of having a more standardised and streamlined way of entering, tracking and transferring player medical records. The new surveillance system was called the Health and Injury Tracking System (HITS). It also allowed for data linkage with other relevant data sets, including player travel data and game stats to help inform the development of injury prevention policies and programmes.

The National Basketball Association Injury Surveillance System

In 2012, the National Basketball Association (NBA) established a centralised, audited electronic medical record system that has been linked with external sources to provide a platform for research in the league and also to allow the NBA to conduct player health and safety reviews. The system is used by all 30 teams in the league, which allows for standardised data on injuries, illnesses and player participation in NBA games and practices. The electronic medical record data are enriched by linkage with other external data sources that provide additional information about injuries, players, game and practice participation, and movement. These data linkages allow for the assessment of potential injury trends, development of injury-prevention programmes, and rule changes, with the ultimate goal of improving player health and wellness (Mack *et al.*, 2019). The NBA EMR database has been developed since its inception in 2012. The ability to link other data sources to the main EMR database allows for more detailed and robust data analysis. This is especially true when it comes to athletic exposure.

Athlete Management Systems

"The Sports Office" and other companies offer athlete management systems to store performance, medical and administrative data. At present, "The Sports Office" system is utilised by 5048 teams in 85 different countries. They provide league-wide solutions to major sporting organisations, implementing their performance management tools with each of their associated clubs. Their customers include the Premier League, the Rugby Football Union, the FA, the English Cricket Board, the Scottish FA, the Irish Rugby Football Union, the FA Women's Super League and the British Horseracing Authority.

2.6. System Variable Comparisons

2.6.1. System Type

All systems reviewed are available as an electronic online system. Some of the systems used are based on an athlete management system such as "Sports Tracker" used by Cricket Australia and "The Sports Office" used by the English Premiership and IRFU. Other systems have been developed specifically for the different governing bodies. Participation in the surveillance is compulsory in the NBA, World Rugby, MLB and NCAA, while it is voluntary in the SRU.

The HS RIO and NCAA-ISP, used in amateur sports, are also compulsory. Therefore, they allow for the collection of large amounts of data for robust research in this population. Sports injury surveillance studies in universities in Ireland and the UK are based on voluntary participation with the option of opting out of studies if the participant wishes. The participation in the other sports leagues are compulsory and are also built into players professional contracts which also allows for the sharing of medical records through other electronic record systems.

2.6.2. Data Input

Different systems allow for data to be inputted by different personnel. Data is inputted by athletic trainers in the NCAA-ISP, HS RIO, HITS and NBA EMR systems. The NBA EMR data also requires the team physician to sign off on the data before uploading. In the WRR systems, data is reported by the medical team (Doctor, Physiotherapist and S/C coach). The SCRUMS system in Scottish rugby allows data to be entered by the coach, teacher or physiotherapist. In the systems reviewed, no system facilitates data entry by a player.

Data is collected on both injured and uninjured players prospectively on all systems except for the HS RIO, SIT and SCRUMS system which facilitate data collection on injured players only. All systems store data on player demographics with the exception of the SCRUMS which stores data only on the player's name, club or school.

2.6.3. Athletic Exposure/Injury Incidence

In a team sport exposure/risk hours may be calculated for the number of players participating on the court or field at one time. An example of this calculation would be players x game duration x games in season. For example, 12 players x 1.5 hours x 30 games = 540 player exposure hours. Then to calculate the incidence in relation to these exposure hours, the total number of injuries recorded over a period is divided by the total exposure for that period, and the result is multiplied by 1000 to obtain the rate per 1000 hours.

Observed injuries are those recorded over the period under consideration. Expected injuries are calculated by dividing the total injuries (for example, over four seasons) by the total exposure (for example, for the same four seasons) and multiplying the result by the exposure for the period under consideration (for example, one season only), giving an expected injury case for that one season. Significance tests may then be applied (Phillips, 2000). Injury incidence is defined as the number of injuries expressed per 1,000 player-hours of match exposure (or training exposure) in the PRISP, WRR ISS, and SCRUMS.

Athlete Exposure (AE) has also been used as a metric for calculating rates of injury in sports injury research. In this review, the HITS, NBA EMR, NCAA-ISP and HS RIO use AE for calculating rates. An AE is defined in the NCAA-ISP and the HS RIO program as 1 student-athlete participating in 1 school-sanctioned practice or competition in which he or she was exposed to the possibility of athletic injury, regardless of the time associated with that participation. However, the HITS system defines AE as the average number of players per team per game calculated based on analysis of regular season game participation via (publicly available) box scores. This average number over a season multiplied by the number of team games at each professional level of baseball yields an estimate of AE. The NBA EMR defined an AE as one athlete appearing in one game, which differs from the other AE definitions, as training and pre-season games are not included in the calculation.

2.6.4. Injury Classification – Type - Mechanism

All systems included the following variables on injuries – injury site, injury type, mechanism of injury, contact/non-contact injuries. All systems except for SCRUMS and HITS included gradual or overuse injuries as a variable. Previous injury was recorded in the WRR, MLB and NCAA-ISP systems. Variables associated with injury due to player violation were only found in the NCAA, SIT and SCRUMS systems. While these questions may be embedded in other systems, it was not possible to confirm this through research papers. Injury surveillance systems used injury classification based on consensus reports for their sports and in many cases utilised the Orchard injury classification codes in the back end of their system.

2.6.5. Injury Occurring Outside of Team Sport under Surveillance

Injuries that occur outside of the sport being monitored are not collected in any of the electronic systems included in this review. Professional clubs may at different times be required to release their players during the season to represent their country in international games and tournaments. At the professional level, players will not be allowed to participate in another sport on a competitive level outside of their sport of employment. This may account for data not being collected in the various injury surveillance systems.

The amateur player is often a multi-sport athlete and can play or train in more than one sport per week. Training and game exposures may differ greatly from player to player on a team and this data is important when looking at training load in players and their increased risk to injury due to fatigue. For example, the training/match load for an U16 school basketball player in Ireland may require School training (1.5 hours x 2 per week), Club training (1.5 hours x 2 per week), and two games (1.5 x 2). At the very least, 9 hours per week. This can greatly increase if the player is also playing on the U18 team. The same game and training load may be added for each sport the player participates in which can often be three sports. Injuries suffered in the multi-sport athlete may be as a result of different injury risk factors, over-training, or even the contact/non-contact nature of the sports in which they participate. For completeness, a system needs to have the ability to collect information on the multi-sport athlete or collect information on injury which occurred outside of training in order to avoid misinterpretation of data.

2.6.6. Data Analysis

Data analysis from the professional injury surveillance systems is utilised for injury reporting within a team and carried out by members of the medical team or may be outsourced to a consultancy firm. Data collected from the WRR system is compiled, quality assured and analysed by independent consultants. Findings from each competition are then written up in the form of tournament reports. Collected data may be analysed using systems such as SPSS software. The NCAA-ISP operates differently in the fact that data collected by each AT is uploaded to the online system and data analysis is carried out centrally by the Datalys Center for Sports Injury Research. Data analysis is not returned to each specific AT and their team. Aggregate data, in the form of sport-specific reports containing text and tables, are provided to the NCAA annually and used by committees such as the Committee on Competitive Safeguards and Medical Aspects of Sports to develop health and safety policies and monitor ongoing injury trends.

The injury surveillance system is particularly valuable given its ability to generate analyses related to the effects of policy and rule changes on injury rates (Kerr *et al.*, 2014). Data collected through the HS RIO software system is analysed by HS RIO staff team and carried out at the Center for Injury Research and Policy of the Research Institute at Nationwide Children's Hospital. The data reported is used to produce nationwide estimates on time loss injuries in high school sports and serves as the first step toward the development, implementation and evaluation of evidence-based, targeted prevention programmes to reduce the number and/or severity of injuries among high school athletes (Datalys).

An important characteristic of an injury surveillance system is that the data is collected in such a way that it can be easily exported and analysed by the research team without the necessity of having to use a third party. The Datalys Center requires a non-refundable application fee if requesting data from a specified academic year.

2.6.7. Game Time of Injury, Diagnosis, Treatment and Fitness Test for Return to Play

All systems collected data on the time of injury occurrence during a game. The location where the injury occurred on the court or field was recorded by all systems, apart from the WRR IS, SCRUMS and SIT systems. While these questions may be embedded in all systems, it was not possible to confirm this through research papers.

Injury diagnosis data was collected in all systems but this information was not accessible for the SIT system. Further research identified that the sports injury reporting form used by SMA did not include questions on diagnosis. Questions on treatments for sustained injuries were included in all systems except for the HS RIO and WRR ISS. Time loss through injury was collected in all systems with the exception of the SIT and SCRUMS. Time loss specific definitions were included in the PRISP System and NBA and NCAA systems. Return to play or clearance was not included in the SCRUMS, NCAA or HS RIO systems. Information on player illness was included the NBA EMR, HITS, WRR ISS and NCAA systems. Fitness tests and clearance to play were included in the HITS, NBA EMR and the WRR ISS systems. The NBA and HITS systems have the ability to link with external data sources to access wider data available on players such as travel and game box stats.

2.7. Sports Injury Definition

Injury definitions are descriptive and can contain a variety of elements including missed games or training, medical attention, diagnosis, hospitalisation, tests or treatments. The National Collegiate Athletic Association Injury Surveillance Program (NCAA-ISP) (Dick, Agel and Marshall, 2007) and High School Reporting Information Online (HS RIO) (Borowski *et al.*, 2008), state that an injury can be recorded if it occurred as a result of participating in a game or training; however this is not included in the NBA definition. While all three definitions have similar elements with regard to the player requiring medical attention, they differ when discussing an element of time loss. The NCAA-ISP and HS RIO programs discuss the restriction of the student-athlete's participation for one or more days beyond the day of injury, while the NBA defines an injury occurring only if a practice or game is missed as a result of an incident. The Health Injury Tracking Systems (HITS) (Pollack *et al.*, 2016) definition for injury is broader in scope, being described as an injury or physical complaint sustained by a player that affects or limits participation in any aspect of baseball-related activity (e.g. playing in a game, practice, warm up, conditioning, weight training). Using this type of injury definition relies heavily on the ability to collect multiple pieces of data on each injury to investigate data in a meaningful way. A benefit worth considering in using the HITS injury definition may be for a self-reporting player, who often will not attend a doctor or physio and therefore not register an injury. The Scottish Rugby SCRUMS use a time loss injury definition which is described as an injury resulting in a player's inability to participate fully in training or match play after an injury that occurred during either rugby training or game. This injury definition is used as directed from an IRB consensus statement.

A central element to designing this system was finally deciding on the injury definition that would underpin the study. As seen in Chapter 1, the NBA and NCAA injury surveillance systems all use their own injury definition that subtly differs across the systems. As a result, the definition selected for use in this study is stated as:

> *"A reportable injury is defined as any injury which occurred during a game or training regardless of absence from competition in the days after initial injury."*

2.8. Discussion

This scope review has highlighted that injury surveillance systems in the sport of basketball are available in the US, Canada and Australia, but they are non-existent at an elite level in Ireland and the UK, as well as other basketball federations. The lack of engagement by governing bodies on any level was surprising. This research gave an opportunity for these bodies to promote their strategies to reduce injuries in their sports. As a result, the search methodology focused more on what was publicly available to establish any variables being observed in each sport. It should be noted that in a 2010 report for FIBA Europe, a recommendation was made that all national associations include an injury prevention module in their trainer education curriculums and to designate an official staff member as 'safety promotion ambassador' of the federation. And, last but not least, that all sustained injuries should be reported to trainers and coaches and systematically recorded at club and national level in order to identify individual and situational risk factors, to monitor injury trends and to evaluate the effect of measures taken (Luig *et al*., 2010).

The scope review documented the gaps and differences in both the systems and the information collected by them. Different systems have a different focus on the data and there are as many definitions of relevant injury as there are systems available. These gaps and differences had to be taken into consideration for this study and its participants. Injury definitions may limit data collected as not all athletes have a medical team to support them in their identification of an injury. Often, a member of the medical team would be solely responsible for inputting the data. Amateur players are often self-guided on their absence from and return to sport. Consequently, some injury data will be lost through a non-medical assessment of "bumps and bruises". The restrictive nature of some of the injury definitions will limit the system's ability to pick up injuries like bruising or minor sprain because the athlete will not deem it enough to warrant time off training or game. The embedded questionnaire should be able to register these bumps and bruises in the absence of a medical support team. The player should be guided to give a complete picture of their current state.

The benefit of the proposed injury definition is a broadening in the scope of the questionnaire. Many players will not attend team physios or doctors unless they are directly involved with the team or club and are covered under insurance policy. Data could be missed if a player suffers an injury and "does not seek medical attention" or "does not miss the next activity" as per other injury definition requirements. They may not perceive this injury as notable. This "play with injury" scenario may skew any resulting data collected. By making the definition less conditional, it can capture what may have been previously inaccessible data where a player will continue training and playing with some "bumps and bruises". The questions contained within this system would enable the research team to extract more information about time loss, medical attention and treatment in the event of an injury to produce a data set comparable with other similar studies using previously described systems.

As noted with the NCAA licensing of their injury surveillance system, companies can build their own front end for the questionnaire. This has resulted in inconsistencies across the data collected. For example, the inclusion of inactive players while entering exposure data to the system varied depending on the company involved and the software they produced. Sometimes the system only collected information if the player was injured, rather than the complete picture of all minutes played by players. This will not provide the total athlete exposure to training and games which is an important metric in an injury surveillance system.

Even with the availability of commercial systems, many governing bodies opt for the development of a bespoke system for their sport. They still see the value in having their own system designed for them. Two major organisations (NBA, MLB) have created their own system which can dovetail on other data collections available to them. The inclusion of data sets on player travel and game stats that are publicly available can provide a more robust and global picture of contributing factors to injury. Looking beyond the immediate scope of injury data can provide some relevant context for analysis and conclusions. The UKIBIPS system profiled the players based on demographic, equipment and other sporting activities. This data identified other factors that may contribute to potential injury during a season of basketball at the amateur and semi-professional level in Ireland and the UK. Multi-sport collection of data is not facilitated in the injury surveillance systems examined in this chapter.

Bespoke systems are predicated on the availability of a medical support team. These will bear the responsibility for injury assessment and entry of the relevant data. They will also instruct the athletes on further treatment and participation in future training sessions and games. In Ireland and the UK, the number of teams with sport-specific medical personnel available is negligible at anything except National League level and above. During games, a generic first aider may be available, but more often than not, the coach just has a basic first aid kit. Players have to seek independent evaluation on their injury and treatment. They may not have professionally trained team staff to guide a safe return to active training and play post-injury. For an Injury Surveillance System to be effective in this environment, it needs to rely on the non-medical, self-reporting player to input the data and, as such, needs to guide them carefully through a set of questions to gather accurate and complete data on a regular basis.

At the time of research, there were no suitable systems available to the Primary Investigator. This was due to cost, access to underlying data, geographical availability or a combination of these. The completeness of the questionnaire when used by a non-medical athlete was also a major factor in the decision to design and implement the UKIBIPS. Any system developed would have to be universally accessible to allow the athletes to enter the data in a complete and correct fashion for further study and analysis by researchers.

The key learnings from the scope review carried out in this research are:

1. Injury Surveillance Systems, while common place in professional sports, are not frequently used in all sports or at all levels in sports equally.

2. While definitions on injury are quite descriptive and easily used and interpreted by medical staff, they are not easily translated over to amateur sports where a strategy to collect data on injury will require the players themselves to enter data.

3. There are gaps in our understanding of the level, quantity and types of injuries occurring in basketball and other sports. The development of a new injury surveillance system will contribute to our knowledge of sports injury and provide researchers with a valuable data collection tool to inform injury prevention strategies.

4. The development of a UKIBIPS-ISS is fully justified for amateur sports in light of the discussion in this chapter.

Chapter 3 – UK and Ireland Basketball Injury Prevention Study Injury Surveillance System (UKIBIPS-ISS) Version 1

3.1. Introduction

Injury Surveillance Systems, while commonplace in professional sports, are not frequently used in all sports or in all levels of sports equally. The scope review presented in Chapter 2 identified the injury surveillance systems employed in eight sports, their professional leagues and governing bodies, and also highlighted a variety of injury definitions in the different sports. While definitions of injury are quite descriptive and easily used and interpreted by medical staff, they are not easily translated over to amateur sports where a strategy to collect data on injury will depend on the players themselves entering data without the presence of any qualified medical personnel.

The injury surveillance systems reviewed had a number of injury variables in common with each other. However, the review identified that all systems were not equal in the data they collected and had a number of limitations or functionality restrictions that would have made them unsuitable for use in this research study. Along with gaps identified in these systems, many are limited to use in their country of origin, and also collected data solely for their chosen sports. Outside of some of the largest collegiate and high school educational institutes, there are very few systems that collect injury data in amateur sports worldwide. The two systems included in the scope review for amateur sports were not available for use outside of the US. What we can take from the systems in the scope review is that there is a common base of variables that must be included in any ISS. These variables were not the main drivers for the development of a bespoke system. Rather, the unique variables that were observed in different systems needed to be brought together in a single model along with additional variables proposed by the Principal Investigator in order to provide for a more complete and robust data collection system in the amateur basketball arena under investigation here.

Developing an injury surveillance system for the UKIBIPS will allow the Principal Investigator to gather data to address specific queries but would also facilitate data collection by a variety of personnel involved in any team.

Variables to include in the UKIBIPS are:

- Date of player registration

- Player demographics
- Shoe and sole type
- Protective equipment
- Participation in other sports
- Injury in other sports
- Medical conditions
- Team information – name, league, country, level and international participation
- Player – playing position, experience, first five (starting team line out)
- Home Court training and playing surface
- Pre-season – individual training, team training, pre-season fitness tests. Basketball and other sports (if multi-sport athlete)
- In Season – Basketball team and individual training and other sports (if multi-sport athlete)
- Game-Related – home / away, time played
- Injury Information – game/training, location, type, mechanism of injury, previous injury, reoccurring injury, court location, continued to play or stopped after injury, immediate injury care (first aider doctor physio or other), attended hospital, investigation (x-ray, Scans) treatment, treatments post-injury (physio), fitness test before return to play (physio, team doctor s/c coach) return to play advice and or orthopaedic supports)

When designing the UKIBIPS-ISS, it was important to use injury diagnosis coding for comparison with other studies. Rae and Orchard (Rae and Orchard, 2007), in their 2007 study, stated that the two purposes of sports injury coding were to "facilitate retrieval of records on injuries, and once done, to collate diagnoses into common groups to follow trends into injury surveillance and prevalence". It had been suggested by Orchard that when using a computerised system, it is not ideal to have an unfiltered drop-down list of all the OSICS (Orchard Sports Injury Classification System) terms to choose from. They further suggested that programmers use basic terminology for the participant to select the body part injured from a drop list and then a separate drop list to select the injury type.

It is vital to establish the mechanism of injury, specifically when identifying whether this was a contact injury or a non-contact injury. Non-contact modifiable injury occurrence can be influenced by appropriate injury prevention strategies informed by relevant data collected through a system like this. Therefore, it is prudent to explicitly question the player about the nature of the incident of injury. A variety of mechanisms of injury in basketball can be seen in Table 3-1 in the methodology section.

Thus, it was decided to develop a practical and accessible tool to collect injury-related data on a large scale from teams and players with the primary function of simple and centralised data collection for this study. This system would eventually emerge as a data collection tool suitable for future epidemiological research. This chapter describes the process of development of the system and its use as an online tool for data collection in the sport of basketball.

3.2. Chapter Aims

- To establish a suitable injury definition to use in the UKIIPS that would be accessible for both medical and non-medical team staff and/or the self-reporting player in order to collect as much player data as possible.
- Describe the development of a practical and accessible tool to collect injury-related data in basketball.

3.3. Methodology

3.3.1. Sports Injury Definition

A central element of designing this system was finally deciding on the injury definition that would underpin the study. As seen in Chapter 1, the NBA and NCAA injury surveillance systems all use their own injury definition that subtly differs across the systems. Further, the gaps in these systems were identified in Chapter 2. As a result, the definition selected for use in this study is stated as:

"A reportable injury is defined as any injury which occurred during a game or training regardless of absence from competition in the days after initial injury."

The benefit of this definition is a broadening in the scope of the questionnaire. Many players will not attend team physios or doctors unless they are directly involved with the team or club or covered under an insurance policy. Data could be missed if a player suffers an injury and "does not seek medical attention" or "does not miss the next activity" as per other injury definition requirements. They may not perceive this injury as notable. This "play with injury" scenario may skew any resulting data collected. By making the definition less conditional, it can capture what may have been previously inaccessible data where a player will continue training and playing with some "bumps and bruises". The questions contained within this system would enable the research team to extract more information about time loss, medical attention and treatment in the event of an injury to produce a data set comparable with other similar studies using previously described systems.

3.3.2. UKIBIPS System Design

Having performed a scope review, it was clear that when developing an ISS for the UKIBIPS it would need to have the capability to collect data on a large scale from teams and players with the primary function of simple and centralised data collection.

The proposal was to provide a system that would:

- Use a skeletal display to make it easier for the player to select a part of the body as the site of their injury, thus reducing the risk of incorrect entries into the system.
- Use a guided set of questions based on clinical assessment methods and other consensus reports to gather injury-related data.
- Present an intuitive User Interface (UI) that minimises the amount of data that the user inputs to the system. Variations in user input are minimised by offering a choice from a list. This ensures a consistency of data entry that is not possible using free text input.
- Use a basketball court schematic to indicate where the injury occurred on the court. For many people, the visual representation of a court may make it easier to recall

where they were on court at the time of injury, rather than a list of terms describing those areas.

Some of the questions used to collect the data would come from early studies such as (McKay *et al.*, 2001a; Kofotolis and Kellis, 2007) to make sure that data collected would be easily comparable. Questions included: What position do you play? What type of playing shoes do you wear – hi-top, mid-cut, low-cut? Have you suffered a previous injury? How many training sessions do you participate in per week? What level of competition are you playing at? Are you playing international basketball? Do you play any other sports? Do you wear any orthopaedic supports? Additional questions included by the Principal Investigator were in relation to treatment that a player received at the time of injury. For example, did you take a fitness test before returning to play, or do you play more than one sport?

The questionnaire is structured to collect demographic information first, and then ask specific basketball-related information, before asking questions in relation to the type and mechanism of injury. A requirement of the data collection system was that it could easily transfer all collected data to an analysis system held on a server. The mobile device used by the players needed to operate without necessarily being connected to the server. In "local" mode, the data could be entered and when appropriate, the data could be uploaded/synchronised with the server.

The objectives of the software development element of the study were:

- To set up a data storage area to centrally manage and query the data collected.
- To produce a multi-platform mobile application to simplify the collection of injury data based on the Principal Investigator’s questionnaire.
- To produce a software application for the querying and report generation, based on the data stored.
- To investigate the development of a software application to help manage individual injury management programmes for the coaches, athletes and medical staff involved.
- To assess the suitability of the UKIBIPS-ISS as a reliable tool for injury surveillance.

- To monitor the adherence rates of participants in using the Injury Surveillance System.

To achieve these objectives, it was important to identify and engage expertise in the development of software to meet the needs of this research project. Additionally, as previously stated in Chapter 1, the Injury Risk Framework model by Van Mechelen (Van Mechelen, Hlobil and Kemper, 1992) would require the Principal Investigator to establish a sports-specific questionnaire in order to provide data which, at a later date, may be used in the development of injury prevention strategies. The injury definition and target population for this study dictated the structure of the questionnaire to be used.

The Principal Investigator identified the Galway-Mayo Institute of Technology (GMIT), Ireland, to potentially work with on the research project as collaboration with industry is a feature of projects in the GMIT Software Development course. After meetings between with Mr Damien Costello (GMIT Lecturer in Maths and Computing), it was agreed that there was potential for a mutually beneficial working relationship. Software development students had the necessary skills to design the database, create the website and set up the hosting environment for the UKIBIPS project.

3.3.3. Injury Classifications and Mechanisms

During the development of the UKIBIPS-ISS, Orchard's recommendations were taken into consideration. The online system began with the question "Did you suffer an injury this week?" If, and when, any injury occurred, the first option available to the player was to select the body part which was injured. This body part was described in simple terms. Medical terminology was removed from the front end of the system to prevent confusing the user. An example of this is to use "shoulder joint" rather than "Glenohumeral joint and "elbow" rather than "Olecrannon process". After the injured body part was selected, the player was asked to select what kind of injury occurred. The injury types to select from were fracture, dislocation, subluxation, muscle strain, bruising, ligament sprain, tendon injury (tendonitis or tear), cuts and nerve, disc, cartilage or nail injury. The mechanisms (the "how") of injury are shown in the Table 3-1. These are linked to basketball activities and the contextual risk factors associated with them.

Table 3-1: Mechanisms of Injury in Basketball

Mechanism of Injury	Defining Attributes
Contact Injury	Contact with a player or equipment, Contact rule violation
Non-Contact Injury	Non-contact sudden onset Injury (hamstring pull), Non-contact gradual onset injury (Achilles tendonitis), Reoccurring injury
Activity Outside Basketball	Random injury outside basketball, possibly in another sport
Shot/Blocking Injury	Shooting, blocking or landing
Running Injury	Running in offence or defence
Rebounding	Rebounding in offence or defence
Driving to the Basket	When a player tries to dribble the basketball past the defence and attempts to layup or dunk the ball
Taking a Charge	An offensive player has made significant contact with a defender that has an established position
Court Location of Injury	Base line, key area, inside or outside 3-point area, half court
Offence Injury	Vs Man or Zone
Defence Injury	In Man to Man or Zone
Transition	Offensive or Defensive

Additionally, there are environmental factors that are accounted for in the questionnaire. These include home or away venues and training or game time. The context is important as a player will be more familiar with the home court and different courts are not standard. They may be adequate to meet governing body requirements, but standards of construction and materials will be different. For example, ventilation can be a contributing factor to the playing surface friction. Game time and training time can vary in intensity, speed and duration. For example, overtime brings additional fatigue and risk of injury. While training is a more controlled environment, individual or team training sessions have obvious differences in injury risk and need to be recorded. In the amateur sport, times allocated for training are based on availability rather than the most suitable time for the players to train. For example, players may tire more than usual if a training session is scheduled late and ends around 11pm. Players may also suffer sleep disturbance having trained at such a high intensity so close to going to bed.

3.3.4. UKIBIPS Questionnaire Design

During the preliminary stage of planning the questionnaire, the Principal Investigator divided the questionnaire into nine specific parts for development.

- Player Demographics
- Player Equipment
- Player Basketball and Training Details
- Previous Injuries
- Player Medical Conditions
- New Injury Details
- New Illness Details
- Injury Treatment Details
- Return to Sport Details

To provide such a comprehensive range of data, the questionnaire needed to be detailed but at the same time not difficult for the user to understand. The Principal Investigator used Excel to develop the questionnaire template for the software design team. The questionnaire development was time intensive as the Principal Investigator not only had to design the questions but also present the questions in a way that the computer programmers could link each question to the next, based on the variety of potential selections made by the user. This is one of the key differences between a paper-based questionnaire and a computer-based one and the flow of questions for both player and programmer had to be addressed. The advantage of a computer system is that the player will have the next appropriate question presented rather than have to search through the physical pages to find it based on questionnaire notes. This significantly reduces the time burden on the player using the system.

The first draft of the flow of questions was broken into four columns. Column one contained the number of the question in the sequence of the questionnaire. Column two contained the primary question. Column three contained a note giving direction to the computer engineer. Column four contained the question number to which the player would be brought next in the logical sequence. See Figure 3-1.

Question Number	Question Text	Reply Options	Follow-On Question
1	Who are you	player	5
		medic	2
2	medic first name		3
3	surname		4
4	team name		5
5	player first name		6
6	surname		7
7	age		8
8	weight		9
9	height		10
10	dominant side		11
11	race	list	13
		other	12
12	enter other race		13
13	gender		14
14	country of birth		15
15	country at present		16
16	number of years in this country		17
17	medical conditions	list	19
		other	18
18	enter other medical condition		19
19	type of shoe		20
20	type of sole		21
21	gumshield		22
22	taping		23
23	orthotics		24
24	orthopediac support		25

Figure 3-1: First Draft of Question Flow on Injury Questionnaire

After the questionnaire was submitted to the development team, they were asked to create a system that could incorporate all aspects of the questionnaire. As this was the first submission to the team, they were asked to report back weekly and identify any problems they encountered. While the team worked on the mechanics of the system, there was a need to develop the flow of the questions to ensure that the data was gathered accurately.

Free-text input had to be kept to a minimum to avoid ambiguous entries ("Senior Irish Men" v "Irish Senior Men"). Drop-down lists are a reasonable solution to this consistency in software development and were adopted by the team.

To develop the questionnaire, the Principal Investigator produced another more detailed version with the options for the drop-down lists included. A portion of this is presented in Figure 3-2 for the flow after the question "Have you suffered an injury?"

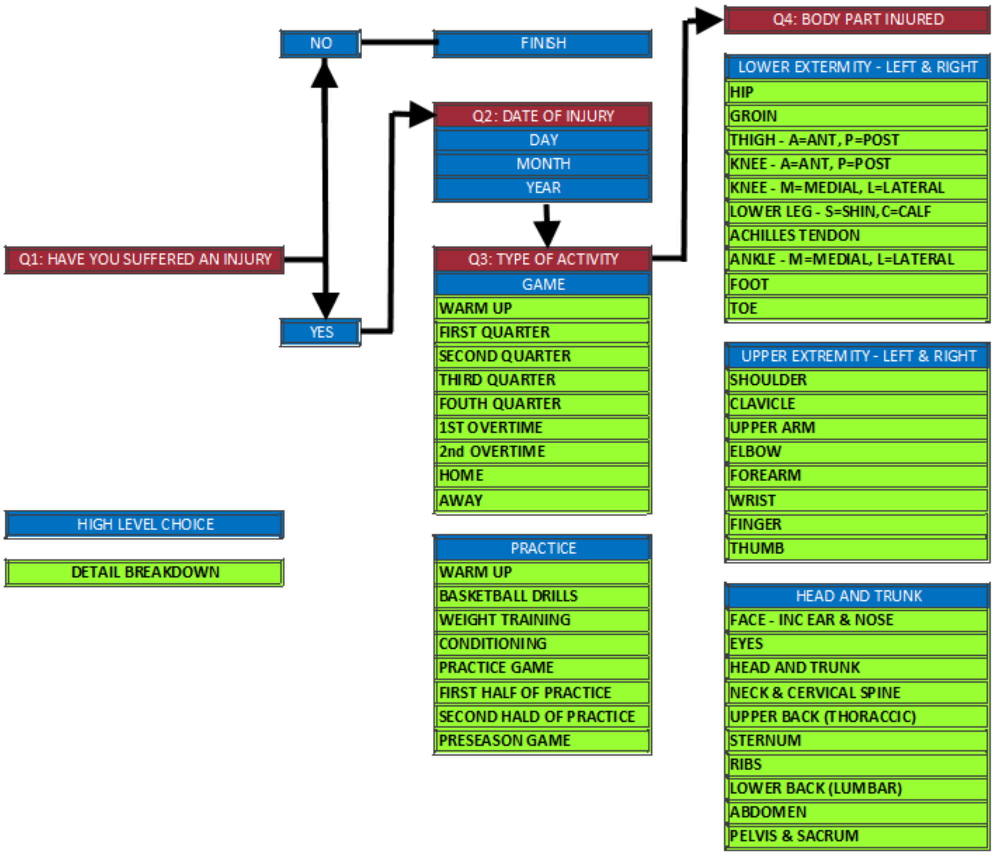


Figure 3-2: Sample Question Flow Showing Predefined Answer Options

Medical terminology was used in the back end of the system for storage, while the user interface displayed queries in simple text where possible. The back end of the system used the Orchard Sports Injury Classification System (OSICS) Version 10, (Rae and Orchard, 2007) (see Appendix 5). This draft questionnaire was the first time diagrams were included. A section of this is provided in Figure 3-3 showing the location and terminology for the design team when describing an injury to either the right or left upper extremity (arm).

The diagrams, while sometimes not exhaustive, served three purposes at this early stage of the development:

1. They helped the computer programmers understand the terminology.

2. They were useful for deciding the most appropriate diagrams to include in the final system.

3. They acted as a visual aid for the player in understanding the question being asked of them.

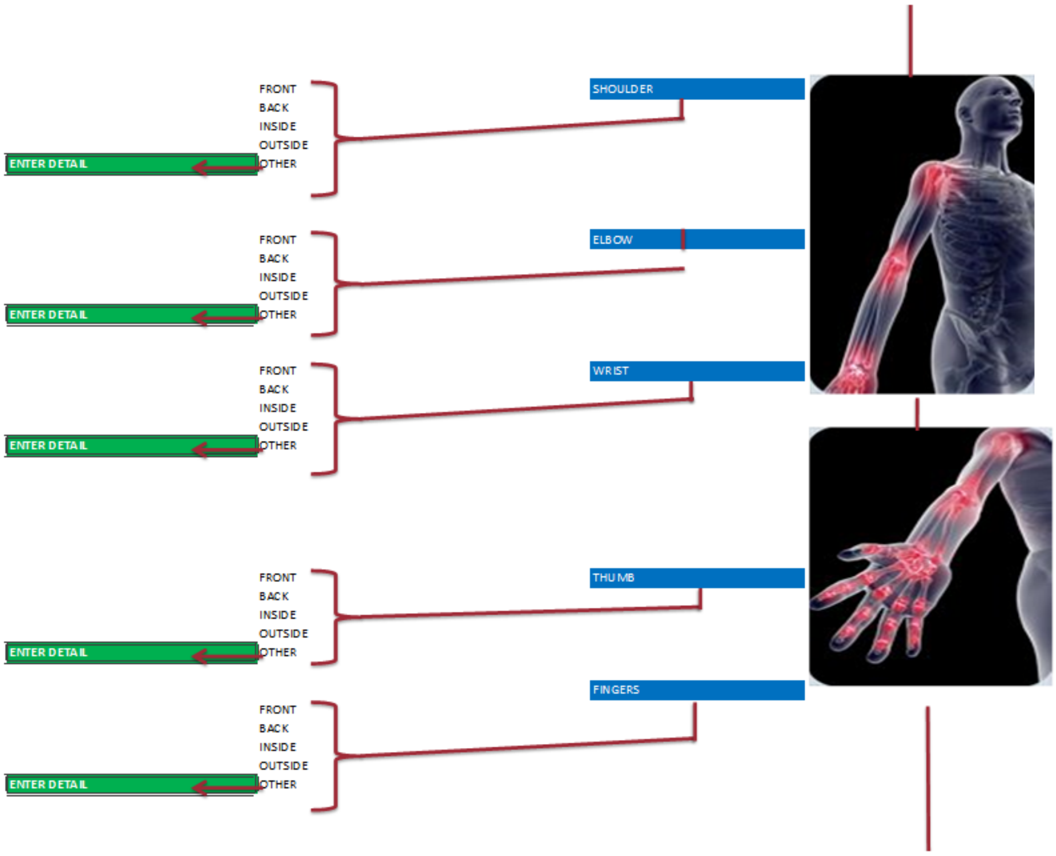


Figure 3-3: Questionnaire Diagrams for Upper Extremity Injury Locations

The final version presented to users was a combination of text-only questions and questions supported by diagrams. In some cases, the diagrams were not used due to difficulties the software developers had incorporating them and maintaining the format of the UI. Figure 3-4 shows a screenshot from the system of the choices available to a player entering details about a previously existing injury. Figure 3-5 shows the entry dialog for the player as they provide details of the location that an injury occurred on court during a game.

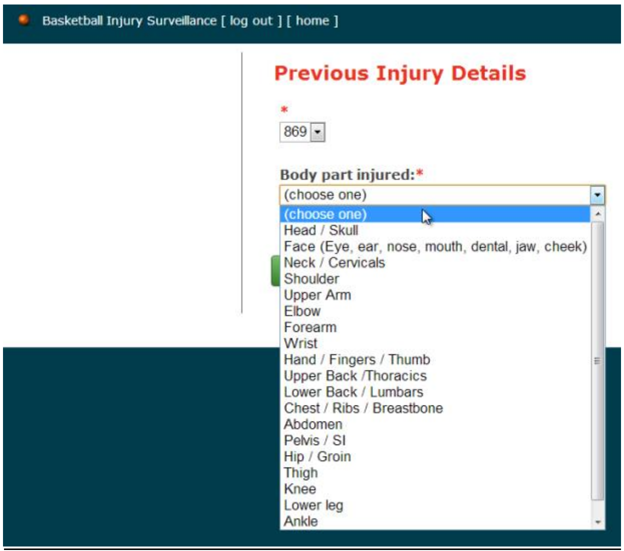


Figure 3-4: UKIBIPS-ISS Screenshot Selecting Injured Body Part

Figure 3-5: UKIBIPS-ISS Screenshot Adding Details about a Game Injury

Video footage and basketball images were purchased from Shutterstock Ltd and these were used in the final software when launched online. It was hoped that bright and related basketball imagery would engage the user.

3.3.5. System Development Collaboration

The first UKIBIPS-ISS design team meeting was held at GMIT Galway in September 2012. Angela Forde (BSc Student) and Damian McGuinn (BSc Student) volunteered for the project with the agreement that Damien Costello would act as their supervisor for the duration of the project. At this meeting, the Principal Investigator gave an outline for the overall aims and objectives for the research. At subsequent meetings with the development team, the Principal Investigator produced an Excel document which contained the vision of how he would like the application to function. Over the course of development, the Excel document was revised to a more suitable model. (All major versions are included in Appendix 6).

3.3.6. System Architecture and Design

The system needed to be available across multiple platforms including desktop, tablet, laptop and mobile systems. Rather than developing in a native environment for each, it was decided that a web-based approach would be more appropriate. The United Kingdom & Ireland Basketball Injury Prevention Study – Injury Surveillance System (UKIBIPS-ISS) web application was built using CakePHP 2.3.1. PHP (recursive acronym for PHP: *Hypertext pre-processor*), a widely used open-source general purpose scripting language that is especially suited for web development and can be embedded into Hypertext Mark-up Language or HTML (a standardised system for tagging text files to achieve font, colour, graphic, and hyperlink effects on World Wide Web pages).

CakePHP was selected as it was a free open-source rapid development framework programme. It provided a foundational structure for the coding to create the logic required for the UKIBIPS-ISS. The system engineering incorporated the following software design patterns. *Convention over Configuration*, where the computer programmer can decrease the number of decisions they have to make because their working environment, such as *Systems & Language*, already assumes logical situations by default. If used appropriately, it can eliminate the complexity of the programmer having to configure all of their application development, and therefore save time. *Model-View-Controller (MVC)* may be defined as a design/architectural pattern for how a programmer arranges their code. The model is like the brain of the application, and it is responsible for collecting and manipulating the data. It interacts with different databases and communicates with the controller. The View *(User Interface)* is what the viewer sees when they interact with the application. The Controller interacts with the view as well as the model. The controller takes in user input from someone who has looked for a specific page or clicked a link and then makes a request to the controller. An example may be where a user submits a form which would be a post request to the controller.

An Active Record (AR) is held within the model, which is responsible for the database and logic. An AR may be defined as that which facilitates the creation and use of business objects, whose data requires persistent storage to a database.

To integrate and make use of data that has been collected, associated Data Mapping (DM) is used as the process which helps establish relationships between separate data models. More simply, it is mapping data fields between a source file and their related target field. The Front Controller handles all requests to a website. It provides a security element also to allow users different levels of access.

CakePHP was specifically chosen for the project as its default cascading style sheet (CSS) layout is supported by all the standard desktop and mobile browsers. Other applications had been considered by the design team, but the licensing costs for these packages were too expensive.

The UKIBIPS system was built using a process called “Baking”. CakePHP achieves this by generating the code based on the developer code and configuration files that follow specific naming conventions to ensure the resultant database and HTML files can communicate correctly. Each controller is related to another by virtue of code in the model. For example, “User is a player” and “Player has one or more injuries”.

User data is validated in the underlying models, ensuring proper email domains, minimum character field lengths, and making sure fields are not left empty. Validation of the questionnaire is handled in the front end by providing a choice for data entry through drop-down lists, check boxes and radio buttons.

While the system provided basic Create, Read, Update and Delete (CRUD) functionality, a more advanced query mechanism had to be provided to the Principal Investigator. Once the questionnaire logic and validation were implemented, the focus of the design team shifted to that of security for the UKIBIPS.

Each user in the system has a unique identifier. The authentication component identified each user as Administrator, Team Management or Player when they access the system.

Players can only view and edit their own personal data while the Principal Investigator can access any page and has full read/write access to the database.

The final phase of the project involved creating a user-friendly front end for querying the database. As the Principal Investigator had no prior knowledge of coding or using SQL, the design team created a variety of views to allow the Principal Investigator obtain information from basic to complex queries for analysis. Figure 3-6 displays a screen shot of the complex query page.

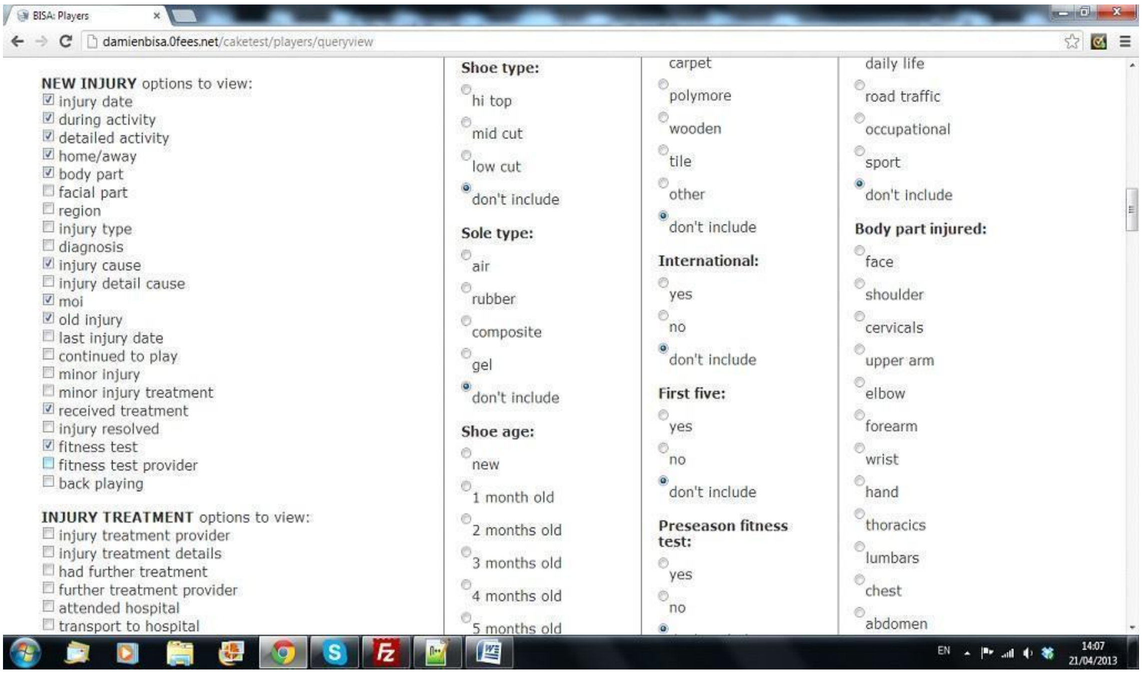


Figure 3-6: Complex Query Page Showing Selection Criteria Available

To obtain the information from the database, the Principal Investigator had to tick the preferred option from the cascade drop-down feature. An example of a query is how many players suffered a right ankle injury on a wooden court wearing mid-cut runners during a game in the 4th quarter.

3.3.7. Definition of System User

The UKIBIPS-ISS was designed primarily to be used by the player, but also needed to have the flexibility to be used by others. For the purpose of this study, three types of user of the system were defined.

The Administrator - The Principal Investigator is the administrator for the UKIBIPS-ISS. The administrator is the only person who has access to the complete data set and is required to use more than one password to access the encrypted data stored on the server. The administrator can monitor the overall usage of the system.

The Player/User - The player refers to any basketball player who competes in any of the UK and Ireland National or Premier Leagues and may also play in any of the four home nations (Ireland, England, Scotland and Wales) International squads. The player is the primary user of the system. After a player registers on the system, they are asked to log on once per week throughout the season and update their file with any injuries or illnesses which caused them to miss training or a game. The player is unable to edit their details after registration. Each player is given a user ID on registration and each entry by the player after the initial registration date is given a separate ID number.

The Team Doctor, Physiotherapist and Team Manager - A professional club management team includes a head coach, assistant coach, team manager, doctor and physiotherapist. The system allows for one of these staff team members to update the files of individual players. The team staff member will also be assigned a user ID and this will be identifiable by the administrator. It is important to note that a member of the management team i.e. the physiotherapist has no access to the player's personal details and cannot view previous entries.

3.3.8. System Stage Development

The system was developed between September 2012 and April 2013, in order to have it ready and tested before pre-season training for the 2013-2014 season, following a schedule agreed between the Principal Investigator and the design team. The system was deployed to several hosting platforms for testing but was eventually hosted on 0fees.net which offered all the necessary data storage, hosting and scripting support required. After testing, the 0fees hosting was found to be stable and meet the requirements for the research to get under way.

3.3.9. System Security and Encryption

Security is always an issue when dealing with sensitive medical data. As a result, in the final system, personal data, such as name, username and password, were stored separately from the then anonymous injury data. Data was encrypted before sending over the network. The information was stored on two separate hard drives for additional security.

The data store was accessed by a separate secure software application to allow reporting and analysis of the data.

3.3.10. Test Group Selection

The system was initially tested for functionality by running a series of test players through the system. Exported data was checked to see that it matched the inputted data on each player. Once the system was operational, a group of volunteers were needed for focus group feedback. Traditionally, focus group research is “a way of collecting qualitative data, which essentially involves engaging a small number of people in an informal group discussion (or discussions), ‘focused’ around a particular topic or set of issues” (Wilkinson, 2004).

The participants for this focus group were sought from basketball clubs based in Galway city. The clubs agreed to offer feedback, and a group was set up which consisted of seven players from the senior men’s and women’s squads. It was important to get user feedback by age and competition level, as well as user friendliness for players, and from some of the players for whom English was not their first language. Seven players (m3/f4) from five different nationalities Lithuanian (1 male 30 years old, national league), Irish (1 male 16.81 years old, local league), Spanish (1 male player 24.69 years old, national league), English (1 female 42 years old, local league), United States of America (1 female 24.81 years old, super league) South African (1 female 17.65 years old, super league), Welsh (1 female 23.34 years old, national league) and Polish (1 female 15.61 years old, local league) took part in the feedback focus group.

3.3.11. Test Group Feedback

After completing the registration and using the system for two weeks, the players were met by the Principal Investigator to discuss the functionality of the system and to look for any feedback which may improve the system before its official launch. After the players had used the system to enter test data, they reported no difficulty understanding the text or following the questions. Two reported a slow upload speed time of the system to their devices. This was investigated by the design team and the problem was traced back to the broadband speed utilised by the player. The other problem identified was that some players had difficulties when free-text was allowed. It was decided to further reduce free-text entry on the system and to use more drop-down features to gather data. Once the design team made modifications to the interface, the system was retested. Retesting involved getting a player to go through the process of entering data and signing off on the modification to the data entry elements. The Principal Investigator and software engineer ran a number of player injury scenarios through the system to make sure data was being collected and data stored matched inputted information on a player before the system went live online for the 2013-2014 season.

Sample of Player System Support Email Queries

Player (01)

Hi UKIBIPS Admin Team

I have filled in sections of the systems but it is taking too long to upload. Is there a problem with the system at the moment? Or do I need to download something else to log in?

Admin – Player contacted. Problem identified – Broadband speed.

Action – Registration completed on desktop.

Player (01) – Registered, thank you.

Player (02)

Hi UKIBIPS Admin Team

Having problems trying to upload the page when I finished filling in the section. Seems to freeze and won't let me proceed.

Admin – Player contacted. Problem identified – Broadband speed.

Action – Registration completed on a different device.

Player (02) - It's working now, thank you.

Player (03)

Hi Admin Team

I was not able to log in to complete my registration. I started it and hadn't the time to finish it. I tried to register again but it won't allow me to do so. Can you send me a link or password thanks.

Admin – Player contacted. Problem identified – issue with username and date of birth in free-text section.

Action – Data cleared and username reset. Registration completed over the phone.

3.3.12. Player Registration and System Use

Once registered and logged in, the player entered demographic/baseline information, including age, height, weight, dominant hand, player position, competition level and shoe type. Once completed the player could view and make an edit if needed before submitting. A screenshot of the player registration page is provided in Figure 3-7.

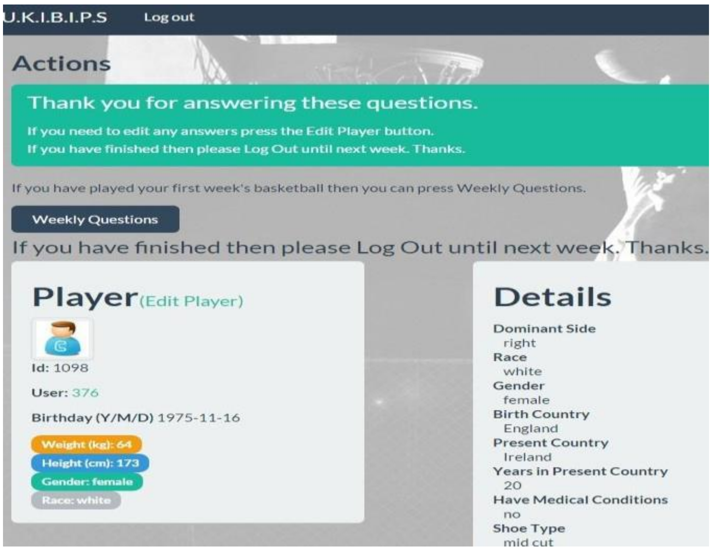


Figure 3-7: Player Registration Screenshot

Once per week, the player received an email prompt to log on and record any injury details. If an injury had occurred, the player was guided through a series of injury-related questions. The weekly login is shown in Figure 3-8.

Figure 3-8: Weekly Login Questionnaire

If the player registered a new injury, they were guided through each section to record information on the injury. Each new injury was given a specific ID and data was gathered about:

- Date of injury
- Activity at time of injury
- Home or away game
- Body part injured
- Injury type
- Mechanism of injury
- Treatment
- Fitness test
- Return to play date

Figure 3-9 illustrates the court schematic used to identify the floor type and position on court where the injury happened. Both have been identified as risk factors for injury.

Figure 3-9: Schematic to Identify Floor Type and Position on Court for Injury

If the player had signed in and selected “No Injury Option”, the screenshot in Figure 3-10 appeared. Players logged out and received an email prompt the following week again.

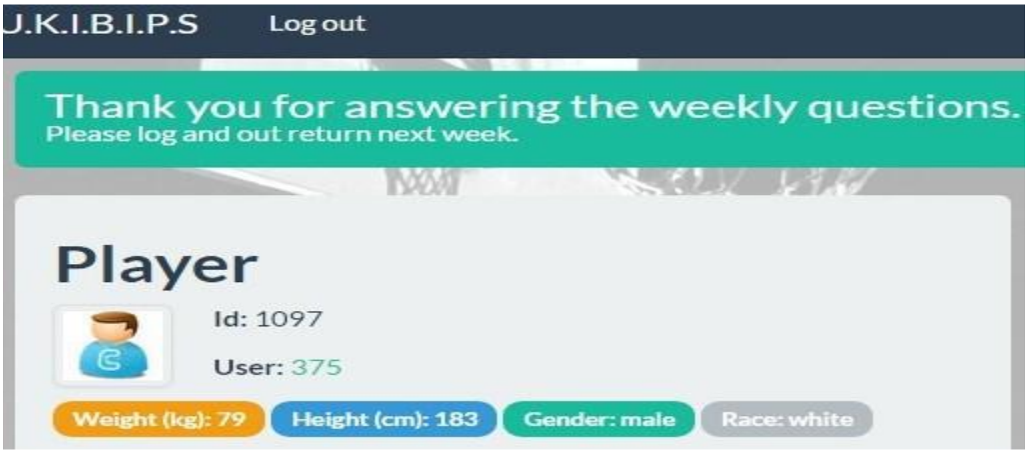


Figure 3-10: No Injury Selection Option

3.3.13. Study Population Selection

Following ethics approval, the Basketball Associations of Ireland, Scotland, England and Wales were approached to seek permission and support for their players to participate in the United Kingdom and Ireland Basketball Injury Prevention Study. All associations were contacted by phone and email, and all received a letter outlining the purpose of the study which had been prepared and signed by the Principal Investigator and his supervisors. A

PowerPoint presentation was prepared and all governing bodies had the opportunity for the Principal Investigator to attend and present information on the research proposed. Approval was granted for the UKIBIPS by the governing sports bodies in March 2013.

The Basketball Associations of Ireland, Scotland and Wales requested that, if possible, they would also like if their international squads could be considered for participation in the study. This was approved in May 2013 by the research supervisors and ethics approval was obtained on 8 July 2013.

Volunteers were sought from players competing in the National and Super Leagues of the UK and Ireland as well as Under 14, Under 15, Under 16, Under 17, Under 18 and Under 20 International Basketball Teams of the UK and Ireland. Twelve professional teams of the British Basketball League (BBL) were also approached to participate in the study. The potential pool size for recruits to this study was ~2250. Clubs and coaches contact details were provided to the Principal Investigator from the participating countries governing bodies' databases.

3.3.14. Informed Consent

As part of the ethics approval for the UKIBIPS research study, a simple language document was provided for each participant. This was sent both electronically and by hard copy to clubs as part of the research information packs (see Appendix 7). All forms were to be read and signed before the commencement of the programme and where players were under the age of eighteen, they were required to have their forms co-signed by a parent or legal guardian.

3.3.15. Research and Innovation / Intellectual Property

As part of the ongoing development of any system associated with the study, the Principal Investigator was required to attend a number of meetings at the Research Strategy & Innovation Office at the University of Glasgow with Dr Alasdair Street (IP and Licensing Manager, Research Strategy & Innovation Office), Mr Paul Eilis (Senior Contract Manager, Research Support Office) and Dr Debra Stuart Research (Governance Manager, College of Medical, Veterinary & Life Sciences) to discuss if there were any issues relating to intellectual property with the research. All issues were discussed with the team, and support and advice were provided to the Principal Investigator.

3.4. Results

3.4.1. Study Participant Profile

A total of 98 basketball clubs (67 male, 31 female) were invited to participate in the UKIBIPS study across the UK and Ireland. A total of 183 players (105 male, 78 female) registered on the UKIBIPS-ISS for the 2013-2014 season. Players registered from 35 male clubs and 18 female clubs. See Figure 3-11 and Table 3-2, with the breakdown provided.

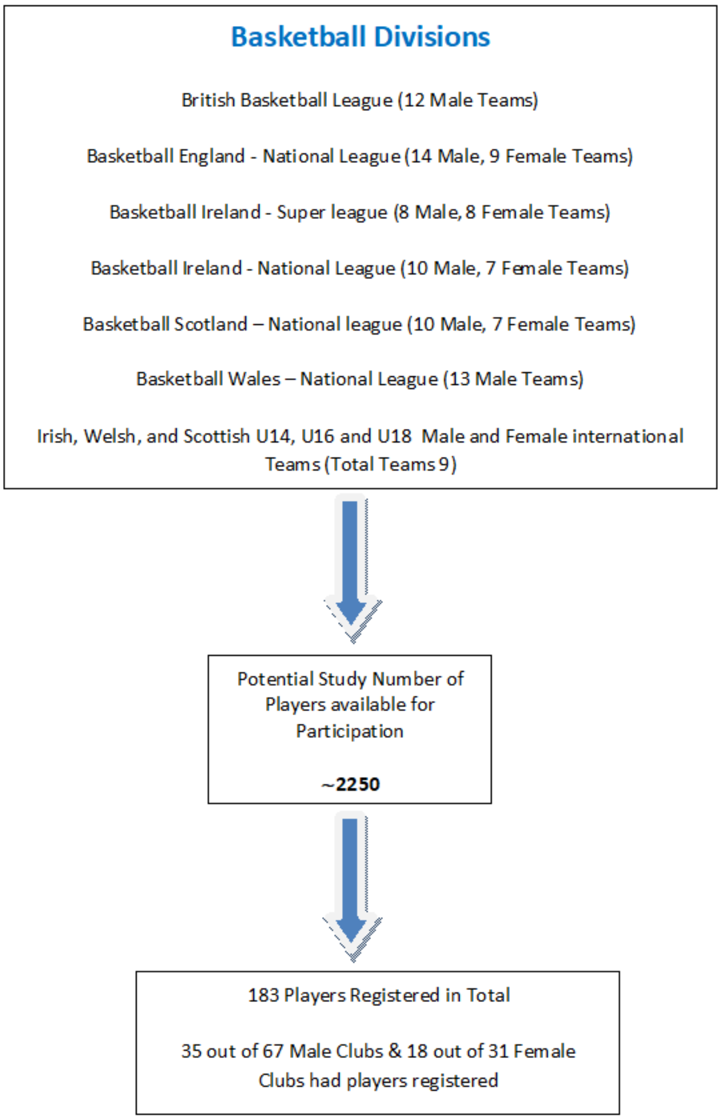


Figure 3-11: Flowchart of Associations Invited to Participate in the UKIBIPS Study

Table 3-2: Breakdown of Participants by League, Players and Clubs

League Type	Male Clubs and Participating Players	Female Clubs and Participating Players
Irish National League	18 players (7 out of 10 clubs)	35 players (7 out of 7 clubs)
Irish Super League	9 players (5 out of 10 clubs)	26 players (7 out of 8 clubs)
British Basketball League	2 players (2 out of 10 clubs)	No league
Scottish National League	4 players (1 out of 10 clubs)	9 players (2 out of 7 clubs)
Welsh National League	50 Players (8 out of 13 clubs)	1 player († international)
English National league	23 Players (13 out of 14 clubs)	7 players (2 out of 9 clubs)

† Welsh international player- no female Welsh club participated

Demographics for male and female Irish and UK basketball players in the National and Premier Divisions who completed the questionnaires during the 2013-2014 season can be seen in Table 3-3. The breakdown for male and female playing position was as follows – Point Guards 44 (m25/f19), Shooting Guards 45 (m23/f22), Centers 21 (m12/f9), Forwards 51 (m32/f19) and All-round 22 (m13/f9). The mean male age was 18.81 years ±6.89 years while in the female group the mean age was 20.57 years ±5.54 years.

Seventy-two male international players participated in the study: U14 (3), U15 (21), U16 (17), U17 (4), U18 (19), U20 (2) and Senior (6). In the female group, there were fifty-seven international players who participated in the study: U15 (19), U16 (8), U17 (10), U18 (17), U20 (2) and Senior (2). Race in the study population was broken down as black players three (m3), mixed race players eleven (m10/f1) and white players one hundred and seventy (m97/f69). Outside of the Irish basketball leagues and the Welsh international teams, other leagues were not well represented. In particular, there were no Welsh female clubs represented and only one Welsh female international player registered who attended the testing session for the underage Welsh men's teams as her father was a national team coach attending on the day. International team training may occur on opposite weekends and testing times may not have been suitable to attend. No other reason can be offered as all countries and their leagues and clubs were invited to participate.

Table 3-3: Irish and UK Basketball Player Demographic in National and Premier Divisions 2013-2014

		Men			Women	
Demographic						
N (183)		**N 105**			**N 78**	
	Mean	**StDev**	**Range**	**Mean**	**StDev**	**Range**
Age (yrs)	18.81	± 6.86	11.82 – 42.72	20.57	± 5.54	12.97 – 42.95
Height (cm)	181.18	± 13.59	142 - 208	173.92	± 8.30	140 - 191
Weight (kg)	72.10	± 17.57	38 - 117	66.51	± 8.21	29 – 86
Age						
U14		20			1	
U16		29			14	
U18		25			23	
U20		6			5	
Senior		25			35	
International Player Level						
U14		3				
U15		21			9	
U16		17			8	
U17		4			10	
U18		19			17	
U20		2			2	
Senior		6			11	
Player Position						
Point Guard		25			19	
Shooting Guard		23			22	
Center		12			9	
Forward		32			19	
All Round		13			9	
Player Weeks of Adherence						
N 1920.79	**Mean**	**StDev**	**Range**	**Mean**	**StDev**	**Range**
	9.33	± 12.23	0 – 42.83	12.06	± 12.70	0 – 38.89
Player Dominant Hand						
Right		97			69	
Left		5			6	
Ambidextrous		3			3	
Ethnicity						
Black		2				
White		93			77	
Mixed		10			1	

3.4.2. System Usage/Adherence

28 male players logged into the system for 4 months or greater compared with 32 female players over the same period. The largest drop-off rate for male and female players occurred after the first week of registration. Player adherence to using the UKIBIPS-ISS is shown in Figure 3-12.

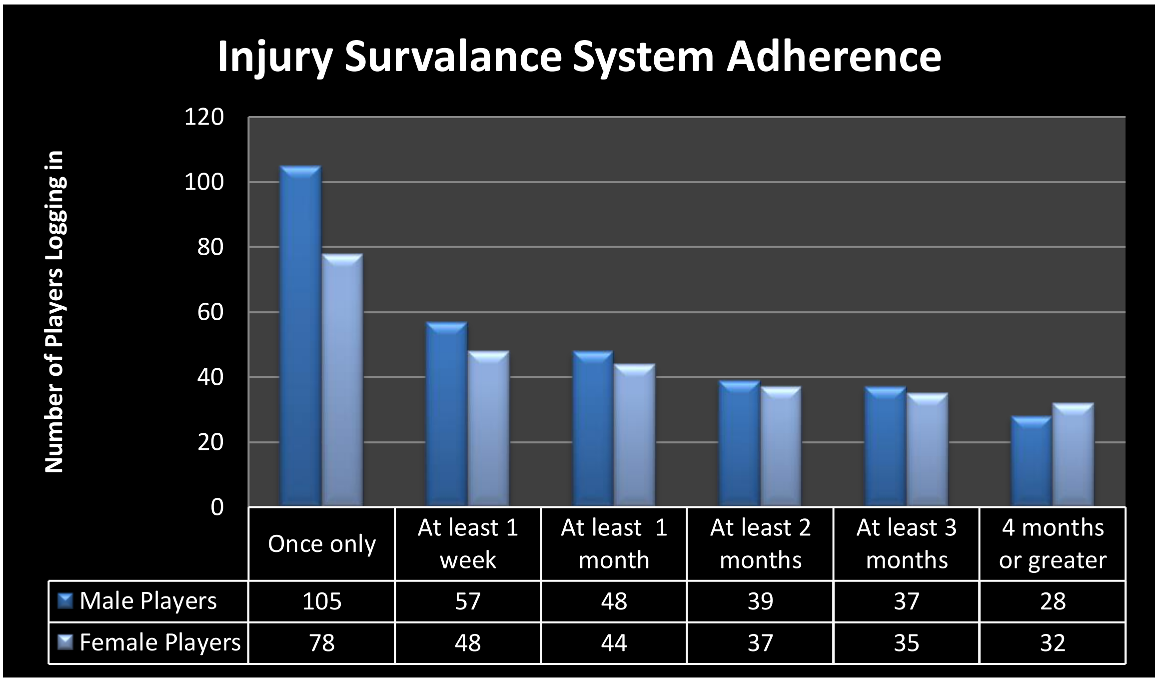


Figure 3-12: Player Adherence to Using the UKIBIPS-ISS

The 15 – 19 year old group made up the largest number of participants in the study. Players from the men's and women's Irish Leagues had the greatest number of combined weeks (1,213.54) using the system. The mean weeks of system usage with male Irish players was 9.33 weeks ±12.23, and for female players the mean was 11.84 weeks ±13.22. The British Basketball League recorded the lowest combined weeks of usage (30.71). Two players participated with a mean of 15.35 weeks ±21.71 of adherence to the system. International female players had a higher average usage of the system at 13.48 weeks over their male counterparts with 9.42 weeks. Male and female players with prior injuries did not show any great difference for using the system with 11.76 and 13.07 weeks respectively. See Table 3-4 for full details of player adherence to the system.

Table 3-4: System Adherence for all Players in National and Premier Divisions 2013-2014

	Men			Women		
Demographic	**N105**			**N78**		
N (1920.81)	**Mean**	**StDev**	**Range**	**Mean**	**StDev**	**Range**
	9.33	± 12.23	0 – 42.83	12.06	± 12.70	0 – 38.89
International players	**N65**			**N55**		
N 1464.03 Total Weeks	**722.56**			**741.47**		
	Mean	**StDev**	**Range**	**Mean**	**StDev**	**Range**
	9.42	± 11.77	0 – 42.83	13.48	± 12.98	0 – 38.89
Players Previous injury	**N54**			**N48**		
N1263.23 Total weeks	**635.48**			**627.75**		
	Mean	**StDev**	**Range**	**Mean**	**StDev**	**Range**
	11.76	±14.18	0 – 42.83	13.07	±12.93	0 – 38.89
Players by country's leagues						
Ireland	**N26**			**N61**		
Total weeks	**491.30**			**722.24**		
	Mean	**StDev**	**Range**	**Mean**	**StDev**	**Range**
	9.33	± 12.23	0 – 42.83	11.84	± 13.22	0 – 38.89
England	**N25**			**N6**		
Total Weeks	**147.82**			**81.82**		
	Mean	**StDev**	**Range**	**Mean**	**StDev**	**Range**
	5.91	± 8.64	0 – 24.65	13.63	±7.61	0 – 21.99
Scotland	**N4**			**N9**		
Total weeks	**18.26**			**131.81**		
	Mean	**StDev**	**Range**	**Mean**	**StDev**	**Range**
	4.56	± 7.20	0 – 15.14	14.64	± 13.11	0 – 34.72
Wales	**N41**			**N0**		
Total weeks	**258.54**					
	Mean	**StDev**	**Range**	**Mean**	**StDev**	**Range**
	6.30	±7.69	0 – 22.93			
British	**N2**			**N0**		
Total weeks	**30.71**					
	Mean	**StDev**	**Range**	**Mean**	**StDev**	**Range**
	15.35	± 21.71	0 – 30.71			
Other	**N7**			**N2**		
Total weeks	**33.48**			**4.83**		
	Mean	**StDev**	**Range**	**Mean**	**StDev**	**Range**
	4.78	±8.22	0 – 18.44	2.41	± 3.41	0 – 4.83

3.5. Discussion

A total of 183 players registered on the UKIBIPS-ISS for the 2013-2014 season which was quite a small proportion from the potential pool size of ~2250 players. Continued usage of the system by the players, or player adherence to the system, dropped off over the course of the study. There was no exit questionnaire built into the system so as players dropped off, the reasons were not known to the Principal Investigator. Some suggestions for the drop-off rate may have been players being dropped from squads (International or Club), time burden with the system and a varied end-of-season date for each league. The 15 – 19 year old group made up the largest number of participants in the study. This age group most often will have a higher game and training exposure rate as they would be playing on a larger number of teams between school, college, club and international programmes, and for future studies should be the target group for the researcher.

While there was no written feedback available from clubs as to why they declined to participate, there were several contributing factors for the lower participation rate. Communication and access to teams was totally in the control of the country governing bodies. The delay in granting permission by the various basketball governing bodies was the largest reason for not being able to get access to eligible players in time. While the Primary Investigator contacted all governing bodies by email, phone and hard copy repeatedly, there was a very short time period given to contact each league's teams once permission had been granted. The main reason given for delay in granting approval was that there had been restructuring of leagues and that new committees were being appointed.

All the participating countries' leagues have a different season commencement date, and in turn this results in different dates for pre-season training schedules. Getting access to international teams was also dictated by what stage they were at in their international training programme. International development squads were easier to access than those who had entered formal competition. In many of the American sports injury epidemiology studies, it is compulsory for teams to participate. However, in this study, participation was totally voluntary.

An unexpected difficulty encountered by both the Principal Investigator and the software development team was finding a common language to work with during the project. Software development vocabulary and medical terminology did not dovetail well during initial communications and caused unforeseeable delays which in hindsight could have been avoided by clarifying gaps in the knowledge of both parties in the initial planning meetings. The system had to mimic the line of questioning taken by medically qualified team members to collect the relevant data. However, while doing this, the language of the user interface had to be that of a non-medical person. It was essential that the design of the questionnaire for the system was accurately understood by the software developers for both the translation of terminology and the sequencing of questions. The developers were essentially the first users of the system questionnaire, so their understanding of the language paved the way for a more accessible system in the longer term. This interface of communication between the Principal Investigator and the developer requires an investment of time and understanding from both parties to ensure consistent understanding of the other's position. As a result, a considerable amount of time was spent rewording the questions, so that the end user only had to answer questions that were relevant to them. Several draft questionnaires were created to ensure that the language used was simple and easily understandable by the user. It was necessary to ensure that all conditional questions were correctly placed and that no question could be skipped by mistake. Having a natural flow to the questions was of paramount importance to reduce the time burden on the user.

While the system facilitated data collection from the participants in the study, it had limitations with respect to monitoring use. The system was only able to report the first and last time a player had used the system. As a result of this, the system was only able to offer the Primary Investigator a report on how many players used the system more than once and not the total number of interactions with the system and when they occurred.

The system did not gather details on training and game time exposure during the study. In their initial registration, players were asked how often they trained during pre-season and the regular season and how many games they play during pre-season and the regular season. As this was a general question, it did not take into consideration the training time and game time to which a player was actually exposed. This was a major oversight by the Principal Investigator as it did not allow comparison with other studies which used an exposure rate of time played per 1000 hours.

Exporting data from the database to a suitable format for efficient analysis was not possible with the system. Although some export options were available, they were limited in their capability and to get the data into the required format for analysis took months of work.

Coupled with the feedback received from the players, the limitations of the system were key factors in planning a Version 2 of the UKIBIPS-ISS. The reliance on players to log in every week of their own volition was also a problem. It was recommended that these issues be addressed in the new version of the software by:

- Introducing <u>both</u> text and email notification facility.

- Embedding a tutorial video on the system to guide participants in the initial stages.

- Refining the series of questions to reduce the time burden on the player for data input.

- Ensure that exposure time for both injured and uninjured players was collected.

It was also recommended that the new system have the ability to export data in a more appropriate format for analysis. For the new UKIBIPS-ISS, a computer software engineer who was familiar with the sport of basketball was engaged to work with the Principle Investigator and the system was required to be ready to collect data for the 2014-2015 pre-season.

Chapter 4 – UK and Ireland Basketball Injury Prevention Study Injury Surveillance System (UKIBIPS-ISS) Version 2

4.1. Introduction

The UKIBIPS-ISS Version 1 in its first season showed that it was reliable and capable of collecting and storing inputted data for analysis. There were no functional issues once launched and while monitored throughout the first season it did not require technical support. While participating numbers were low, the system showed that it had the capability to collect the first data online in UK and Irish basketball. The limitations of the UKIBIPS-ISS Version 1 are documented in Chapter 3. The additional requirements to overcome the limitation of the current system for data collection in year two prompted the Principal Investigator to further develop the UKIBIPS-ISS system and make the necessary modifications and improvements to get more in-depth and detailed data.

The numbers of players who registered to the UKIBIPS in the first season were disappointing, when the potential numbers available to participate were over 2,500. It was important for the Principal Investigator to reflect on the reasons for this. Was it a lack of interest on behalf of players and unsupportive clubs, coaches or governing bodies? It is also worth considering the time burden and user-friendliness of the system. While the effort of developing an electronic system was difficult and time-consuming, the benefits compared to paper questionnaires used by the Principal Investigator in previous research made it worthwhile. After review, it was decided that in order to further understand/identify the risk of injury in the UK and Irish basketball population, the system as a tool required further refinement. Further efforts were also required to engage with governing bodies on the merits of participating in the study, especially in line with the recommendations made in a report to FIBA Europe about injury prevention in the sport. As previously stated, player participation in this study is voluntary, and as such players may choose not to register as they do not see an immediate benefit for themselves regardless of the methods used to engage with them to participate.

Considering the limitations or shortfalls identified after the first season of data collection in basketball in Ireland and the UK, the objectives for Version 2 were to increase participant numbers, further enhance the user experience and optimise the amount of data collected for analysis.

The second season of the study allows for the comparison of data monitored over two seasons, which may show trends in injuries in the sport. It will add to our knowledge on acute injuries, overuse injuries, illnesses and exposure. The number of treatments recorded may also add to our knowledge on the financial burden associated with injuries in the sport. Data collected through the UKIBIPS-ISS Version 1 and data collected through UKIBIPS-ISS Version 2 over two seasons will be discussed in Chapter 6.

4.2. Aims

- Develop and implement a new system (UKIBIPS-ISS Version 2) that addresses issues identified in the first version of the software.
- Collect data on injuries occurring in Irish and UK basketball leagues over a full season.

4.3. Methodology

Following a review of the UKIBIPS-ISS Version 1, the first task of the Principal Investigator was to source another software development team to develop the new system as the previous software engineers were unavailable to work on the project. Damien Costello (GMIT Lecturer in Maths and Computing) agreed to assist where possible on the development of the new UKIBIPS-ISS along with software developer and basketball player Mr Paulius Peldizus. Researcher-developer communication was still a key element in this stage of the study to ensure the UI with the additional features remained user-friendly and that the data collected was stored in a format that would easily present for analysis at the end of the season. The objectives of the UKIBIPS-ISS Version 2 were to:

- Improve adherence rates and monitoring of participants by including weekly text and email prompts.
- Embed a tutorial video on the system to guide participants.
- Include an online informed consent form for underage players.
- Refine the series of questions to reduce the time burden on player data input.

- Improve the graphics of the system.
- Set up a data storage area that could be used to centrally manage and query the data collected.
- Have the ability to export data in the format required for easier analysis.
- Capture injury data in the new season.
- Provide data for analysis on athlete exposure, mechanism, rate and type of injury.

4.3.1. UKIBIPS Questionnaire Design

The questionnaire was reviewed to take into consideration player training time and exposure rates, and also to gather data on the non-injured player. While the questionnaire was refined for the new version, it still included all the relevant questions needed to gather the required data. The sections of the questionnaire were broken down into the following groups:

- Player Demographics
- Player Equipment
- Player Basketball and Training Details
    - Total Player Exposure Time
    - Total Player Game Exposure Time
    - Total Player Training Exposure Time
- Previous Injuries
- Player Medical Conditions
- New Injury Details
- New Illness Details
- Injury Treatment Details

- Return To Sport Details

As with the previous system, in order to provide such a comprehensive range of data, the questionnaire needed to be detailed but at the same time not difficult for the user to understand. One of the benefits of working with the new software engineer was that he was familiar with the sport from playing at a high level of competition. This meant he had a better understanding of the nature of the questionnaire from the start and there was less time required to communicate concepts and ideas. An Excel format was used again as the method of mapping questions for the questionnaire and again, on completion, was handed over to the software developer with specific requests on modifications of the previous system.

4.3.2. Ethics Approval

The research study proposed was a prospective cohort study in design. Ethics approval was sought for this study from the College of Medical, Veterinary & Life Sciences Ethics Committee for Non-Clinical Research Involving Human Subjects. Ethics approval for this study (Project No: 200140034) was granted by the University of Glasgow Ethics committee on 6 November 2013. During this phase of the study, the Principal Investigator attended several meetings with the Research Strategy & Innovation Office at the University of Glasgow where issues relating to intellectual property were discussed and support and advice given to the Principal Investigator. The ethics application form/ethics approval, consent forms and participant information sheet are available in Appendices 8 and 9.

4.3.3. Study Population Selection

Following ethics approval, the Basketball Associations of Ireland, Scotland, England and Wales were again approached to seek permission and support for their players to participate in the United Kingdom and Ireland Basketball Injury Prevention Study. All associations were contacted by phone and email, and all received a letter outlining the purpose of the study which had been prepared and signed by the Principal Investigator and his supervisors. A PowerPoint presentation was prepared and all governing bodies had the opportunity for the Principal Investigator to attend and present information on the research proposed. Approval was granted for the UKIBIPS by the governing sports bodies in March 2014.

Volunteers were sought from players competing in the National & Super Leagues of the UK and Ireland as well as Under 14, Under 15, Under 16, Under 17, Under 18 and Under 20 International Basketball Teams of the UK and Ireland. Twelve professional teams of the British Basketball League (BBL) were also approached to participate in the study. The potential pool size for recruits to this study was ~2250. Clubs and coaches contact details were provided to the Principal Investigator from the participating countries governing bodies' database.

4.3.4. Informed Consent

As part of the ethics approval for the UKIBIPS research study, a simple language document to be given to each player interested in participating was forwarded to coaches and clubs asked to participate. This was sent both electronically and by hard copy to clubs as part of the research information packs (see Appendix 7). One of the recommendations to try and increase participant rates was to include an online informed consent form.

As there was no field testing for this season, it meant that the assessment team would not be registering underage players in a face-to-face environment. Therefore, the online, embedded, informed consent form provided the best solution to ensure all participants were fully informed as per the ethics requirements. An online tutorial video was also included on the front page of the system and participants were unable to register until the informed consent section was completed. This provided a mechanism to register underage/youth players through an online system. It also provided a breakdown between the youth and adult players registered. The informed consent screen from the UI is shown in Figure 4-1.

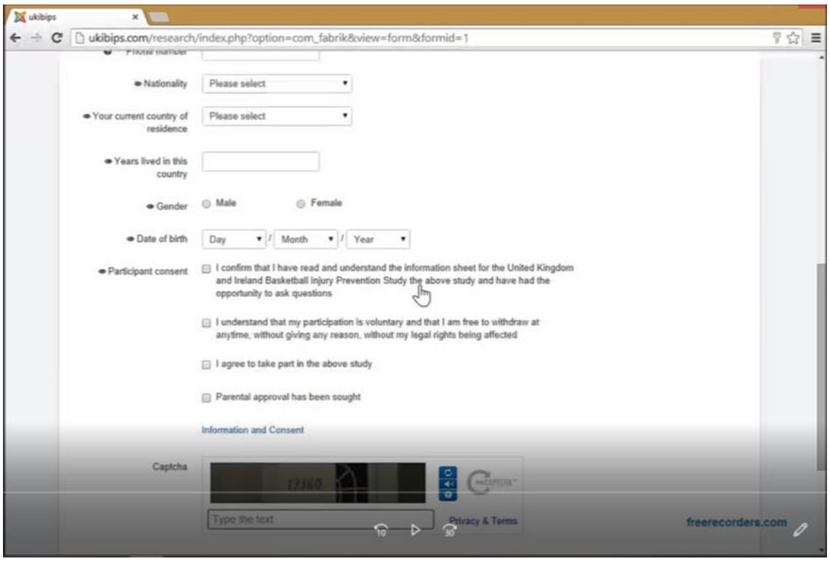


Figure 4-1: Participant Informed Consent Section

4.3.5. System Architecture and Design – Technical Element

After our initial face-to-face planning meeting in April 2014, meetings were held by conference calls and encrypted files shared for work and review. The UKIBIPS-ISS Version 2 web application was built on Joomla! This is an open-source content management system (CMS) for publishing web content. A CMS is an application (web-based) that provides capabilities for multiple users with different permission levels to manage (all or a section of) content, data or information of a website project or intranet application. Additional specific modules and scripts were developed using PHP 5.6.

Joomla! was selected for the project as it was a free open-source CMS. It provided a foundational structure for the coding to create the logic required for the UKIBIPS-ISS. Similar to the first version of the application, the system engineering incorporated best practice and used design patterns like Convention over Configuration and the Model-View-Controller.

The Joomla! CMS is device responsive. Simply stated, Joomla! is mobile-friendly and can be used with any modern device independent of browser or platform. Other platforms had been considered, but the licensing costs for these packages were too expensive for the development team. Even if cost wasn't a factor, Chapter 2 provides the justification for this bespoke system.

4.3.6. System Infrastructure

It was decided to use Digiweb's free hosting package for the application. The data storage and associated services of the package fulfilled the requirements for hosting the UKIPBIPS-ISS. Digiweb also provided an SSL certificate with the hosting package. As security of the data was a key consideration, this was another factor in choosing Digiweb. SSL has been mandatory for all websites since 2019.

After completing registration, each individual user was assigned a unique ID for the site. This user ID was used to identify individuals independently using the site and give them pre-defined permissions. UKIBIPS had three front end access control levels: player, coach or physio and two back end levels (administrator and Primary Investigator). No further types were needed, but it was possible to modify in case a change was requested by the Principal Investigator.

The Joomla Access Control List (ACL) system can be thought of as two completely separate systems that control how the user interacts with the application. One system determines what the user can see on the website, the other controls the actions a user can take. Players could only view and edit their own personal data, while the Principle Investigator could access any page and had full read/write access to the database. It is important to note that the Principal Investigator had no rights to drop/empty database or modify system files which could potentially compromise system functionality. Such access level was held by the software engineer only.

Additionally, the software engineer implemented a special safety feature to prevent unauthorised data access (such as SQL injections) by hackers and other parties. The user and user profile were stored in different database tables. This was done in such a way that user data were divided into two sets, with different purposes and different requirements:

- Identity data including username, password hash, email address, last log in time
- User profile data including user preferences, latest activity, status updates, shoes and other configurable items

The difference between these two sets is that the first one was tightly controlled and only through certain Joomla! workflows can it be modified. For example, changing a password may require providing an existing password, changing the email may require verification of email, and it would be used in the case where the user forgot their password.

Preferences do not require such ACLs and can be modified by the system administrator or Principal Investigator which is not the case for identity data.

4.3.7. UKIBIPS – ISS Front End

The new system went into construction in April 2014, and a completion date was scheduled for no later than 21 June 2014. This would allow for a test run of the system and give time to make any necessary adjustments on feedback received or difficulties identified by the administrator/Primary Investigator and system engineer. Over the design period there were twice-weekly meetings scheduled and each section of the online questionnaire was dealt with in order of occurrence on the online system. Once the back end of the system was completed and tested for functionality and data export, attention was then focused on the front page. It needed to be user-friendly and easily navigated. Mobile-friendly and lean websites were already a must for businesses and researchers in 2014; therefore a new responsive Joomla! template was selected as the front end of the system to give players the chance to submit their data in real-time. The system had been designed to be responsive and mobile-friendly to enable the user to input accurately and efficiently.

The home page, shown in Figure 4-2, gave information on the study and its aims. The system was accessed by the UKIBIPS.com link. This page would be the page viewed on player log in for the remainder of the study. By design, the UKIBIPS was not for public use. Therefore a standard user registration module was configured to accept or reject participant applications. This was a key requirement of the Principal Investigator from the system engineer due to possible contamination of data by unauthorised applicants. Initial user registration prompted applicants to input username, team name, age, email and telephone number. A workflow item was triggered immediately to accept or reject the registration. Only approved user registrations were granted access to use the system. Such workflows allowed considerable application control, as well as preventing SPAM and automated attack tools from obtaining access to the system and potentially leaking the research data.

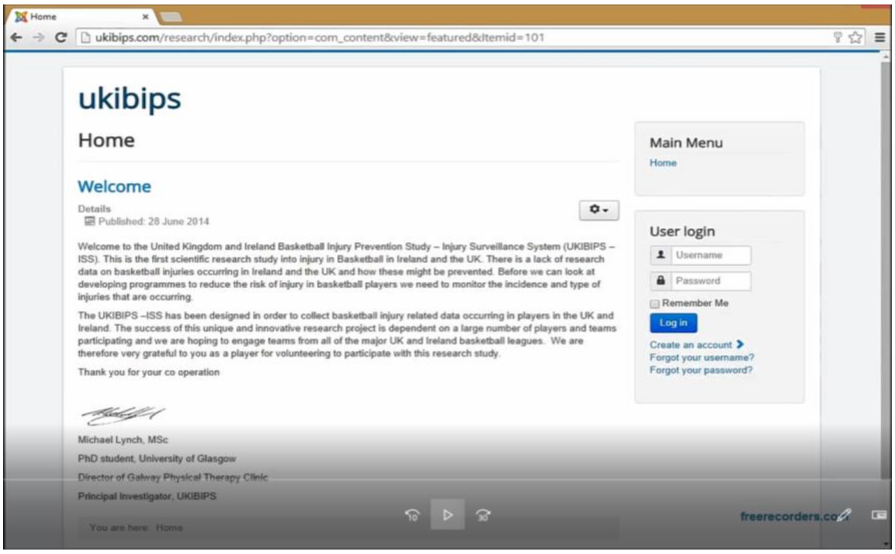


Figure 4-2: UKIBIPS-ISS Version 2 Home Page 2014 – 2015 Season

4.3.8. User Set Up and Registration

An authorised user was able to log in and complete the user registration process by filling in the User Profile section. The User Profile provided the administrator/Primary Investigator with some basic information on the participant. See Figure 4-3. User Profile completion was a mandatory workflow item in order to start submitting essential research data. Upon completion, users were asked to log in on a weekly basis and update their status until the end of the season. Each week, the system triggered reminders by text and email to those players who for whatever reason forgot to submit weekly status reports. Reminders were sent every seven days calculating from the last log in date. The personalised email message contained the participant’s name and a direct link to the UKIBIPS-ISS.

For follow up purposes, the administrator/Primary Investigator and software engineer were bcc’d on the emails. Reminders were not triggered if user(s) logged in and submitted data within seven days. This was to avoid overwhelming/overburdening participants with unnecessary texts or emails.

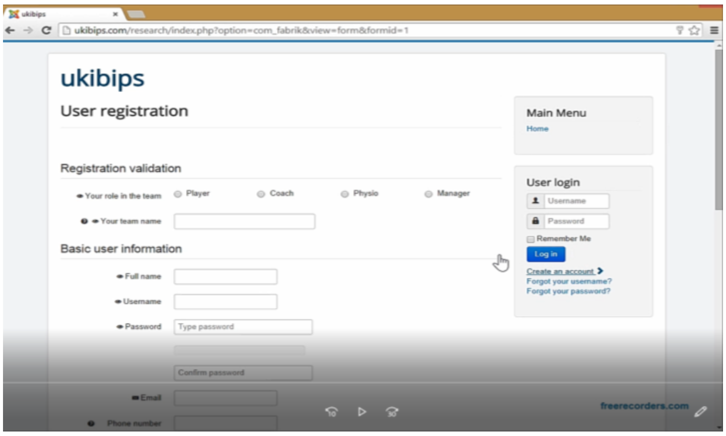


Figure 4-3: User Set Up Page 2014 – 2015 Season

An important part of any participation in a study is that full and proper informed consent is attained before anyone can participate. It was recommended that this consent form was part of the system registration. All fields were required to be completed in this section before the player was allowed continue with registration. The form is shown in Figure 4-4.

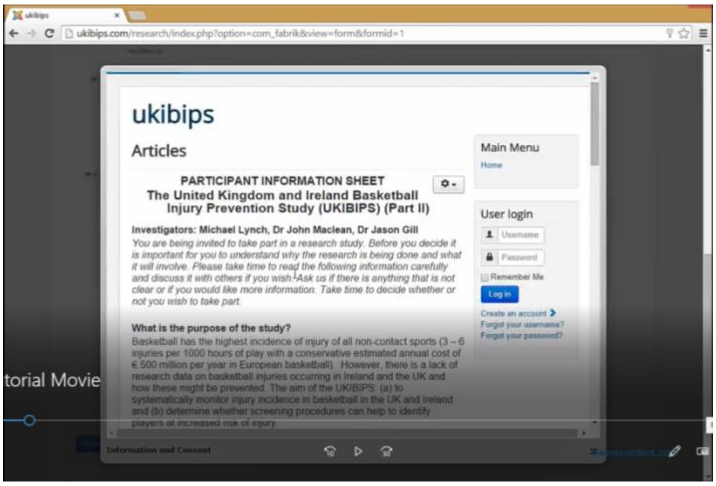


Figure 4-4: Participant Information Sheet and Consent Form in the 2014 System

4.3.9. Player Profile Section

Once the informed consent section was completed, the player was brought to the home page which included the user menu section used to provide information on user/player profile for demographics. The system had the ability for a coach, athletic trainer or physical therapist to input data on behalf of each player and, if used in this way, would not allow duplication of entries as the system would identify any attempted double entries.

The player profile section (Figure 4-5) provided the administrator/Primary Investigator with data on the demographic of the players participating. The player could review their profile once completed before final confirmation. Drop-down lists were used to reduce the incidence of errors from free-text entries.

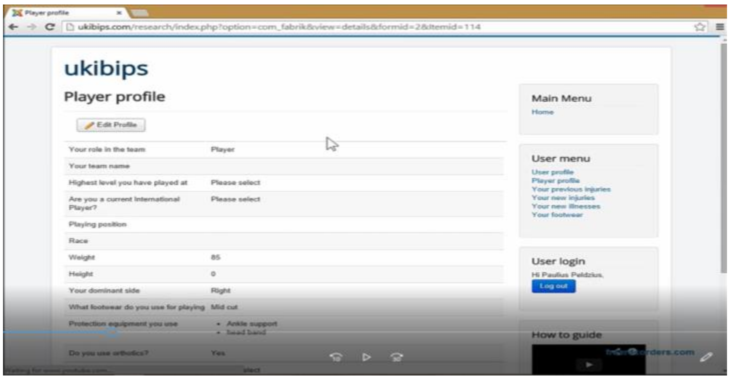


Figure 4-5: Player Profile Section 2014 – 2015

Once completed, the player was brought to the previous injury (Figure 4-6) section which has been identified as a risk factor for injury. The player could add multiple injuries if necessary and view a summary record of these once completed.

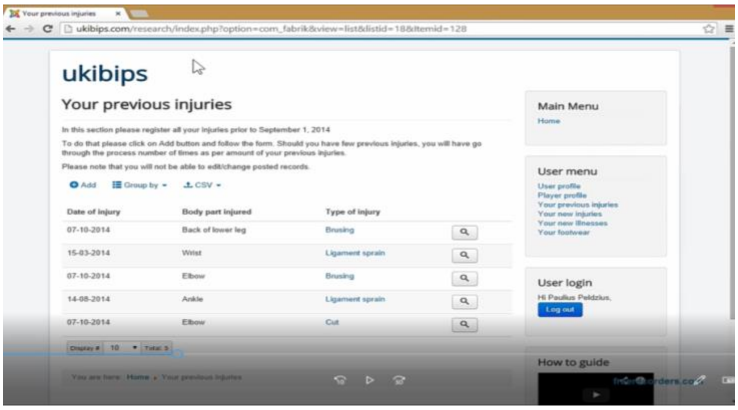


Figure 4-6: Previous Injuries Section 2014 – 2015 Season

4.3.10. New Injury Section

The new injury section (Group 1) gathered data on the training and game exposure time for the player during the previous week. This section is shown in Figure 4-7 and provided additional data not available in Version 1 of the system.

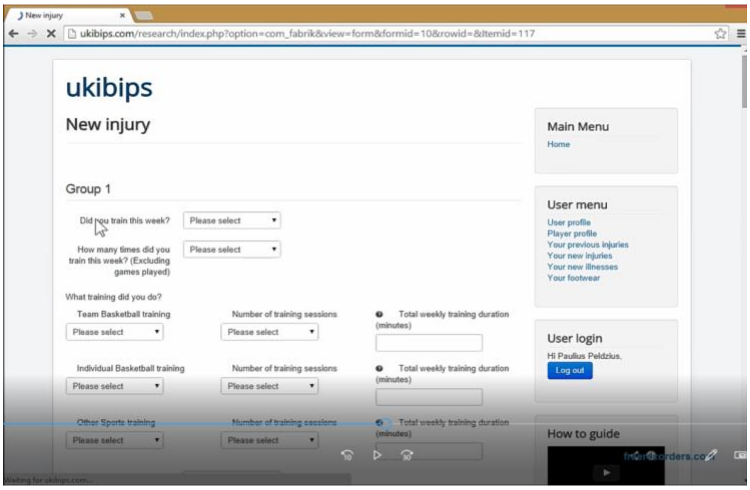


Figure 4-7: Weekly Update of Injury Status 2014 – 2015 Season

If no injury occurred, the player just submitted their training and game details and logged off. See Figure 4-8. However, if an injury occurred the player was brought through a further range of sections to provide details.

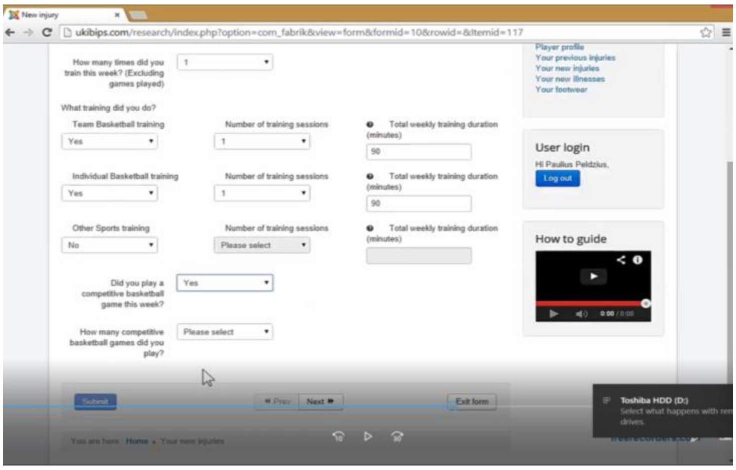


Figure 4-8: Weekly Update - Training/Game/Other Sports Section 2014 – 2015

Once the player selected "an injury had occurred" they were brought to the Group 2 section as shown in Figure 4-9. The first question the player answered "During what activity did the injury occur?" determined the line of questioning that the software system would offer the player. Injuries that occurred during a game led to specific questions about the stage of game, home or away, court area and time of injury. Injuries during training prompted a different set of questions including what type of training - team, personal, other sport, team strength and conditioning, and so on.

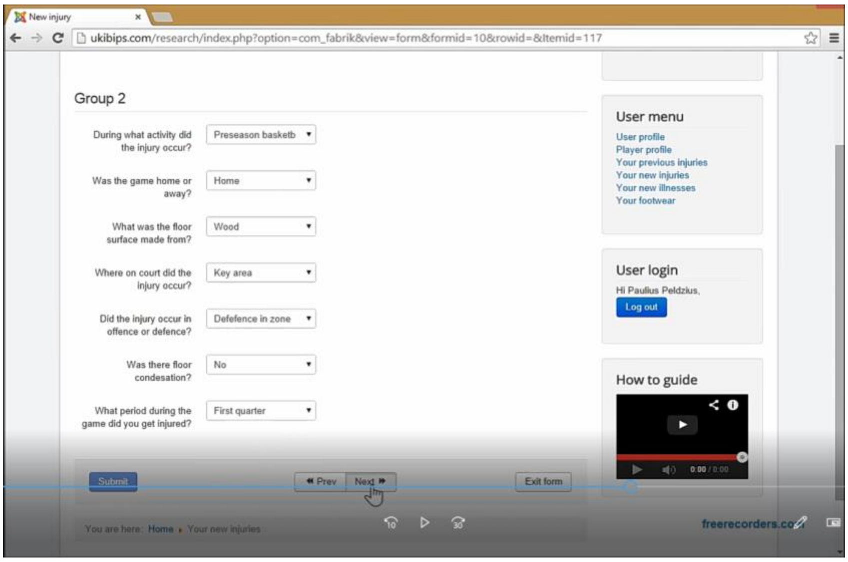


Figure 4-9: New Injury Section - Mechanism of Injury 2014 – 2015 Season

Once the player had completed the questions on how the injury occurred and what they were doing at the time, they were brought to the Group 3 section (Figure 4-10) which would gather information on the type of injury, causes and if a diagnosis had been made. Group 4 (Figure 4-11) questioned whether it was a reoccurring or previous injury and treatment. Group 5 (Figure 4-12) looked at hospital presentations and the number of treatments, which was important when establishing the cost burden of injury for teams and players.

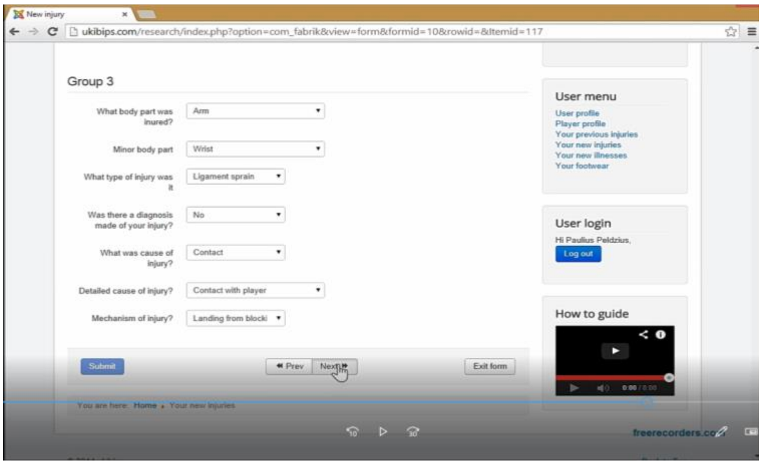


Figure 4-10: Injured Body Part and Cause of Injury Section 2014 – 2015 Season

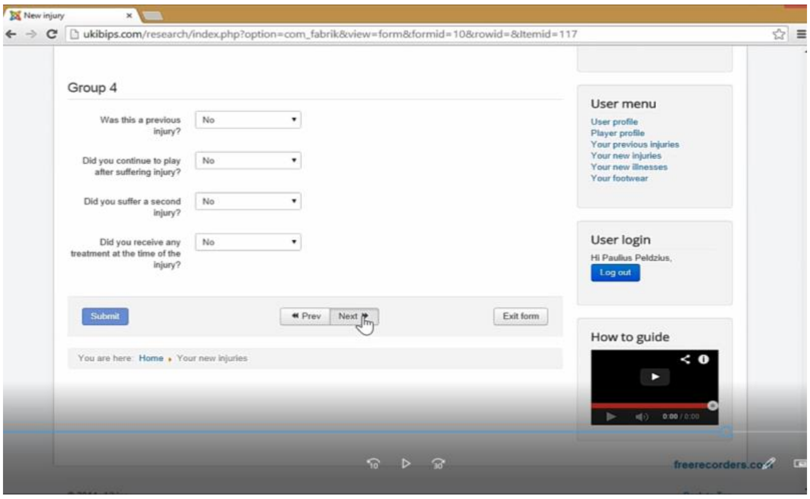


Figure 4-11: Reoccurring or Previous Injury and Treatment 2014 – 2015 Season

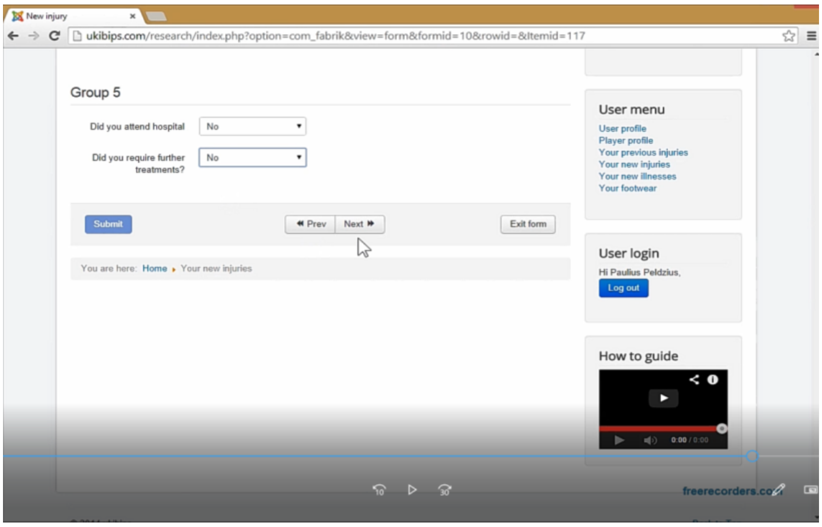


Figure 4-12: Hospital Presentations and Number of Treatments 2014 – 2015 Season

4.3.11. New Injury Section – Post Injury Data

Group 6 (Figure 4-13) gathered information on the player's return to sport. Many injuries occur due to faulty rehabilitation programmes and the player returning to sport too soon. There are many players who return to play once they are pain-free and end up re-injuring themselves at the same location. They may also suffer a more serious injury as a result of not being strong enough or put another joint/body part at increased risk due to compensatory or dysfunctional movement patterns.

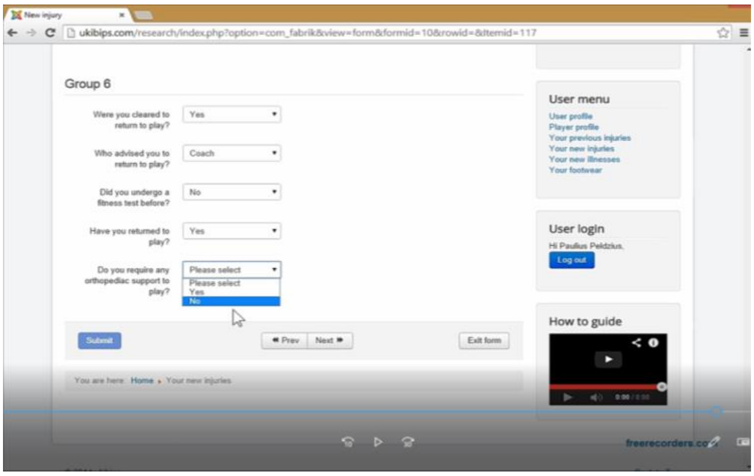


Figure 4-13: Post Injury Data - Fitness Test, Return to Play and Orthopaedic Supports 2014 – 2015

4.3.12. New Illness Section

While the system was created to gather information on injuries, the Principal Investigator also included questions on any illness that occurred for the player during the season. This addition in Version 2 meant that the absence of a player from a game or training through illness was now available to be recorded separately, especially when working out injury and exposure time and time lost from playing due to injury. Once this final section was completed, the player was asked to submit and was able to see a summary review of the report which they could edit before logging out. See Figure 4-14.

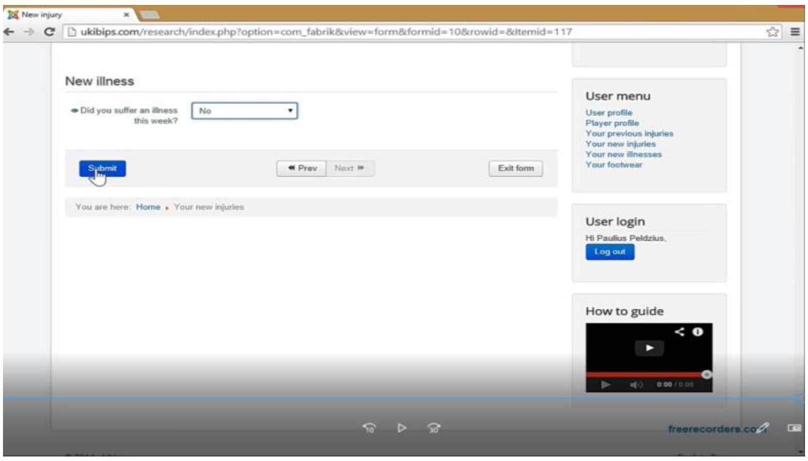


Figure 4-14: New Illness Section

4.3.13. Pre-Launch Testing and Pilot Group

As the Principal Investigator was a former player and the software engineer was still a competitive player, they both understood the needs and benefits the system would bring to the sport of basketball. While both Principal Investigator and software engineer had been involved in the design and completion of the system, it was appropriate to test the system thoroughly by themselves first and then with a pilot group completely unfamiliar with the system.

For such purpose, a local National League men's basketball team was selected to perform the initial trial registration and provide direct feedback on the User Interface (UI). Fifteen players along with their coach and physiotherapist piloted the system over two weeks and met before a team training session with the Principal Investigator and software engineer to discuss the trial.

4.3.14. Feedback

The system proved to be complete and easy to operate by the players, coaches and physiotherapist. One participant had a minor log in issue. This was solved simply by troubleshooting with the participant online and the issue was with the participant's laptop. Another issue was identified during the system pilot with a player who had access issues. However, after log files analysis, it was concluded that the issues were with the Android OS rather than with the cloud-based application. The user continued participating in the trial by using a laptop rather than an android phone. There were no issues with regards to language for any of the players in the pilot group, even those whose first language was not English. Players reported it was straight forward and easy to use. Two samples of the exchanges between players and the administrator are provided here.

Player (02)

Hi UKIBIPS

Having problems trying to log in on the system. It won't allow me to proceed.

Admin – Player contacted. The issue was troubleshooted with the participant while online.

Problem identified – Participant's laptop settings.

Action – Registration completed after laptop setting adjustment.

Player (05)

Hi Admin

Having problems trying to access the system on my phone. Can you advise?

Admin – Player contacted.

Problem identified – After analysis it was concluded that the issues were with the participants Android OS rather than with the cloud-based application.

Action – The user was advised to continue participating in the trial by using a laptop.

4.4. Results

The additional questions about training and game exposure time were included following the recommendations of the previous study and gave very valuable information for comparison with other studies. The study had 56 male participants and 21 female participants. One possibility for the lower number of participants in the study was that there was no field testing in the 2014 – 2015 pre-season. Many of the players tested in the first study had registered and completed the online system during the season. A second possibility is that international underage programmes are constantly rotating players. Players who are cut from squads often remove themselves from any research programmes they were participating in. The participants for this second study again came from all leagues and all age groups with both professional and amateur status.

The mean usage of the ISS by male players was 19 ±13.74 weeks and range of 1-50, while in the female players mean weekly usage was 17 ±12.91 weeks and range of 0-40. There were a total of 1387 player logins. The average number of logins for male players was 18.38 ±14.76 and range of 4-122, while in the female group the average number of logins per player was 15.72 ±6.89 and range of 2-28. See Table 4-1.

Player adherence to the system dropped off over the course of the study. There was no exit questionnaire built into the system so as players dropped off the reasons were not known to the Principal Investigator. Players were asked if they had any individual feedback to contact the Principal Investigator by email. No emails were received. Suggestions offered for the drop-off rate include players being dropped from squads (International or Club), time burden with the system and a varied end-of-season date for each league.

Table 4-1: System Adherence for all Players in National and Premier Divisions 2014 – 2015

	Men			Women		
Demographic						
N (77)		56			21	
	Mean	StDev	Range	Mean	StDev	Range
Age (yrs)	21.58	± 8.38	14 - 48	20.14	± 3.66	16 - 29
Height (cm)	185.98	± 9.70	155 - 207	174.04	± 8.04	152 - 185
Weight (kg)	80.87	± 12.68	45 - 105	68.61	± 6.69	52 - 78
Player Weeks of Adherence						
N (1414)	Mean	StDev	Range	Mean	StDev	Range
	19	± 13.74	1 - 50	17	± 12.91	0 - 40
Total Player logs	Mean	StDev	Range	Mean	StDev	Range
N (1387)	18.38	± 14.76	4 - 122	15.72	± 6.89	2 - 28
Age						
U16		6			0	
U18		21			4	
U20		11			8	
Senior		18			9	
International Player Level		(M32)			(F12)	
U14		0				
U15		1				
U16		3				
U17		13			2	
U18		7			2	
U20		6			6	
Senior		2			2	
Player Position						
Point Guard		13			3	
Shooting Guard		16			6	
Center		8			4	
Forward		17			8	
All Round		2			0	
Player Dominant Hand						
Right		52			19	
Left		2			2	
Ambidextrous		2			0	
Ethnicity						
Black		3			0	
White		50			21	
Mixed		2			0	
Hispanic		1			0	

26 male players logged into the system consistently for a period of greater than 4 months compared with 11 female players over the same period. In the male group, 46% of the players who registered continued using the system for longer than 4 months. In the female group, 52% of the players who registered continued using the system for longer than 4 months. Player engagement with the UKIBIPS-ISS is represented in Table 4-2 showing the durations that players consistently used the system.

Table 4-2: Player Engagement with UKIBIPS

	Only once	At least 1 week	At least 1 month	At least 2 months	At least 3 months	At least 4 months
Male Players	56	56	52	45	35	26
Female Players	21	19	18	15	12	11

International players made up 57% of total participants in the 2014 – 2015 season. The average weekly adherence rate in male international players was 18 ±12.18 weeks and range of 1-47, while in the female international group the average weekly adherence rate was 20 ±13.12 weeks and range of 0-40. Players who had suffered from previous injury had a high average weekly adherence averaging 22 ±15.85 weeks and range of 2-50. The highest weekly adherence rate (50 weeks) was in male players who had suffered a previous injury, while the highest weekly adherence rate was 40 weeks in the female group. Scottish male and female players had the highest average weekly adherence rate over other countries at 27 weeks and 26 weeks respectively. Irish players had the highest number of weeks of adherence to the system at 958 weeks collectively (m700/f258). The lowest weekly average adherence rate was in male English players at 15 weeks and the Irish female players also had a 15 week average adherence rate. See Table 4-3.

Table 4-3: System Usage by Gender for Ireland and UK National and Premier Divisions 2014 – 2015

	Men			Women		
Player system Usage	N56			N21		
N 1414 Total Weeks	1053			361		
Weeks per person	Mean	StDev	Range	Mean	StDev	Range
	19	± 13.04	1 – 50	17	± 12.91	0 – 40
International players (44)	N32			N12		
N 1464.03 Total Weeks	579			239		
	Mean	StDev	Range	Mean	StDev	Range
	18	± 12.18	1 – 47	20	± 13.12	0 – 40
Players Previous injury	N27			N11		
N 1263.23 Total weeks	597			225		
	Mean	StDev	Range	Mean	StDev	Range
	22	±15.85	2 – 50	20	±14.95	0 – 40
Players by country's leagues						
Ireland (58)	N41			N17		
Total weeks (958.20)	700.20			258		
	Mean	StDev	Range	Mean	StDev	Range
	18	± 13.82	1 – 50	15	± 11.77	0 – 40
England (3)	N3			N0		
Total Weeks (44)	44					
	Mean	StDev	Range	Mean	StDev	Range
	15	± 3.11	11 – 17			
Scotland (9)	N5			N4		
Total weeks (236)	133			103		
	Mean	StDev	Range	Mean	StDev	Range
	27	± 14.66	7 – 41	26	± 15.89	5 – 40
Wales (7)	N7			N0		
Total weeks (156)	156					
	Mean	StDev	Range	Mean	StDev	Range
	22	± 7.28	10 – 31			

System user adherence levels are down to the individual player, in a study where participation is voluntary. While the number of participants was down to 77 compared to 183 in the previous study, the UKIBIPS-ISS Version 2 proved to be a much more efficient and robust system for data collection in the 2014-2015 basketball season being monitored.

4.5. Discussion

It was identified from the first study that the exportation of data needed to be easier and more manageable. This was addressed by the software engineer and the data was easily exported. The Principal Investigator had asked the engineer to present the data in a specific way on the Excel sheet. All information on each player needed to be contained on individual rows. This was a request by the Principal Investigator's supervisor as it was felt that the data could be analysed easier in this format.

Converting from relational to columnar type format was extremely difficult. Relational databases are very popular and very suitable for transactional applications, which was very much the design type of the UKIBIPS-ISS. The software engineer came up with a solution for this requirement that saved a lot of time in comparison to the first system.

Another new addition to the system was the inclusion of an embedded tutorial video. Standard screen recording software was used to prepare this introductory video for the system. Most of the functions were showcased and explained with a voice over by the Principal Investigator. It was very important to have an intuitive system design, which was essential for users to be self-sufficient. The video inclusion received positive feedback from the pilot group who trialled the system before being launched online. There was no problem maintaining the system. Infrastructure maintenance was not needed due to the selected hosting package – unlimited data storage, unlimited databases and good bandwidth. Data validation was achieved through the use of pre-defined answer fields and drop-down lists in preference to free-text entry.

The application was device independent, working across PC and mobile devices, adjusting to device resolution and screen size. The flow of questions through the system was designed in a way that the players only answered necessary questions. This reduced the amount of time required for them to enter data to minimise the time burden for them participating in the study. For example, if no injury was selected, then this would finish the workflow as further questions were redundant. For the Principal Investigator, the engineer's design allowed for much easier exporting of data, which had click of the button functionality.

One of the main aims in the redesign of the ISS was to improve on user-friendliness to increase usage/adherence by players on the first system. System adherence was improved from the first season. The average system usage per male player more than doubled from the first season observed (2013-2014 mean system usage was 9.33 ±12.23 weeks compared with 19 ±13.04 weeks of the 2014-2015 season). Similarly, in female players there was an increase in system usage from the previous season going from a mean of 12.06 ±12.70 weeks in 2013-2014 compared to 17 ±12.91 weeks in the 2014-2015 season. The inclusion of text and email reminders as a feature on the new system may have contributed to the increase of system usage/adherence.

Player participation in the 2014-2015 season was down on the previous season by 106 participants (n=183:n=77). One of the main factors which may account for the drop in numbers was that there was no team testing in the 2014-2015 pre-season. In the previous season, there were 110 players involved in testing of which all registered on the system prior to testing.

The ISS was created to provide a data collection tool capable for use with a large study population. While every effort was used to increase participation in the study, this did not happen as it is reliant on voluntary participation. Basketball epidemiology studies carried out in the America NCAA divisions have used data collected and stored on the Datalys system. The benefit of using the Datalys ISS for researchers is that participation is compulsory for athletes and teams in the NCAA college divisions, ensuring sufficient numbers for analysis in large scale research. As with the design of any software system, there is always room for improvement.

Suggested Improvement to the UKIBIPS-ISS:

- Interface – could use more videos to support user experience and have more predefined fields (for example, pictures of player's shoes, orthopaedic supports, court types).

- System Support – as with many online products another recommendation could be to offer live support on the system, which would be beneficial if the system was to become commercial at any stage in the future.

- Data analysis – another recommendation which would make the system more desirable for the user, team coach, physiotherapist or athletic trainer is that the system could be set up for data manipulation/analysis online directly, which would allow the user to utilise pivot tables, graphs, analytics etc.

Despite these possible improvements, the data collected were valid and reliable. Users completed the questionnaire in the same order as they would answer questions in a clinical assessment. They used consistent terms in their answers and free-text discrepancies were eliminated. No player entries were missed in data queries as a result of this. The time taken to design the questionnaire and implement it in this clinical style was completely justified.

On a final note, the system is reliable, robust and efficient in its ability to collect, store and export the data collected during the course of this study. The system has the ability to link both test and injury data to help identify players at increased risk of non-contact modifiable injury. The system can also be used to measure the individual athlete exposure rates in training and game scenarios for basketball.

Team sports have a lot of commonalities in structure and environment. They also share many intrinsic and extrinsic injury risk variables and consequently have potentially similar injury profiles. The UKIBIPS system was designed using the Orchard Sports Injury Classification System, which is applied universally in both clinical and sports-based epidemiological research. The questionnaire was designed to elicit data using non-medical terminology while storing it in a medical format. This process is transferrable across sports with respect to variables including player demographic, body part affected, time, location and nature of the injury. The front end of the system was implemented in this study specifically for basketball. Some characteristics including playing surface, shoe type, duration of games and equipment used would have to be added to build a more universally accessible system to cater for other sports.

As a data collection tool, the system already has the potential to be used in other research in either the sports science/medicine fields or that of epidemiological study. Further, the data collected can be used by multiple disciplines with different needs for that data, and, through appropriate analysis, can be used to answer various research questions for each.

The data collected could be cross-referenced with other data sets to provide further insight into injury occurrence in sport, similar to that done in the NBA study linking travel data and sleep patterns with player injury data in an effort to identify other risk factors. Linking with external data sources could be done through the development of a API (application programming interface) that could be published to allow for this cross-referencing by third-party applications.

Chapter 5 – Pre-Participation Examination of Key Modifiable Intrinsic Personal Level Risk Factors in Basketball Players in the UK and Ireland

5.1. Introduction

Cardiac and musculoskeletal pre-participation examination (PPE) is commonplace within professional sports. The professional athlete may undergo and pass a rigorous series of fitness testing, scans, blood tests, a cardiac stress test and a clinical examination before a contract is offered. These tests are usually conducted by a sports physician or orthopaedic consultant.

In the US, it is a requirement for all high schools to carry out some PPE on athletes in their programmes (Chorba *et al.*, 2010). However the High Schools Associations in America have opted not to select a standard type of PPE. In the National Collegiate Athletic Association (NCAA), all players entering a sports programme are required to have a PPE before being allowed to participate (NCAA, 2011).

PPE can provide the researcher, medical team, team coaches, strength & conditioning coaches and trainers with valuable information on the suitability of a player for a variety of reasons. These include selection, normative data for research, developing pre-season sports specific programmes for a team or individual athletes and to assist in the rehabilitation of an injured athlete to include a fitness test for a return to sport evaluation.

While some professional and international basketball teams in Ireland and the UK carry out pre-season testing, this is not the norm. Anecdotally, the time and cost burden of assessments are suggested as possibilities for non-engagement in this area. The Principal Investigator, having previously served as an international coach for Ireland, can support this statement as S/C coaches have only become a standard part of the sports management team in the last 5-6 years in Irish Basketball and often their background is in Gaelic games or rugby. There is no official unit within Basketball Ireland with the responsibility for elite player performance or injury prevention programmes. Teams may engage S&C coaches on an individual basis and these coaches may often be interns on placement from educational institutes. Basketball Ireland is self-funded so all positions from coaches to management teams are appointed on a voluntary basis, and the engagement of any medical or sports management team personnel requires the players to cover the costs.

PPE as part of injury prevention programmes for teams can often be expensive. In the amateur game, it can be very difficult to arrange times to test all players outside of pre-arranged team training schedules. As this testing reduces their contact time with players, many coaches frown upon it and injury prevention takes second place to team training. Any efforts to change this attitude towards pre-season and in-season testing must address and engage the primary stakeholders: the coach, the players and those who will carry out the testing.

An important question which needs to be answered is how can the time and cost burden be reduced in pre-season testing. While access to test players at the start of the season may be possible, the same time will most likely not be made available during the season. This is why a more tailored, efficient, triage type assessment for routine season testing may be favourable to stakeholders.

Successful sports injury prevention should rely on permanent surveillance and encompass the collection of epidemiological data, the establishment of risk factors, the implementation of prevention initiatives and the analysis of their effectiveness (Malisoux *et al.*, 2014).

The 4 stage model for injury surveillance proposed by Van Mechelen has been discussed in Chapter 1. The first and second stages have been addressed through the development of a system to collect data on the extent and mechanisms of injury in the sport of basketball in the UK and Ireland. The data collection systems have been discussed in detail in Chapters 3 and 4. Before moving on to address the third stage of introducing preventative measures, it is important to provide a pre-season testing protocol which will serve two purposes:

1. Testing for modifiable personal non-contact injury risk factors in sport.

2. Provide a system of routine assessment, for both the start and duration of the season, to monitor the effectiveness of injury prevention strategies.

Rates of injuries in basketball have been reported at between 7-10 injuries per 1000 hours of player exposure (Agel *et al.*, 2007a; Dick *et al.*, 2007a; Hootman, Dick and Agel, 2007). The evidence suggested in studies is that most injuries (58%-66%) occur to the lower extremity (Dick *et al.*, 2007a; Agel *et al.*, 2007a), thus it was decided to focus on the lower extremity during the pre-participation screening test phase of the study.

Clinical assessment is an incremental, sometimes iterative, approach to diagnosis. The premise in this research was to bring this methodology, normally reserved for the qualified assessor, into the domain of the amateur coach and management team. The clinical tests used in differential diagnosis are often complementary to the standard pre-season tests used to measure an athlete's baseline data. The clinical methodology and tests could be used in partnership with the pre-participation testing and a combination of selected tests may provide a protocol which would be cheaper, equally reliable, reproducible and time efficient. The aim of the research was to test the veracity of this hypothesis. Individual pre-participation tests present results and predictions in a similar fashion to clinical tests making a differential diagnosis.

The results from injury data analysis (presented in Chapter 6) may highlight primary variables (risk factors for injury) contributing to injury occurrence. The suites of tests selected and presented in this chapter assess each of the identified variables for an athlete. Performing a cluster analysis on the selected tests may identify homogeneous clusters of tests for particular risk factors (variables). This would provide a way to select the minimum number of tests with the maximum impact for variable testing. The benefit of this is a reduction in the time and cost that it takes a non-medical person to perform the tests in an efficient way with a team. Further, given that the selected tests result in a binary (either pass or fail) measure, the tester can competently assess the current health and performance status of the team members.

5.2. Aims

- Identify functional and clinical tests that can facilitate the collection of data on potential risk factors for sports injury.
- Carry out pre-season testing of a selection of players participating in National league and International basketball teams in the UK and Ireland.
- Examine the potential relationships between pre-participation and clinical tests.

5.3. Overview of Pre-Participation Screening Tests for Modifiable Intrinsic Risk Factors

Modifiable intrinsic risk factors contributing to injury are athlete dependent. The identification of intrinsic factors, which could be potentially altered, forms the basis for designing effective prevention programmes (Frisch *et al.*, 2009). Key modifiable intrinsic personal level risk factors include fitness levels, balance and propreoception, strength, flexibility, biomechanics and joint stability**.** It is important to this study to test some of the key risk factors which include **flexibility** (muscle tightness) (Krivickas and Feinberg, 1996), (Kreckel, Eysel and König, 2004), (Gabbe *et al.*, 2004), (Ferber, Kendall and McElroy, 2010), (Corkery *et al.*, 2007), (Witvrouw *et al.*, 2003), (Jönhagen, Németh and Eriksson, 1994), **balance and propreoception** (Plisky *et al.*, 2006), (Gribble *et al.*, 2013), (Powden, Dodds and Gabriel, 2019), (Smith, Chimera and Warren, 2015), (Butler *et al.*, 2013), (Trojian and McKeag, 2006), (Linens *et al.*, 2014), (McGuine *et al.*, 2000), **joint stability and biomechanical factors** (Backman and Danielson, 2011), (Pope, Herbert and Kirwan, 1998) and **fitness levels** (Dawes, Marshall and Spiteri, 2016), (Berdejo-del-Fresno and Gonzalez Rave, 2013).

There are a large variety of tests available to measure an athlete's fitness, strength, biomechanics, joint/core stability and balance/propreoception. Tests may be conducted in the lab or in the field. The selection of the tests used is based on the needs of the team (monitoring of baseline pre-season fitness, fitness during the season, rehabilitation or team selection) or the needs of a specific research programme being carried out. It is important to take into consideration the time, costs and equipment required, while also being aware of the specificity, sensitivity, reliability and reproducibility of the test being selected. Topend Sports provide over 400 fitness tests in their database catalogue. The sports medicine clinician will also have a vast catalogue of orthopaedic and functional tests that can be used as part of a decision tree in order to carry out a differential diagnosis and make a logical conclusion about what the patient is presenting with. There are different protocols which can be used for testing to decide on an intervention and possible further investigation. An overview of each of the tests used in this study is provided below.

5.3.1. Test 1: Functional Movement Screen (Variables Tested: Balance, Stability, Functional Movement and Strength)

The Functional Movement Screen or FMS test is a 7-point movement screening test (Hurdle Step, Lunge, Straight Leg Raise (SLR), Trunk Stability Press-Up, Deep Squat, Shoulder Reach Test and the Rotary Stability Test) designed to identify dysfunctional movement patterns and asymmetries within the body (Cook, Burton and Hoogenboom, 2006). The FMS is a ranking and grading system that documents movement patterns which are key to normal function. By screening these patterns, the FMS readily identifies functional limitations and asymmetries. These are issues that can reduce the effects of functional training and physical conditioning and distort body awareness. The FMS generates the Functional Movement Screen Score, which is used to target problems and track progress. There are seven test stations which are scored between 0-3. The breakdown of the FMS scoring system can be seen in Figure 5-1 using the Hurdle Step Test as an example, with the scores in red. The maximum score is 21 while the minimum is 0.

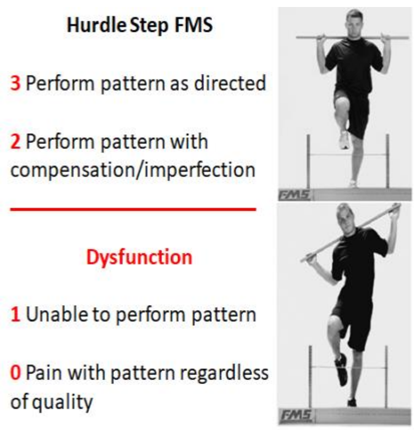


Figure 5-1: FMS Scoring System

The FMS system has previously been utilised in basketball research for injury risk evaluation in elite athletes (Šiupšinskas *et al.*, 2019; Chorba *et al.*, 2010). The scoring chart for the Functional Movement Screening test can be seen in Table 5-1.

Table 5-1: FMS Scoring Chart

FMS	FMS			FMS			FMS
Name	Height			Weight			Hand / Leg Dominance
Test	Raw Test Score Left			Raw Test Score Right			Final test Score
Deep Squat							
Hurdle step							
Lunge							
Shoulder Mobility Test							
Impingement clearing Test							
Active SLR							
Trunk stability Press Up							
Press up clearing test							
Rotary stability Test							
Posterior rocking clearing test							
Hand length							
Tibia tuberosity height							

5.3.1.1. The Deep Squat

The Deep Squat (Figure 5-2) pattern challenges total body mechanics and neuromuscular control. It is used to test the functional mobility and stability of the hips, knees and ankle. The dowel overhead requires bilateral symmetrical mobility and stability of the shoulders, scapular region and the thoracic spine. The pelvis and core must establish stability and control throughout the entire movement to achieve the full pattern (Cook, Burton and Hoogenboom, 2006).

Deep Squat	3 points	2 points	1 point	0 points
	Upper Torso is parallel with tibia or towards vertical Femur below horizontal Knees aligned with the feet Dowel aligned within footprint	Upper Torso is parallel with tibia or towards vertical Femur below horizontal Knees aligned with the feet Dowel aligned within footprint *with modification	Upper Torso and tibia are not parallel Femur is not below horizontal Knees are not aligned over the feet Lumbar flexion is noted	Pain experienced during test

Figure 5-2: Deep Squat Test

5.3.1.2. The Hurdle Step

The Hurdle Step (Figure 5-3) pattern is an integral part of locomotion and acceleration. The Hurdle Step requires bilateral mobility and stability of the athlete's hips, knees and ankles. Pelvic stability and core is challenged during the test and allows the assessor to observe functional symmetry also.

Hurdle Step	3 points	2 points	1 point	0 points
	Hips, knees and ankles remain aligned in the sagittal plane Minimal to no movement is noted in lumbar spine Dowel and hurdle remain parallel	Alignment is lost between hips, knees and ankles Movement is noted in lumbar spine Dowel and hurdle do not remain parallel	Contact between athlete and hurdle Loss of balance is noted	Pain experienced during test

Figure 5-3: Hurdle Step Test

5.3.1.3. The Inline Lunge

The Inline Lunge (Figure 5-4) places the lower extremities in a split stance while the upper extremities are in an opposite or reciprocal pattern. This replicates the natural counterbalance the upper and lower extremities use to complement each other, as it uniquely demands spine stabilisation (Cook, Burton and Hoogenboom, 2006). The test once again tests mobility and stability in the athlete's hip, knee, ankle and foot.

Lunge	3 points	2 points	1 point	0 points
	Dowel contacts remain with L-spine extension No torso movement is noted Dowel and feet remain in sagittal plane Knee touches board behind heel of front foot	Dowel contacts do not remain with L-spine extension Movement is noted in torso Dowel and feet do not remain in sagittal plane Knee does not touch board behind heel of front foot	Loss of balance is noted	Pain experienced during test

Figure 5-4: Lunge Test

5.3.1.4. The Shoulder Mobility Test

The Shoulder Mobility (Figure 5-5) pattern shows the movement in the scapular-thoracic region, thoracic spine and rib cage which occurs in upper-extremity shoulder movements. The range of movement of the shoulder can be observed in the bilateral opposite movements of internal and external rotation of the glenohumeral joint.

Shoulder Mobility Test	3 points	2 points	1 point	0 points
	Fists are within one hand length	Fists are within one and a half hand lengths	Fists are not within one and a half hand lengths	Pain experienced during test

Figure 5-5: Shoulder Mobility Test

5.3.1.5. The Active Straight Leg Raise Test

The Active Straight Leg Raise (Figure 5-6) identifies the mobility of the hip during active straight leg flexion, core stability during the pattern and hip extension in the opposite hip. This pattern also challenges the athlete's ability to dissociate their lower extremities while maintaining stability in their pelvis and core.

Active SLR	3 points	2 points	1 point	0 points
	Ankle/dowel reside between mid-thigh and ASIS	Ankle/dowel reside between mid-thigh and mid-patella/joint line	Ankle/dowel reside below mid-patella/ joint line	Pain experienced during test

Figure 5-6: Active Straight Leg Raise Test

5.3.1.6. The Trunk Stability Press-Up Test

The Trunk Stability Press-Up (Figure 5-7) test is performed to observe basic reflex core stabilisation. This movement is initiated by the upper extremities without allowing spinal or hip movement. Spinal stability in the sagittal plane, during closed kinetic chain and upper body symmetrical movement is being assessed during this test.

Trunk stability press up	3 points	2 points	1 point	0 points
	Males perform 1 repetition with thumbs aligned with the top of the forehead Females perform 1 repetition with thumbs aligned with chin	Males perform 1 repetition with thumbs aligned with the chin Females perform 1 repetition with thumbs aligned with clavicle	Males are unable to perform 1 repetition with thumbs aligned with the chin Females are unable to perform 1 repetition with thumbs aligned with clavicle	Pain experienced during test

Figure 5-7: Trunk Stability Press-Up Test

5.3.1.7. The Rotary Stability Test

The Rotary Stability Test (Figure 5-8) is a complex movement pattern, which requires neuromuscular coordination and energy transfer through the torso. Multi-plane pelvis, core and shoulder girdle stability observed during combined upper and lower extremity movements may be identified. The movement demonstrates reflex stabilisation and weight shifting in the transverse plane, and it represents the coordinated efforts of mobility and stability observed in fundamental climbing patterns (Cook, Burton and Hoogenboom, 2006). It is also similar to the movement which occurs during a lay-up in basketball.

Rotary Stability Test	3 points	2 points	1 point	0 points
	Performs 1 correct unilateral repetition while keeping spine parallel to board Knee and elbow touch in line over the board	Performs 1 correct diagonal repetition while keeping spine parallel to board Knee and elbow touch in line over the board	Inability to perform diagonal repetition	Pain experienced during test

Figure 5-8: Rotary Stability Test

As part of the FMS assessment, a number of clearing tests must be performed on the athlete. The FMS system includes three clearing tests that assess for pain: 1) shoulder internal rotation and abduction with the hand placed on the opposite shoulder, 2) lumbar extension performed in the prone press-up position and 3) end-range lumbar flexion in the quadruped position. If a player has pain on any of the clearing tests, this results in a score of 0 for the shoulder mobility, trunk stability push-up, or rotary stability test, respectively. If a player receives a zero, they are referred to a medical practitioner for further in-depth assessment (Chorba *et al.*, 2010).

5.3.1.8. Shoulder Impingement Clearing Test

The athlete puts a palm on the opposite shoulder and lifts the elbow as high as possible while keeping the palm touching the shoulder (Figure 5-9). If pain is present, a positive test is recorded (Cook, 2010).

Figure 5-9: Shoulder Clearing Test

5.3.1.9. Spinal Flexion Clearing Test

The athlete starts on hands and knees and rocks back to touch buttocks to heels and chest to thighs. Hands remain in front of the body stretched out as far as possible (Figure 5-10). If pain is present, a positive test is recorded (Cook, 2010).

Figure 5-10: Spinal Flexion Clearing Test

5.3.1.10. Spinal Extension Clearing Test

The athlete performs a press-up in which they push their upper body off of the ground, but keeps their quadriceps on the ground (Figure 5-11). If pain is present, a positive test is recorded.

Figure 5-11: Spinal Extension Clearing Test

5.3.2. Test 2: Y-Balance Test (Variables Tested: Balance, Flexibility)

The Y-Balance Test kit is used to test a person's risk for injury as well as demonstrate functional symmetry. It allows the assessor to measure and quantify a person’s motor control and, while testing how the athlete’s core and each limb work under bodyweight loads, to look at the body in four parts: left versus right and upper body versus lower body. The Y-Balance Test protocol was developed through years of research in lower extremity injury prevention using the Star Excursion Balance Test (SEBT) (Plisky *et al.*, 2009). The Y-Balance Test in its simplest form is an instrumented version of components used in SEBT, and was developed to improve the repeatability of measurement and standardise performance of the test. The device utilises the anterior, posteromedial and posterolateral components of the SEBT.

In a study with soccer players by Plisky *et al.*, they used the Y-Balance Test kit (Figure 5-12) to measure single limb excursion distances and concluded that the Y-Balance Test kit and protocol is highly accurate and can be used for measuring pre and post rehabilitation performance, improvement after performance enhancement programmes, dynamic balance for fitness programmes, and return to sport readiness (Plisky *et al.*, 2009). Plisky's 2006 study found that components of the SEBT to be reliable and predictive measures of lower extremity injuries in high school basketball players. They concluded that the SEBT (which the Y-Balance Test has been designed to measure) can be incorporated into pre-participation physical examinations to identify basketball players who are at increased risk of injury (Plisky *et al.*, 2006).

Figure 5-12: Y-Balance Test Kit

Players practice six trials on each leg in each of the three reach directions prior to formal testing. The subjects are tested within 20 minutes of practicing. Subjects do not wear shoes during the test. The subjects stand on one leg on the center foot plate with the most distal aspect of the foot at the starting line. While maintaining single leg stance, the subject is asked to reach with the free limb in the anterior, posteromedial and posterolateral directions in relation to the stance foot. See Figure 5-13 for Y-Balance Test positions.

Figure 5-13: Y-Balance Test Positions

The testing order involves three trials standing on the right foot reaching in the anterior direction (right anterior reach) followed by three trials standing on the left foot reaching in the anterior direction. This procedure is repeated for the posteromedial and the posterolateral reach directions.

The maximal reach distance is measured by reading the tape measure at the edge of the reach indicator, at the point where the most distal part of the foot reached. The trial is discarded and repeated if the player:

1) Fails to maintain unilateral stance on the platform (e.g. touches down to the floor with the reach foot or fell off the stance platform)

2) Fails to maintain reach foot contact with the reach indicator on the target area while it was in motion (e.g. kicked the reach indicator)

3) Uses the reach indicator for stance support (e.g. places foot on top of reach indicator)

4) Fails to return the reach foot to the starting position under control. The starting position for the reach foot is defined by the area immediately between the standing platform and the pipe opposite the stance foot (Plisky *et al.*, 2009)

Since the reach distance is related to limb length, reach distance is normalised to limb length. To express reach distance as a percentage of limb length, the normalised value is calculated as reach distance divided by limb length then multiplied by 100. Composite reach distance is the sum of the three reach direction values divided by three times limb length, and then multiplied by 100. Greater than 4 cm right/left difference in anterior direction is indicative of 2.5 times more likely to be injured. The Move2Perform software system will be used to analyse the data to see if a player is at risk of lower leg injury. See Table 5-2 for Y-Balance Test Score chart.

Table 5-2: Y-Balance Test Score Chart

Movement	Left	Right	Difference ***	Right Leg Length
Anterior				
Posteromedial				
Posterolateral				

The Composite Score is calculated using the formula:

Score = (Anterior + Posteromedial + Posterolateral) (3 x Limb Length) x 100

Move2Perform Software

The Move2Perform (M2P) software programme is a movement measurement and analysis tool that identifies deficits and risk of injury from test measurements data inputted. The software has been used extensively in research and has been utilised by many professional and international sports teams. Lehr *et al.*, in their 2013 study, concluded that the M2P with its injury risk algorithm when used with field testing equipment such as the FMS Test kit and Y-Balance Test kit can help identify individuals with an elevated risk of injury for non-contact lower extremity injury (Lehr *et al.*, 2013).

The Move2Perform software was also utilised by Teyhan *et al.* when looking for an efficient field-testing analysis tool for hand-held devices and laptops. Their tests included measures for quality of movement, balance, trunk stability, power and mobility. Data was entered into hand-held computers and netbook computers. An automated algorithm for injury risk stratification was run on a computer server.

Their results found that without automation support subjects were assessed in 84.5 ±9 mins per subject compared with 66.8 ±6.1 minutes per subject with automation and 47.1 ±5.2 minutes per subject with automation and process improvement measures ($p < 0.001$). They stated that their average time to manually enter the data was 22.2 ±7.4 minutes per subject and that an additional 11.5 ±2.5 minutes per subject was required to manually assign an intervention strategy. They concluded that the device allowed for real-time data entry and enhanced the efficiency of the field screening process, risk stratification and prescription of a risk mitigation strategy (Teyhen *et al.*, 2012). The software tool was downloaded to the UKIBIPS field testing laptop. The software can be used off line and was purchased for $390. The algorithm used in the Move2Perform system was not publicly available to include. See Figure 5-14 for Move2Perform screenshot.

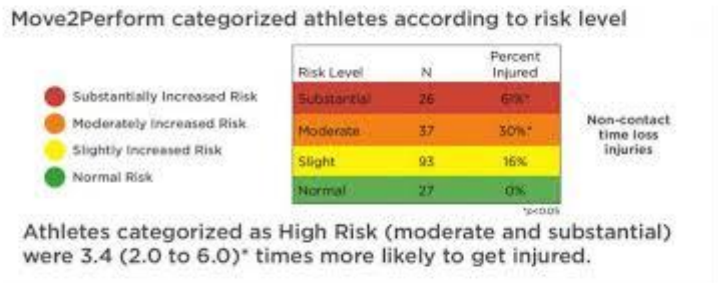


Figure 5-14: Move2perform Risk Category Screenshot

The algorithm used for the FMS system and Move2Perform software were not available to the Principal Investigator. As stated above, in the Y-Balance Test, the composite score is calculated using the formula: ***Score = (Anterior + Posteromedial + Posterolateral) (3 x Limb Length) x 100.***

5.3.3. Test 3: The Bleep Test (Variables Tested: Fitness)

The Bleep Test, also known as the multi-stage fitness test, or shuttle run test, is used by sports coaches and trainers to estimate an athlete's maximum oxygen uptake, better known as VO2 Max. The Bleep Test Software used in the assessment phase of the study was from Topend Sports Network Bitworks Design and Consultancy England.

The recording is typically structured into 23 levels, each of which lasts 60 seconds. Usually, the interval of bleeps is calculated to require a speed at the start of 8.5 km/h, which increases by 0.5 km/h with each level. The progression from one level to the next is signalled by 3 rapid beeps. The highest level attained before failing to keep up is recorded as the score for that test. The procedure is designed to measure the maximum endurance of an individual (Léger and Lambert, 1982).

In a study by Berdejo-del-Fresno, they used the Bleep Test to evaluate fitness levels in high-level British female basketball players, and concluded that the cardiorespiratory levels recorded in these athletes were lower than high-level female basketball players from other countries where basketball is more popular and better developed (Berdejo-del-Fresno and Gonzalez Rave, 2013).

Test procedure: The test involves running continuously between two points that are 20 metres apart. These runs are synchronised with audio playing the bleeps at set intervals. The test is designed to force the athletes to increase their run speed until it is impossible to run in sync with the recording. The general guide calculation table for normative data in Bleep Tests for male and female athletes 12yrs+ is shown in Table 5-3.

Table 5-3: Normative Data in Bleep Tests for Male and Female Athletes 12yrs+ (Topend Sports)

Age Male	Very Poor	Poor	Fair	Average	Good	Very Good	Excellent
12-13yrs	< 3/3	3/3 – 5/1	5/2 – 6/4	6/5 – 7/5	7/6 – 8/8	8/9 – 10/9	> 10/9
14-15yrs	< 4/7	4/7 – 6/1	6/2 – 7/4	7/5 – 8/9	8/10 – 9/8	9/9 – 12/12	> 12/12
16-17yrs	< 5/1	5/1 – 6/8	6/9 – 8/2	8/3 – 9/9	9/10 – 11/3	11/4 – 13/7	> 13/7
18-25yrs	< 5/2	5/2 – 7/1	7/2 – 8/5	8/6 – 10/1	10/2 – 11/5	11/6 – 13/10	> 13/10
26-35yrs	< 5/2	5/2 – 6/5	6/6 – 7/9	7/10 – 8/9	8/10 – 10/6	10/7 – 12/9	> 12/9
36-45yrs	< 3/8	3/8 – 5/3	5/4 – 6/4	6/5 – 7/7	7/8 – 8/9	8/10 – 11/3	> 11/3
46-55yrs	< 3/6	3/6 – 4/6	4/7 – 5/5	5/6 – 6/6	6/7 – 7/7	7/8 – 9/5	> 9/5
56-65yrs	< 2/7	2/7 – 3/6	3/7 – 4/8	4/9 – 5/6	5/7 – 6/8	6/9 – 8/4	> 8/4
> 65yrs	< 2/2	2/2 – 2/5	2/6 – 3/7	3/8 – 4/8	4/9 – 6/1	6/2 – 7/2	> 7/2

Age Female	Very Poor	Poor	Fair	Average	Good	Very Good	Excellent
12-13yrs	< 2/6	2/6 – 3/5	3/6 – 5/1	5/2 – 6/1	6/2 – 7/4	7/5 – 9/3	> 9/3
14-15yrs	< 3/3	3/3 – 5/2	5/3 – 6/4	6/5 – 7/5	7/6 – 8/7	8/8 – 10/7	> 10/7
16-17yrs	< 4/2	4/2 – 5/6	5/7 – 7/1	7/2 – 8/4	8/5 – 9/7	9/8 – 11/10	> 11/10
18-25yrs	< 4/5	4/5 – 5/7	5/8 – 7/2	7/3 – 8/6	8/7 – 10/1	10/2 – 12/7	> 12/7
26-35yrs	< 3/8	3/8 – 5/2	5/3 – 6/5	6/6 – 7/7	7/8 – 9/4	9/5 – 11/5	> 11/5
36-45yrs	< 2/7	2/7 – 3/7	3/8 – 5/3	5/4 – 6/2	6/3 – 7/4	7/5 – 9/5	> 9/5
46-55yrs	< 2/5	2/5– 3/5	3/6 – 4/4	4/5 – 5/3	5/4 – 6/2	6/3 – 8/1	> 8/1
56-65yrs	< 2/2	2/2 – 2/6	2/7 – 3/5	3/6 – 4/4	4/5 – 5/6	5/7 – 7/2	> 7/2
> 65yrs	< 1/5	1/5 – 2/1	2/2 – 2/6	2/7 – 3/4	3/5 – 4/3	4/4 – 5/7	> 5/7

5.3.4. Test 4: Ankle Dorsiflexion Test (Variables Tested: Flexibility, Joint Biomechanics)

Reduced ankle dorsiflexion has been identified as a risk factor for lower leg injuries (Backman and Danielson, 2011). The player is measured with runners and is tested, both weight bearing and prone and supine. See Figure 5-15 for Test equipment and player position. The test is carried out using two separate pieces of measuring equipment, the bubble inclinometer and a digital goniometer as the players are being tested in a supine and standing position.

Figure 5-15: Dorsiflexion Test Equipment and Player Position

Goniometer

The Goniometer is also used to measure the joint movement. When using the Goniometer the lateral malleolus, fibula head and fifth metatarsal are used as the anatomical landmarks for joint range of motion testing. See Test Chart in Table 5-4.

Low ankle dorsiflexion range is a risk factor for developing injury in basketball players. In the studied material, an ankle dorsiflexion range of 36.5° or less was found to be the most appropriate cut off point for prognostic screening (Backman and Danielson, 2011).

Table 5-4: Score Chart for Ankle Dorsiflexion Test

Ankle Movement	Standing Bubble Inclinometer	Supine Bubble Inclinometer	Prone Dorsiflexion	Supine Dorsiflexion
Right				
Left				

Bubble Inclinometer

Ask the player to lie down supine on the plinth (table). Place the Bubble Inclinometer on the sole of the foot, set at zero. Dorsiflex the ankle and read the result. The readings are more accurate when the player is wearing basketball shoes. Testing in a standing position is also required.

5.3.5. Test 5: Muscle Hypertonicity (Variables Tested: Flexibility)

The muscle hypertonicity and orthopaedic test assessment consists of thirteen specific tests. The test outcomes and procedures follow below.

Ober's Test

This is a muscle tightness test for Tensor Fascia Late (TFL) with the player lying on their side with knee flexed to 90 degrees and ankle supported by assessor as in Figure 5-16. If the knee remains in this position or fails to drop toward the table, consider this a positive test for muscle tightness in the TFL (Kendal, 1993).

Figure 5-16: Ober's Test

Psoas and Rectus Femoris Muscle Test (Thomas Test)

The player is tested in the supine position as shown in Figure 5-17. If the hip remains in a flexed position, consider the Psoas muscle positive for tightness. In this test position, consider Rectus Femoris positive if the knee is held in greater than 90 degrees of extension (Hoppenfeld, 1976).

Figure 5-17: Thomas Test

Vasti Muscle Group Test

With the player in a prone position, the assessor brings the heel of the player passively towards the glutes as in Figure 5-18. An inability to touch the heel with the glutes is considered a positive test for muscle tightness (excluding muscle opposition) (Hoppenfeld, 1976).

Figure 5-18: Vasti Test

Gastrocnemius and Soleus Muscle Tightness

The player is in a supine position on the treatment table for the test. The Soleus is tested with the knee in flexion and considered positive for tightness if the assessor is unable to achieve passive dorsiflexion past 90 degrees. The Gastrocnemius is tested with the player in a supine position with the knee in full extension. If the assessor is unable to achieve passive dorsiflexion past 90 degrees, consider the Gastrocnemius positive for tightness (Hoppenfeld, 1976). See Figure 5-19.

Figure 5-19: Soleus Muscle (left) and Gastrocnemius (right) Test

Upper Hamstring Fibre Test

The player is in a supine position on the treatment table. Assessor lifts the player's fully extended leg with the opposite leg flat on the floor as in Figure 5-20. An inability to achieve 90 degrees indicates tightness in the upper fibres of hamstrings (Hoppenfeld, 1976).

Figure 5-20: Upper Hamstring Test

Lower Hamstring Fibre Test

The player is placed in a supine position. Assessor brings the player's knee toward the player's chest and holds it in this position as shown in Figure 5-21. At the same time the assessor tries to bring the player's knee into extension. An inability to reach 90 degrees of extension indicates tightness in the lower fibres of the hamstrings (Hoppenfeld, 1976).

Figure 5-21: Lower Hamstring Test

Medial Hamstring Fibre Muscle Test

The player is in a supine position on the treatment table as shown in Figure 5-22. Assessor brings hip into abduction. An inability to achieve 45 degrees of abduction or greater is an indication of tightness in the medial fibers of the hamstrings (Hoppenfeld, 1976).

Figure 5-22: Medial Hamstring Fibre Tightness Test

Adductor Muscle Group

As with the medial hamstrings the player is tested in a supine position. Assessor brings hip into abduction, and lets the lower leg into 90 degrees of flexion off the table (Figure 5-23). An inability to achieve 45 degrees of abduction or greater with the knee in flexion is an indication of tightness in the adductor muscles (Hoppenfeld, 1976).

Figure 5-23: Adductor Test

Piriformis Muscle Test

The player is tested in a supine position (Figure 5-24). Align the player by asking them to flex their knees and bring both ankles together while keeping their feet flat on the table, then lift their buttocks off the table for a moment and then return again. Ask player to fully extend both knees. The assessor lifts both legs off the table and gently lets the feet fall back to the table. If one or both feet go into an externally rotated position, consider the piriformis muscle to be tight (Hoppenfeld, 1976).

Figure 5-24: Piriformis Test

5.3.6. Test 6: Orthopaedic Tests (Variables Tested: Strength Joint Stability, Joint Biomechanics)

5.3.6.1. Trendelenburg Test

The Trendelenburg Test is a muscle strength test for glutes medius. This test is considered positive if the posterior superior iliac spine (P.S.I.S) drops on the non-weight bearing leg (Hardcastle and Nade, 1985). See Figure 5-25.

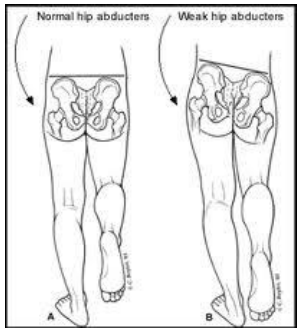


Figure 5-25: Trendelenburg Test

5.3.6.2. Leg Length Discrepancy Test

A leg length discrepancy (LLD) may contribute to shortening of soft tissues, joint contractures, ligamentus laxity, axial malalignments and foot biomechanic dysfunction such as excessive ankle pronation.

The player is placed in a supine test position. Align the player by asking them to flex their knees and bring both ankles together while keeping their feet flat on the table. If there is a difference in height of the knees we must consider a longer tibia on the higher side. If one knee is more anterior than the other we must consider a longer femur.

A second method is to measure the player from their anterior superior iliac spine (ASIS) to the medial malleolus and see if there is a difference in this measurement indicating a possible leg length discrepancy. Finally, with equal traction on both ankles compare both the left and right malleolus to see if they are in alignment. If not, consider a leg length discrepancy (Hoppenfeld, 1976). See Figure 5-26.

Figure 5-26: Leg Length Discrepancy Test

A Test Chart for recording the results of the muscle and orthopaedic tests is shown in Table 5-5 for reference.

Table 5-5: Test Chart for Muscle and Orthopaedic Tests

Muscle + Orthopaedic test	Left/Positive/-Negative	Right/Positive/-Negative
Trendelenburg Test		
Tensor Fascia Late		
Psoas		
Rectus Femoris		
Vasti Group		
Gastrocnemius		
Soleus		
Hamstrings Lower Fibers		
Upper Hamstrings Fibers		
Medial Hamstring Fibers		
Piriformis		
Adductors		
Leg length Discrepancy Test		

5.3.7. Test 7: Single Leg Balance Test (Variables Tested: Balance/Propreoception)

The Single Leg Balance Test (SLBT) has been identified as a reliable test for predicting ankle sprains in athletes in a study by Trojian and McKeag (Trojian and McKeag, 2006). The athlete stands on one foot without shoes with the contralateral knee bent and not touching the weight bearing leg as shown in Figure 5-27. The hips remain level to the ground; the eyes open and fixed on a spot marked on the wall; and then the eyes are closed for 10 seconds. The athlete reports any sense of imbalance. The investigator notes if the athlete's legs touched each other, the feet moved on the floor, the foot touches down, or the arms moved from their start position. If the athlete has a positive test (fails to remain balanced or described a sense of imbalance) during their first trial, a second trial is carried out with the results of the second trial counting (positive or negative) for analysis. Both legs are tested. An SLB test is considered positive if the athlete was unable to carry out the test on either or both legs. The SLB test has been used to measure intrinsic risk factors for ankle sprains in elite football and basketball players (Halabchi *et al.*, 2016). The associated test result chart is provided in Table 5-6.

Figure 5-27: Single Leg Balance Test

Table 5-6: Single Leg Balance Test Score

Single leg balance test	Left /Positive/-Negative	Right / Positive/-Negative
First Test		
Second Test		
Final Result		

5.4. Methodology

As previously stated, most injuries occur to the lower extremity in basketball players. A review of studies testing the reliability of equipment was carried out which looked at identifying risk factors for lower extremity injury. All equipment selected needed to have been used in previous research, shown to be reliable for field testing and easily transported to the testing facility. After review, the following tests and equipment requirements were selected for the team assessment phase of the study (see Table 5-7).

A combination of manual and electronic equipment was used to assess intrinsic risk factors of balance, flexibility, strength, biomechanics, fitness and dysfunctional movement patterns.

Table 5-7: Modifiable Risk Factors and Appropriate Options

Balance / Propreoception	Flexibility	Fitness	Mobility/Stability Biomechanics
Single Leg Balance Test	Muscle Hypertonicity Tests	20m Bleep Test	FMS Deep Squat
Y-Balance Tests	Clinical Orthopaedic Muscle Tests		FMS Inline lunge
			FMS Hurdle Step
			FMS Active Straight Leg Test
			FMS Trunk Stability Push-Up
			FMS Shoulder Mobility Test
			Ankle Dorsiflexion Test
			Trendelenburg Test
			Leg Length Discrepancy
			Y-Balance Test

5.4.1. Ethics Approval/Participant Selection

Following approval from the Ethics Committee of the University of Glasgow, the Basketball Associations of Ireland, Scotland, England and Wales were approached to seek permission and support for their players to participate in the United Kingdom and Ireland Basketball Injury Prevention Study (UKIBIPS). Approval was granted for the UKIBIPS by the sport governing bodies in March 2013.

The Basketball Associations of Ireland, Scotland and Wales requested that their international squads also participate in the study. This request was brought before the ethics committee and approval was received in May 2013.

Volunteers were sought from players competing in the National and Super Leagues of the UK and Ireland as well as Under 14, Under 15, Under 16, Under 17, Under 18 and Under 20 International basketball teams of the UK and Ireland. Twelve professional teams of the British Basketball League (BBL) were also approached to participate in the study. The governing bodies of the basketball associations of the UK and Ireland informed their clubs and members of the nature of the study through hard copy, email and the other social media platforms that they use. A simple language document was provided by the Principal Investigator which covered the procedure for registering on the online injury surveillance system as well as the player pre-participation screening assessment phase, which occurred later in the study. Participation in the study was voluntary and players were able to withdraw from the study at any time.

The inclusion criteria for participating in the study were:

(A) Any players both male and female from Under 14, 15, 16, 18, 20 and Senior International training programmes from Ireland, England, Scotland and Wales.

(B) Any registered male or female players from the National or Super League teams in Ireland and the UK, as well as players from the British Basketball League.

(C) Players under the age of 18 were required to have informed consent to participate from either their parent(s) or guardian(s).

The exclusion criteria for the pre-participation screening phase of the study was that any player injured at the time of testing was not allowed to be tested. Field testing occurred in Ireland, Scotland and Wales.

5.4.2. Field Assessment Team Selection and Training

The field assessments were carried out by two teams, one based in Ireland and the other based in Scotland. The Irish assessment team included three physiotherapists, a sports scientist and computer programmer. The Scottish assessment team included three physiotherapists from Strathclyde University as well as a sports scientist and computer programmer. The Welsh player assessments were carried out by the same team who performed the Irish assessment. Garda and police vetting was carried out on each team member in order to participate as part of the assessment team.

A UKIBIPS assessment manual was developed for the field assessment phase of the research (Appendix 10). The assessment training took place over a weekend and consisted of four testing sessions. The six stations were set up and assessors assigned to their specific test number. All equipment was demonstrated and each member was observed and given feedback on the operation of their specific test. On arrival, all participants were informed of the purpose of the tests and were given time to ask questions. Players with injury or pain on the testing day were excluded from testing, thanked for attending and did not continue any further. The remaining players were asked to sign an informed consent sheet.

Each station was allocated 10 minutes for testing. During the first morning session there was a five minute break before the rotation of the players. This gave time for the assessors to input data in real-time and identify any difficulties they had with the application of the test and/or time keeping. A video camera was used at each station for three rotations and this was used later to assess the effectiveness and efficiency of our testing protocol.

After the first day of testing, the assessment team looked at the layout of the tests and made modifications to their test area to improve application or improve observation point for testing. During the morning of the second day of testing, one group of players were assessed on all the stations after which the team took a break to discuss any difficulties. The afternoon session allowed for the testing of a complete team and an hour and a half was identified as the amount of time needed to test a full team of fifteen players.

The assessment team were allowed a further two weeks testing at their own labs to become comfortable with their test station and during this time were contacted by the Principal Investigator to make sure everyone was comfortable and confident in their ability to assess their station. The Scottish team were sent a video of the Irish assessment team being trained on each station by the Principal Investigator. This was accompanied by the training manual and at a later date the assessment team were brought through a training session for the field testing aspect of the research.

5.4.3. Location Set-up and Health & Safety

All testing was carried out in the basketball home court of the team being assessed, with the exception of international teams who were tested at their international team training venue at the time of testing. A first aid station was set up at each venue and emergency procedures and exits for participants were shown to the participants. All teams were to have their management team staff present throughout all aspects of their players' assessment. Players signed in on arrival and no one was allowed leave until they signed out, and if underage (any player under the age of 16 years), they were accompanied by an adult or an identified management team member. All players were advised to bring water/fluids for hydration during the tests and bottled water was provided for those who did not bring water. The screening sessions were video recorded. The video camera was connected directly to the software programme and each player's file was encrypted and could not be accessed without passwords which were only available to the administrator (in this case the Principal Investigator). The risk assessments associated with the procedures were extremely small, as all tests were non-invasive.

All testing occurred indoors, in a safe environment and was monitored by a qualified team of assessors. The Principle Investigator, who is also a physiotherapist, would provide an immediate assessment and treatment for any musculoskeletal injury which may occur during the assessment phase of the study. The project had ethical approval from the University of Glasgow Ethics Committee. The results of the team pre-season assessment will be discussed in Chapter 6. The aim was to have the prototype software piloted in February 2013 and ready for the 2013-2014 basketball season.

5.4.4. UKIBIPS Test Station Layout

All team assessments were carried out in the open court of the team's sports hall. All underage players were accompanied by the coaching staff and a child welfare officer from their club. A member of the coaching staff sat at each of the stations and was there to observe and safeguard the players during assessment. The length of assessment for an individual team took between 1.5 - 2 hours, while testing of international teams was carried out over a full day due to the extra squad members being tested. The assessment test station set up can be seen in Figure 5-28.

Figure 5-28: UKIBIPS – Test Station Layout

To maintain the focus of the players during the testing, results and scores were not discussed with the players. This helped with the efficiency of the testing and reduced unnecessary competition developing between players trying to beat each other's scores.

5.4.5. Statistical Analysis

The aim of a Cluster Analysis is to group variables into homogeneous clusters i.e. groups of variables which are strongly related to each other and thus bring the same information. These approaches can then be useful for dimension reduction and variable selection. Once the variables are grouped into clusters such that attributes in each group reflect the same aspect, the practitioner may select one variable from each cluster knowing that the other variables are carrying the same information.

A simple and frequently used approach for clustering a set of variables is to calculate the dissimilarities between these variables and to apply a classical cluster analysis method to the dissimilarity matrix. For continuous variables many dissimilarity measures can be used (e.g. the Pearson or Spearman correlation coefficient) while measures of association such as χ^2, Rand, Belson, Jaccard, Sokal and Jordan are popular for categorical variables.

The ClustOfVar R package for cluster analysis accommodates a mixture of quantitative and qualitative variables as required. The aggregation criterion is the decrease in homogeneity for the clusters being merged (Chavent *et al.*, 2012).

In this example there were 25 variables, one of which was continuous (i.e. Bleep Test). A set of 5 clusters was identified and are presented in the results section.

5.5. Results

Testing took place at venues in Ireland, Scotland and Wales. Players from eight nationalities took part in the team assessment across leagues in 4 countries. A total of 110 players (m66/f44) were tested in 2013-2014 pre-season. A total of 75 international players (m40/f35) participated. The average age of male players tested was 17.35 ±6.05 years and ranged from 11.82 - 40.95 years, while in the female group the average age was 18.08 ±3.83 years and ranged from 14.8 - 31.3 years. The average male height recorded was 178.07 ±13.20 cms and ranged from 142 cms - 203 cms, while in the female group the average height was 175.52 ±6.93 cms and ranged from 163 cms - 188 cms. The average male participant's weight was 67.81 ±16.59 kgs with a range of 38 kgs - 105 kgs and in the female the average weight was 66.11 ±8.28 kgs with a range 50 kgs - 80 kgs. See Table 5-8 for Demographic breakdown.

Table 5-8: Demographic of Players for Pre-Participation Testing before the 2013 – 2014 Season

Total Players Field Tested		Male			Female	
N=110		n 66 (60%)			44 (40%)	
Age yrs	Mean	StDev	Range	Mean	StDev	Range
	17.35	±6.05	11.82 – 40.95	18.80	±3.83	14.8 – 31.3
Height cm	Mean	StDev	Range	Mean	StDev	Range
	178.07	±13.20	142 – 203	175.52	±6.93	163 - 188
Weight Kg	Mean	StDev	Range	Mean	StDev	Range
	67.81	±16.59	38 – 105	66.11	±8.28	50 – 80
Country of origin						
England		6			1	
Ireland		15			34	
Lithuania		2				
Poland					1	
United Kingdom		2				
United States of America		1			2	
Scotland					5	
Wales		40			1	
Country competing in at present						
England		4				
Ireland		17			39	
Scotland					5	
Wales		45				
International Player						
N=75		40			35	

5.5.1. Single Leg Balance Test Results

As previously stated in Chapter 2, the Single Leg Balance Test (SLBT) has been identified as a reliable test for predicting ankle sprains in athletes (Trojian and McKeag, 2006). A positive test indicated that the player was unable to hold their balance on one leg for 10 seconds with their eyes closed. 100% of all male players (m66) tested positive for right sided SLBT therefore all failing the test. 86.36% of all female players (f38) failed the test. Female players had a higher percentage of positive left SLBT 63.63% (f28) over their male counterparts with 53.03% (m35) testing positive. Male players had a higher rate of bilateral positive tests with 53.03% (m35) over female players with 31.81% (f14).

All male age groups had 100% positive right side SLBT while the highest female age group with right sided positive tests were the U20 group with 100% (f2) followed by senior players 92.85% (f13). Regarding left sided positive tests, the Senior men's group had the highest number at 100% (m9), while 78.57% of Senior women (f11) had the highest positive rate of left sided SLBT. The male group with the highest bilateral positive test was the Senior group with 100% (m9), while in the female group the U16 players had the highest positive bilateral test with 75% (f9). Overall, the Senior male and female groups had the highest number of positive tests results in all three categories, 100% (m9) and right 92.85% (f13), left 78.57% (f11) and bilateral 71.42% (f10) which made them the highest risk groups to potentially suffer an ankle injury. See Table 5-9 for the full results.

Table 5-9: Player Pre-season Single Leg Balance Test Results

Total Players n=183	Male n=105	Female n=78
Tested players n=110	Male n=66	Female n=44
Non- tested Players n=73	Male n=39	Female n=34
Single leg Balance Test	**n=66**	**n=44**
Right Positive	66 (100%)	38 (86.36%)
Left positive	35 (53.03%)	28 (63.63%)
Left and Right Positive	35 (53.03%)	14 (31.81%)
U14 players	**n=15 (22.72%)**	**n=0 (0%)**
Right Positive	15 (100%)	0 (0%)
Left positive	4 (26.66%)	0 (0%)
Left and Right Positive	4 (26.66%)	0 (0%)
U16 players	**n=23 (34.84%)**	**n=12 (27.27%)**
Right Positive	23 (100%)	10 (83.33%)
Left positive	9 (39.13%)	9 (75%)
Left and Right Positive	9 (39.13%)	9 (75%)
U18 players	**n=18 (27.27%)**	**n=16 (36.36%)**
Right Positive	18 (100%)	13 (81.25%)
Left positive	13 (72.22%)	7 (43.75%)
Left and Right Positive	13 (72.22%)	7 (43.75%)
U20 players	**n=1 (1.51%)**	**n=2 (4.54%)**
Right Positive	1 (100%)	2 (100%)
Left positive	0 (0%)	1 (50%)
Left and Right Positive	0 (0%)	1 (50%)
Senior	**n=9 (13.63%)**	**n=14 (31.81%)**
Right Positive	9 (100%)	13 (92.85%)
Left positive	9 (100%)	11 (78.57%)
Left and Right Positive	9(100%)	10 (71.42%)

5.5.2. Ankle Dorsiflexion Test Results

Restricted ankle dorsiflexion (moving foot towards the head) has been identified as a risk factor in previous research studies (Backman and Danielson, 2011). Players were tested in both left and right ankles. In male players 92.42% (m61) tested positive for a restricted right ankle dorsiflexion while 84.09% (f37) of females tested positive. 90.90% (m60) of male players tested positive for left ankle dorsiflexion restriction while 63.63% (f28) of female players tested positive. In male players, 87.87% (m58) had bilateral ankle restriction while 31.81% (f14) of female players had bilateral ankle restriction.

Male U20 and Senior players had the highest level of positive tests for restriction at 100% in left, right and bilateral ankle tests, which made them the highest risk group for potentially suffering an injury to the lower extremity. In the female group, the U20 players had the highest level of positive tests at 100% (f2) placing them in the highest injury risk group. See Table 5-10 for full results.

Table 5-10: Player Pre-Season Ankle Dorsiflexion Test Results

Total Players n=183	**Male n=105**	**Female n=78**
Tested players n=110	**Male n=66**	**Female n=44**
Non- tested Players n=73	**Male n=39**	**Female n=34**
Ankle Dorsiflexion Test	**n=66**	**n=44**
Right Positive	61 (92.42%)	37 (84.09%)
Left positive	60 (90.90%)	28 (63.63%)
Left and Right Positive	58 (87.87%)	14 (31.81%)
U14	**n=15 (22.72%)**	**n=0**
Ankle Dorsiflexion Test		
Right Positive	14 (93.33%)	0 (0%)
Left positive	13 (86.66%)	0 (0%)
Left and Right Positive	13 (86.66%)	0 (0%)
U16	**n=23 (34.84%)**	**n=12 (27.27%)**
Ankle Dorsiflexion Test		
Right Positive	22 (95.65%)	12 (100%)
Left positive	21 (91.30%)	11 (91.66%)
Left and Right Positive	20 (86.95%)	11 (91.66%)
U18	**n=18 (27.27%)**	**n=16 (36.36%)**
Ankle Dorsiflexion Test		
Right Positive	15 (83.33%)	12 (75%)
Left positive	16 (88.88%)	13 (81.25%)
Left and Right Positive	15 (83.33%)	12 (75%)
U20	**n=1 (1.51%)**	**n=2 (4.54%)**
Ankle Dorsiflexion Test		
Right Positive	1 (100%)	2 (100%)
Left positive	1(100%)	2 (100%)
Left and Right Positive	1(100%)	2 (100%)
Senior	**n=9 (13.63%)**	**n=14 (31.81%)**
Ankle Dorsiflexion Test		
Right Positive	9(100%)	11 (78.57%)
Left positive	9(100%)	11 (78.57%)
Left and Right Positive	9(100%)	11 (78.57%)

5.5.3. Bleep Test Results

The Bleep Test has been used universally as a fitness test. Fitness has been identified as an injury risk predictor in basketball. After testing, the mean Vo2 Max (ml/kg/min) rate in male players was recorded as 43.60 ±4.78 and ranges between 57.20 – 34.70, while the female Vo2 Max rate had a mean of 39.8 ±4.65 and ranges between 50.3 – 29.9. See Table 5-11 for Pre-Season Bleep Test Results.

Bleep Test results can be categorised into 7 different levels – Very Poor, Poor, Fair, Average, Good, Very Good and Excellent. In male players the following results were recorded – Fair (12), Average (18), Good (23) and Very Good (13), while in the female group results were recorded as Poor (2), Fair (10), Average (15), Good (11), Very good (5) and Excellent (1).

The lowest fitness score category in male players was Fair U16 (2), U18 (8) and Senior (2), while the U18 female group had the lowest score category with Poor (2). The best fitness score for male players was Very Good in all male categories U14 (2), U16 (5), U18 (3), U20 (1) and Senior (2), while the highest level scored by a female player was Excellent in the U16 category achieved by one player. The category with the largest number for male and female players was Good with 34 (m23/f11). The U18 male and female groups each had the lowest below average scores with Fair (m8/f6) and Poor (f2). See Table 5-11 and Table 5-12 for full results.

Table 5-11: Player Pre-Season Bleep Test Results

N (110)	Men (n=66)			Women (n=44)		
Bleep Test Total (n66)	**Mean**	**StDev**	**Range**	**Mean**	**StDev**	**Range**
VO2 Max (ml/kg/min)	43.60	4.78	57.20 - 34.70 (22.50)	39.8	4.65	50.3 – 29.9 (20.4)
Bleep Test U14	**(n=15)**			**(n=0)**		
	Mean	**StDev**	**Range**	**Mean**	**StDev**	**Range**
VO2 Max (ml/kg/min)	40.10	2.08	43.3 – 36.4 (6.9)			
Bleep Test U16	**(n=23)**			**(n=12)**		
	Mean	**StDev**	**Range**	**Mean**	**StDev**	**Range**
VO2 Max (ml/kg/min)	43.3	3.66	53.7 – 36.4 (17.3)	41.2	5.43	50.3 – 32.2 (18.1)
Bleep Test U18	**(n=18)**			**(n=16)**		
	Mean	**StDev**	**Range**	**Mean**	**StDev**	**Range**
VO2 Max (ml/kg/min)	43.8	5.62	53.7 – 36.4 (17.3)	37.7	4.69	46.8 – 29.9 (16.9)
Bleep Test U20	**(n=1)**			**(n=2)**		
	Mean	**StDev**	**Range**	**Mean**	**StDev**	**Range**
VO2 Max (ml/kg/min)	57.2	0	57.3 – 57.2 (0)	39.5	0	39.5 – 39.5 (0)
Bleep Test Senior	**(n=9)**			**(n14)**		
	Mean	**StDev**	**Range**	**Mean**	**StDev**	**Range**
VO2 Max (ml/kg/min)	43.8	5.52	51.4 – 34.7 (16.7)	41.1	3.51	46.2 – 34 (12.2)

Table 5-12: Bleep Test Score Categories

Total tested 110 (m66/f44)

Bleep Test Results		Very Poor	Poor	Fair	Average	Good	Very Good	Excellent
Under 14 Tested	(n=15)				(5)	(8)	(2)	
Male Players	(n=15)				5	8	2	
Female Players	(n=0)				0	0	0	
Under 16 tested	(n=35)			(4)	(8)	(13)	(9)	(1)
Male Players	(n=23)			2	6	10	5	0
Female Players	(n=12)			2	2	3	4	1
Under 18 tested	(n=34)		(2)	(14)	(9)	(5)	(4)	
Male Players	(n=18)		0	8	4	3	3	
Female Players	(n=16)		2	6	5	2	1	
Under 20 tested	(n=3)				(2)		(1)	
Male Players	(n=1)				0		1	
Female Players	(n=2)				2		0	
Senior tested	(n=23)			(4)	(9)	(8)	(2)	
Male Players	(n=9)			2	3	2	2	
Female Players	(n=14)			2	6	6	0	
Sum			**(2)**	**(22)**	**(33)**	**(34)**	**(18)**	**(1)**

5.5.4. Functional Movement Screening Test (FMS) Results

The FMS test has been used to identify functional movement patterns in athletes. The results have been used to help identify athletes who may be at risk of injury due to dysfunctional movement patterns. The system also allows the trainer or therapist to develop exercises for the individual to improve movement and therefore reduce injuries through prevention. Prior to this study, to the Principal Investigator's knowledge, there has been no FMS screening in an Irish or UK basketball research study.

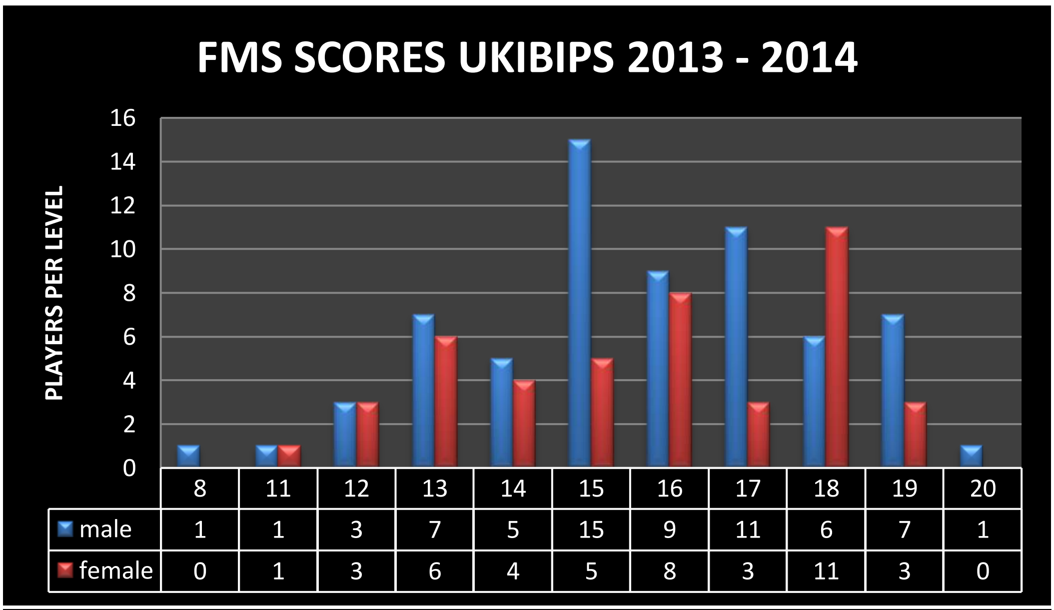
During the 2013-2014 pre-season team testing, the FMS results for the male group was a mean score of 15.65 ±2.29 and range from 8-20, while the female group had a mean score recorded as 15.68 ±2.24 and ranged from 11-19. See Table 5-13 for full details.

Table 5-13: FMS Scores Male & Female Players by Age

	Male Players			Female			Male and Female		
Total Players n=183	105			78			183		
Total Players Tested n=110	66			44			110		
Cumulative FMS Score	n=66			n=44			n=110		
	Mean	**SD**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**
	15.56	2.29	20 – 8	15.68	2.24	19 – 11	15.66	2.26	20 – 8
U14 players FMS Score	n=15			n=0			n=15		
	Mean	**SD**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**
	16.33	1.83	19 – 12	0	0	0	16.33	1.83	19 – 12
U16 Players FMS Score	n=23			n=12			**n=35**		
	Mean	**SD**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**
	15.52	2.10	19 – 11	5.66	2.10	19 – 13	15.57	2.07	19 – 11
U18 Players FMS Score	n=18			n=16			n=34		
	Mean	**SD**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**
	16.05	2.28	20 – 12	15.56	2.22	19 – 12	15.82	2.23	20 – 12
U20 Players FMS Score	n=1			n=2			n=3		
	Mean	**SD**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**
	19	0	0	16.5	2.12	18 – 15	17.33	2.08	19 – 15
Senior Players FMS Score	n=9			n=14			n=23		
	Mean	**SD**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**
	13.66	2.5	17 – 8	15.71	2.61	19 – 11	14.91	2.71	19 – 8

The cut-off point for injury prediction is 14 or less. Thirty one players, (m17/f14) (28.18%), scored 14 or less and therefore were placed in the injury risk category. 25.75% of all male players tested scored less than 14, with a higher percentage of females testing positive at (31.81%). See Table 5-14 for the full data. The relationship between positive tests and injury will be discussed in Chapter 6.

Table 5-14: FMS Score by Level and Gender



5.5.5. The Y-Balance Tests Results

The Y-Balance Test kit is used to test a person's risk of injury as well as demonstrate functional symmetry. When the results of the Y-Balance Test are entered into the Move2Perform software, we can establish the personalised injury risk and peer performance measure according to age, gender and sport/activity (Plisky *et al.*, 2006). In order to calculate the composite reach distance in the Y-Balance Test, the sum of the three reach direction values was divided by three times limb length, and then multiplied by 100. Greater than 4 cm right/left difference in anterior direction is indicative of 2.5 times more likely to be injured. The Y-Balance Test results for Anterior Right/Anterior Left, Medial Right/Medial Left and Posterior Right/Posterior Left reach scores are presented in Table 5-15.

The raw data was exported into the Move2Perform software and the player's results were divided into six levels – Substantial Deficit, Moderate Deficit, Slight Deficit, Below Standard, Pass and Optimal. After testing, 68.18% (m50/f25) of players were recorded with a Substantial Deficit, 30% (m16/f17) of players recorded a Moderate Deficit and 1.81% (f2) recorded a Slight Deficit. See Table 5-16 for full details. Of the 110 players tested, no player passed this test indicating that all players had an increased potential of suffering a lower extremity injury.

Table 5-15: Y-Balance Test Results UKIBIPS 2013 – 2014 * all measurements in cm

Total Players 183	Male 105			Female 78														
Players Tested 110	Male 66			Female 44														
	Anterior Right			Anterior Left			Medial Right			Medial Left			Posterior Right			Posterior Left		
	Mean	StDev	Range	Mean	StDev	Range	Mean	StDev	Range	Mean	StDev	Range	Mean	StDev	Range	Mean	StDev	Range
Male Players (66)	63.6	10.4	84 - 26	65.1	9.0	87 - 42	88.8	19.3	118 - 46	90.9	17.4	121 - 52	90.3	16.4	124 - 60	92.8	14.2	118 - 33
Female Players (44)	68.6	6.6	81 - 44	67.1	7.7	91 – 46	98.0	15.0	117 – 60	96.4	15.6	119 - 53	95.0	16.0	125 - 63	90.7	18.1	110 - 40
U14 Male Players	58.8	12.0	68-26	64.1	6.5	74 -46	81.6	15.6	103 - 52	82.06	17.6	106 - 52	87.0	15	104 - 60	86.0	10.7	101 - 67
U14 Female players	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
U16 Male Players	65.7	9.5	84 - 41	65.5	10.0	84 - 42	89.8	17.98	118 - 50	91.0	16.5	117 - 53	86.3	17.3	115 - 60	93.1	16.3	118 – 33
U16 Female players	69.91	9.8	81 - 44	69.5	7.8	91 - 61	99.5	16.1	117 - 71	98.7	15.8	119 - 69	96.5	20.0	125 - 66	92	20.2	108 – 40
U18 Male Players	65.2	10.6	81 - 46	68.2	9.7	87 - 49	94.7	24.0	116 - 46	97.8	18.6	121 - 52	96. 2	15.8	124 - 64	94.3	14.5	112 – 71
U18 Female players	67.9	5.3	76 - 57	67.0	7.4	76 - 46	94.8	17.4	114 - 60	92.5	16.5	114 - 66	93.2	17.5	113 - 63	87.9	18.9	108 – 40
U20 Male Players	46	0	0	66	0	0	94	0	0	92	0	0	103	0	0	91	0	0
U20 female players	69.5	3.5	72 - 67	58	8.4	64 - 52	92.5	13.4	102 - 83	104.5	6.3	109 - 100	95	4.2	98 - 92	79.5	27.5	99 – 60
Senior Male players	65.3	5.6	73 - 54	64	7.8	78 -51	86	17	108 - 65	91.6	13.5	113 - 68	92.7	16.1	113 - 65	100.8	9.8	110 – 81
Senior Female players	98.2	5.3	77 - 58	66.5	7.6	75 - 48	102.2	11.2	115 - 72	97.7	15.5	112 - 53	95.8	11.9	112 - 70	94.6	14.7	110 - 60

Table 5-16: Y-Balance 2013-2014 Pre-Season Test Result Categories Achieved By Player Groups

Tested Players N (110)			Total Males Tested (N=66)		Total Females (N=44)		
Untested players			Total Male untested (n=39)		Total Female untested (n=34)		
Level achieved		**Substantial Deficit**	**Moderate Deficit**	**Slight Deficit**	**Below Standard**	**Pass**	**Optimal**
Total Tested		75	33	2		0	
Males Tested	**(66)**	50	16			0	
Females Tested	**(44)**	25	17	2			
U14 Males	**(15)**	13	2				
U14 Females	**(0)**						
U16 Males	**(23)**	19	4				
U16 Females	**(12)**	6	6				
U18 Males	**(18)**	9	9				
U18 Females	**(14)**	11	3				
U20 Males	**(1)**		1				
U20 Females	**(2)**	1	1				
Senior Males	**(9)**	9					
Senior Females	**(16)**	8	8				
SUM		**(75)**	**(33)**	**(2)**	**(0)**	**(0)**	**(0)**

5.5.6. Muscle Hypertonicity Test Results

A total of 11 muscle hypertonicity tests were used in the assessment. Muscles have a normal resting length but if they are hypertonic, then it can affect the movement of a joint making the player susceptible to suffering muscle strain or a more severe joint injury. A positive muscle hypertonicity test indicates that the target muscle is tighter than it should be.

In the male group, the upper fibres of the hamstring muscle group had the highest positive test rate 84.84% (m56), while in the female group the quadriceps muscle had the highest positive test rate of 90% (f40). In the male group the piriformis muscle had the least positive tests 36.36% (m24) of all muscle groups, while in the female group the soleus and piriformis muscle had the least positive tests with 18.18% (f8) equally.

In the male group the highest bilateral positive testing muscle group was the upper fibres of the hamstrings at 81.81% (m54), while in the female group the tensor fascia latae muscle group had the highest bilateral positive test with 68.18% (f30). See Table 5-17 for the full results. The relationship between muscle hypertonicity and injury will be discussed later in Chapter 6.

Table 5-17: Player Pre-Season Muscle Hypertonicity Test Results

Tested Players N (110)	Male (N=66)	Female (N=44)
Muscle Testing Positive for Hypertonisity	**Male Positive**	**Female Positive**
Psoas Right	33 (50%)	23 (52.27%)
Psoas Let	38 (57.57%)	20 (45.45%)
Psoas Left and Right	33 (50%)	19 (43.18%)
Rectus Femoris Right	55 (83.33%)	33 (75%)
Rectus Femoris Left	55 (83.33%)	32 (72.72%)
Rectus Femoris Right and Left	53 (80.30%)	29 (65.90%)
Quadriceps Right	39 (59.09%)	40 (90%)
Quadriceps Left	39 (59.09%)	16 (36.36%)
Quadriceps Left and Right	38 (57.57%)	14 (31.81%)
Adductors Right	43 (65.15%)	11 (25%)
Adductors Left	45 (68.18%)	27 (27%)
Adductors Left and Right	42 (63.63%)	11 (25%)
Upper Hamstrings Fibers Right	56 (84.84%)	23 (52.27%)
Upper Hamstrings Fibers Left	56 (84.84%)	19 (43.18%)
Upper Hamstrings Fibers Left and Right	54 (81.81%)	17 (38.63%)
Lower Hamstrings Fibers Right	37 (56.06%)	15 (34.09%)
Lower Hamstrings Fibers Left	37 (56.06%)	12 (27.27%)
Lower Hamstrings Fibers Right and Left	35 (53.03%)	10 (22.72%)
Medial Hamstrings Right	45 (68.18%)	13 (29.54%)
Medial Hamstrings Fibers Left	47 (71.21%)	13 (29.54%)
Medial Hamstrings Fibers Right and left	43 (65.15%)	10 (22.72%)
TFL Right	44 (66.66%)	36 (81%)
TFL Left	41 (62.12%)	31 (70.45%)
TFL Left and Right	40 (60.60%)	30 (68.18%)
Gastrocnemius Right	49 (74.34%)	17 (38.63%)
Gastrocnemius Left	49 (74.34%)	15 (34.09%)
Gastrocnemius Left and Right	49 (74.34%)	14 (31.81%)
Soleus Right	46 (69.68%)	8 (18.18%)
Soleus Left	45 (68.18%)	7 (15.90%)
Soleus Left and Right	44 (66.16%)	6 (13.63%)
Piriformis Right	33 (50%)	12 (27.27%)
Piriformis left	28 (42.42%)	11 (25%)
Piriformis left and Right	24 (36.36%)	8 (18.18%)

5.5.7. Orthopaedic Clinical Tests

5.5.7.1. Leg Length Discrepancy Test Results

Leg Length Discrepancy (LLD), or anisomelia, is defined as a condition in which the paired lower extremity limbs have a noticeably unequal length (Khamis and Carmeli, 2017). There are two types of LLD – functional or structural (anatomical). Structural LLD is a physical (osseous) shortening of one lower limb between the trochanter femoral major and the ankle mortise. Functional LLD is a unilateral asymmetry of the lower extremity without any shortening of the osseous components of the lower limb. Some of the musculoskeletal disorders associated with LLD are lower back pain, osteoarthritis, stress fractures and myofascial pain syndrome. Clinical tests for leg length discrepancy such as radiography or other imaging techniques should be used when accuracy is critical in diagnosis. The average of two measures between the ASIS and the medial malleolus appears to have acceptable validity and reliability when used as a screening tool (Gurney, 2002). For the assessment, a positive LLD test was recorded regardless of whether it was structural or functional in nature.

In the male group, 13.63% (m9) had a right LLD and 16.66% (m11) had a left LLD. In the female group, 24.45% (f9) had a right LLD and 9.0.9% (f4) had a left LLD. In the male group, the highest positive right LLD was in the U16 men's and U20/Senior groups with 7.57% (m5) and the highest positive left LLD occurred in the Senior men's group with 7.57% (m5). In the female group, the highest right LLD positive test was in the Senior groups with 11.36% (f5) in each group equally, and the highest left LLD was in the U16 female group 4.54% (f2). See Table 5-18. The U16 and Senior male and female groups had the greatest potential for injury.

Table 5-18: Player Pre-Season Apparent Leg Length Discrepancy (ALLD) Test

Total Players 183	Male (105)	Female (78)
Total Players Tested n=110	**Male (N=66)**	**Women (N=44)**
Apparent Leg length discrepancy (ALLD) Test		
Right Positive	9 (13.63%)	9 (20.45%)
Left positive	11 (16.66%)	4 (9.09%)
U14 (ALLD) (m15/f00		
Right Positive	0 (0%)	0 (0%)
Left positive	2 (3.03%)	0 (0%)
U16 (ALLD) (m23/f12)		
Right Positive	1 (1.51%)	4 (9.09%)
Left positive	5 (7.57%)	2 (4.54%)
U18 (ALLD) (m18/f16)		
Right Positive	3 (4.54%)	0 (0%)
Left positive	3 (4.54%)	1 (2.27%)
U20/Senior (ALLD)		
Right Positive	5 (7.57%)	5 (11.36%)
Left positive	1 (1.51%)	1 (2.27%)

5.5.7.2. Trendelenburg Test Results

The Trendelenburg Test is an orthopaedic test which helps the clinician or physiotherapist, identify weakness in the gluteus medius muscle. Weakness in the glutes can cause hamstring strain, hip flexor strain, back issues and misalignment of the knee joint. Positive Trendelenburg Test results for male players were recorded as follows: right side 45.45% (m30), left side 53.03% (m35) and bilateral at 31.81% (m21). In the female players Trendelenburg Test, positive results were recorded as right side 45.45% (f20), left 36.36% (f16) and bilateral at 29.54% (f13).

Male U16 players had the highest percentage of positive tests by age group: right 18.8% (n=12), left 19.69% (13) and bilateral 12.12% (n=8) identifying them as the group with the highest potential risk of injury. In the female group, the U20/Senior group returned the highest percentage of positive test with right at 20.45% (n=9), left at 20.45% (n=9) and bilateral at 15.90% (n=7) making them the female group with the highest potential risk of injury. The U20/Senior male group had the lowest positive test results of all groups with right of 3.03% (n=2), left of 4.54% (n=3) and bilateral of 3.03% (n=2). See Table 5-19 for Trendelenburg Test results.

Table 5-19: Trendelenburg Test Results Pre-Season 2013 – 2014

N (110)	Men (N=66)	Women (N=44)
Total Trendelenburg Test positive		
Right Positive	30 (45.45%)	20 (45.45%)
Left positive	35 (53.03%)	16 (36.36%)
Left and Right Positive	21 (31.81%)	13 (29.54%)
U14 Players (m15/f0)		
Right Positive	10 (15.15%)	0(%)
Left Positive	11(16.66%)	0(%)
Left and Right Positive	8 (12.12%)	0(%)
U16 Players (m23/f12)		
Right Positive	12(18.18%)	4 (9.09%)
Left Positive	13(19.69%)	4 (9.09%)
Left and Right Positive	8 (12.12%)	3 (6.81%)
U18 Players (m18/f16)		
Right Positive	6 (9.09%)	7 (15.90%)
Left Positive	8 (12.12%)	3 (6.81%)
Left and Right Positive	3 (4.54%)	3 (6.81%)
U20 / Senior (m10/f16)		
Right Positive	2 (3.03%)	9 (20.45%)
Left positive	3 (4.54%)	9 (20.45%)
Left and Right Positive	2 (3.03%)	7 (15.90%)

5.5.8. Cluster Analysis

One hundred and ten players were examined in the pre-season field testing part of the UKIBIPS study. As previously stated, key modifiable intrinsic personal level risk factors include fitness levels, propreoception & balance, strength, flexibility, bio mechanics & joint stability. A cluster analysis of the selected tests was carried out. The resulting dendogram is shown in Figure 5-29. The cluster analysis performed suggests that there were five clusters consisting of a variety of subgroups tests.

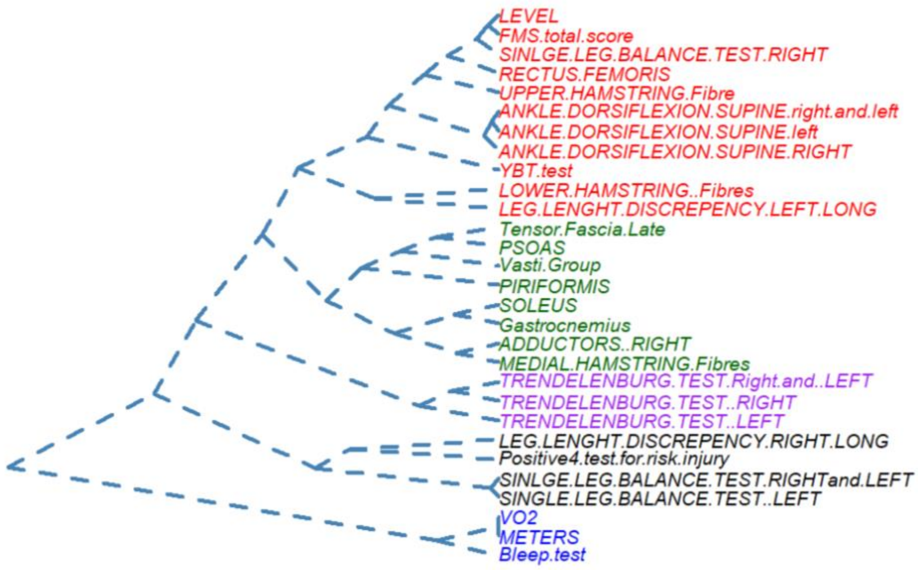


Figure 5-29: Pre-Participation Tests Cluster Dendogram

Cluster group 1 **(Red)** contained the following tests – Muscle Hypertonicity Tests, Single Leg Balance Test, FMS Test, Y-Balance Test, Leg Length Discrepancy Test and Ankle Dorsiflexion Tests (ADT). Four of these tests (FMS Test, Y-Balance Test, Single Leg Balance Test and the Leg Length Discrepancy Test) have elements which can identify or be used to confirm balance dysfunction within the athlete. The Hurdle Step (sub-test of the FMS), SLBT and Y-Balance Test will pick up balance or propreoceptive deficits in the athlete. The Leg Length Discrepancy Test may be used as a test to see if a pelvic dysfunction is contributing to an inability to perform a test. The Inline Lunge Test (FMS sub-test) tests the mobility and stability in the athlete's hip, knee, ankle and foot, and similarly the ADT also tests for mobility/restriction in the ankle. Functional movement dysfunctional patterns in an athlete may be caused by weakness or tightness in muscles or joint restriction. This cluster addresses three of the modifiable personal non-contact injury risk variables: 1) balance and propreoception, 2) flexibility and 3) biomechanics and joint stability.

The second cluster group **(Green)** contains subtests from the Muscle Hypertonicity Tests. Muscle hypertonicity may affect the athlete's flexibility which in turn can affect movement patterns and cause fatigue in players. The Muscle Hypertonicity Tests are used in clinical examination to identify or confirm the findings of other tests during an examination. While these tests are very specific in what they are testing, they may also be used to provide a more detailed reason as to why a player shows a deficit score in the FMS test. This cluster addresses the modifiable personal non-contact injury risk variable of flexibility.

The third cluster group **(Purple)** contains one test – the Trendelenburg Test. This is used to test gluteus medius muscle strength. A weak gluteus medius can contribute to pelvic imbalance which may be a factor in a failed Single Leg Balance Test (Red cluster). An inability to perform the Hurdle Step (FMS) may be as a result of instability in the core and/or pelvis region. The gluteus medius role is to stabilise the pelvis. A contributing factor to a failed SLBT may also be as a result of weakness in the gluteus medius muscle (not supporting the weight bearing hip during the test). The Trendelenburg Test may be used as a more specific regional test to identify or analyse the findings of a deficit observed either through the SLBT and FMS Hurdle Test. This cluster addresses the modifiable personal non-contact injury risk variable of strength.

The fourth cluster group **(Black)** contains two tests – Leg Length Discrepancy Test and the Single Leg Balance Test. The Leg Length Discrepancy Test is a standalone test for a difference in anatomical leg length; it contributes to imbalance in load and compensatory movement. A leg length discrepancy may also contribute to balance/propreoception deficits and therefore contribute to a failed Single Leg Balance Test. This cluster addresses two of the modifiable personal non-contact injury risk variables: 1) balance and propreoception and 2) biomechanics and joint stability.

The fifth cluster group **(Blue)** consists solely of the Bleep Test which is an aerobic test for fitness. The test has little relationship with the tests in the other clusters as it is the only test for cardio-respiratory fitness and as a modifiable non-contact risk factor, this test should be included in any programme of testing.

5.6. Discussion

In the absence of data on pre-participation examination (PPE) in basketball in the UK and Ireland, the UKIBIPS was best placed to carry out this research running parallel to the injury surveillance aspect of the study observed during the 2013-2014 season. The low number of players in this study has already been highlighted. While the potential reasons for this has been discussed in depth in the Chapters 3 and 4, it is important to stress again that in other countries such as the United States, participation in injury surveillance and PPE studies is compulsory unlike in Ireland and the UK. This needs to be addressed and all stakeholders, especially the governing bodies, need to insist that teams include participation in research studies such as the UKIBIPS as part of their duty of care in line with recommendations made by FIBA (Luig *et al*., 2010).

A total of 110 players (m66 /f44) were assessed during the PPE phase of the study. Players who agreed to participate came from teams participating in Ireland, Scotland and Wales. While some of the players participated in teams competing in the English leagues, they were tested while they were on duty training with their countries.

There is an abundance of tests available to the assessor carrying out pre-participation assessment in sport. Similarly, there is a substantial library of tests available to the clinical practitioner when assessing patients with musculoskeletal and neuromuscular conditions. One of the aims set out in the beginning of this study was to select PPE tests to help identify players who may be at risk of injury due to the intrinsic, non-contact, personal, modifiable factors already presented. Having identified that the majority of injuries to basketball players occur in the lower extremity, the tests selected all dealt with the lower extremity in their assessment and measurement, with the exclusion of the Bleep Test. It was selected as fitness is a personal modifiable risk factor. It was hypothesised that existing sports specific tests may be complemented by clinical tests used within physiotherapy clinical practice.

Having considered the ranges of tests available, the equipment, recording and interpretation requirements for those tests and their suitability for the basketball environment, the following tests were selected as relevant, reliable and valid for this study.

The Bleep Test was selected because it is familiar to all players and measures the offensive and defensive transition requirements in the sport. The FMS, Y-Balance, Ankle Dorsiflexion, Muscle Hypertonicity, Trendelenburg, Leg Length Discrepancy, and Single Leg Balance were selected because of the following factors:

- The tests all provide a quantitative pass or fail result.
- They are easy to perform.
- They don’t require expensive or complex equipment.
- The equipment is easily transported and stored.

The tests selected provide a comprehensive testing programme covering the set of key intrinsic, personal, non-contact, modifiable risk factors of concern to this study. Having simple criteria for a pass or failed test allows for a non-clinical practitioner to perform the test and collect the data. A simple decision tree based on the pass or fail allows for the player to be referred for more robust testing and interpretation by the clinical or professional sports team staff.

The non-inclusion of certain tests may be perceived as a limitation of this research, however, the research aim was to identify tests that could be carried out by both the non-clinical and qualified personnel which it feels in this case was a more important selection criteria.

The FMS and Y-Balance Test provide categories of pass and fail results that are easily interpreted. The Move2perform software uses an injury prediction algorithm which analyses data collected on a player's performance. Lehr *et al.* stated that using efficient, low cost, field tested tests could identify individuals at elevated risks of non-contact lower extremity injury (Lehr *et al.*, 2013).

Data measurements for the FMS and Y-Balance Test can be easily collected and inputted into the Move2perform system by the non-clinical person. The system provides information on player deficits which can then be forwarded for clinical review or analysis by sports team professionals if necessary. The inclusion of the tests is further supported as they can identify those who may be at increased risk and, as such, help clubs with limited time and recourses to focus on the players who need it most.

The number of participants in the PPE section of the research study was disappointing, especially as there was no cost to any team and testing was carried out pre-season as to not interfere with team training. The important message of PPE team testing and its benefits in programmes to reduce injury in players is still off the radar for many players, teams, clubs and organisations as shown by their unwillingness to participate in this research. Strategies to increase participation in such studies need to be explored by the Principal Investigator, however it is equally important for governing bodies to ensure their members participate in research which will improve the health and well-being of their overall basketball community.

The testing phase of this study was carried out on players participating in national league and international basketball teams in the UK and Ireland. Testing was carried out during the 1.5 hours allocated per team and no injuries occurred during testing. While the time was allocated by each club or international team, it is agreed that this time would not always be attainable to a testing team during the regular season. For this reason team testing may need to be more streamlined to accommodate repeated testing throughout the season.

Examining how tests relate to each other was identified as another aim which could help to address time and cost burden associated with testing. For example, the Hurdle Test, as a sub-test of the FMS, challenges the stability of the core, pelvis, hips, knees and ankles simultaneously. Ankle stability is also targeted by the SLBT (propreoception) and the Y-Balance Test (function). The Trendelenburg Test measures the weakness of the gluteus medius muscle which can also contribute to a failed balance/propreoception test. Therefore, it may be possible to screen for balance deficits using a single test, namely, the Hurdle Test. In the context of PPE for a team of 20 players, only those that fail the Hurdle Test would need to be further assessed to identify the specific balance deficits that are targeted by the other balance tests and their causes. At the start of the season during PPE, the full battery of tests could be run on all athletes to establish baseline values. However, during the season the same allocation of time would not be necessary for non-medical personnel to determine the status of the players for balance deficits at any point in time. The Hurdle Test could be incorporated into a warm up for a team. This significantly reduces the time burden for testing and may result in a greater acceptance by coaches and consequently increased access to the team for continual testing and monitoring during the season.

The cluster analysis carried out in relation to the tests utilised in this study has been very beneficial. It has provided analysis to show that there are crossovers between what the tests are observing and the information they are providing. Looking at how the tests are related or associated or seem to give similar information may be helpful in trying to identify do we need to do all the tests we carried out. The analysis may be helpful to identify for the practitioner if there were a subset of tests from the different groups that could be used if there were time limitations.

The FMS seven stage sub-test system can identify dysfunctional movement patterns which may be the result of a variety of elements such as balance, muscle tightness and joint restriction and as such may/could be used as a primary triage assessment test. The use of other tests may then be used to provide a more detailed assessment of the variables to support a differential diagnosis and in turn provide a corrective exercise or treatment programme to reduce injury risk in the athlete.

The Single Leg Balance (SLB) Test recorded 100% positive test in male players and 83.6% positive test in female players. The greater percentage of positive SLB tests in male and female UKIBIPS participants may be associated with players who are unfamiliar with pre-season screening tests and the lack of injury prevention programmes in basketball in Ireland or the UK compared to sports in America. The relationship between positive SLB test and injury will be discussed in Chapter 6.

The FMS composite test scores are similar in this study to that of the New Zealand study by Schneiders (Schneiders *et al.*, 2011). As stated previously in Chapter 2, the cut-off score indicating risk of injury in the FMS test is a score of ≤ 14. In Schneider's study, the average composite score for men was 15.8 ±1.8 composite score with a range of 12-20, compared to 15.6 ±2.0 composite score with a range of 11-20 in female players.

In the UKIBIPS study, the mean composite score for male players was 15.56 ±2.29 composite score with a range of 8-20, and 15.68 ±2.24 composite score with a range of 11-19 for female players. The average combined composite score of male and female players in the UKIBIPS study was 15.66 ±2.26 composite score with a range of 8-20, compared with the mean value of 15.7 ±1.9 composite score with a range of 11-20 in Schneiders study. The relationship between FMS test scores and injury will be discusses in Chapter 6.

In this study, the Move2Perform injury risk analysis software was used to analyse the Y-Balance data collected. The results were categorised under the following headings: Substantial Deficit, Moderate Deficit, Slight Deficit, Below Standard, Pass and Optimal. For comparison with other studies, the results were further categorised into high (Substantial Deficit and Moderate Deficit) and low (Slight Deficit, Below Standard and Pass) risk groups. In this study, 98.18% (n=108) of participants have tested in the high risk category and only 2% in the low risk group.

In a study by Lehr, they screened 183 athletes during NCAA pre-season screening. Using the high and low risk groups and non-contact lower extremity injuries, relative risk (RR), sensitivity, specificity and likelihood ratios was calculated. In their study, 34.42% (n=63) were identified as high risk for injury. The study reported 42 non-contact lower extremity injuries (m23/f19). Athletes who were categorised as moderate and substantial risk were 8.9 (95% CI 1.2 to 64.8) and 17.6 times (95% CI 2.5 to 123.6) respectively more likely to suffer an injury compared to those categorised as having a normal risk for lower extremity injury. They also conclude that athletes in the high risk category for injury were 3.4 times more likely to get injured (95% CI 2.0 to 6.0) (Lehr *et al.*, 2013). The Y-Balance Test recorded in this research with a 98% high risk result is still almost three times as high as Lehrs study for a similar population. The Y-Balance and the SLB Test have both looked at balance and postural sway deficits and both report very high positive test in players in this study.

An Ankle Dorsiflexion test of less than 36.5º is an injury risk factor for non-contact knee patellar tendonopathy according to Backman and Danielson (Backman and Danielson, 2011). Their study collected data on 90 elite basketball players who were tested for their ankle dorsiflexion range and observed over a year. 12% (n=16) of players who tested positive developed patellar tendonopathy. Their complimentary statistical analysis showed that players with less than 36.5º had a risk of 18.5% to 29% of developing a patellar tendonopathy, and that a history of ankle sprains may contribute to reduced ankle dorsiflexion. They concluded that if a cut-off point of 36.5º was applied to a group of similar athletes to those they studied, that 83% of athletes who would develop the patellar tendonopathy would have been in a high risk group.

The results in the UKIBIPS study identified that 92.42% of male players tested positive for a restricted right ankle dorsiflexion while 84.09% (f37) of females tested positive. 90.90% (m60) of male players tested positive for left ankle dorsiflexion restriction while 63.63% (f28) of female players tested positive. In male players, 87.87% (m58) had restricted bilateral ankle restriction while 31.81% (f14) of female players had bilateral ankle restriction. These positive test results may predispose a high number of players to develop a knee condition and possibly an ankle injury due to joint stiffness or calf muscle strain. In a study by Renström (Renström, 1994), he stated that multiple recurrent sprains are reported by 80% of varsity basketball players. The relationship between restricted ankle dorsiflexion and injury will be discussed later in Chapter 6.

Muscle tightness testing in males identified the upper hamstrings (84.84%) and rectus femoris (83.33%) as the muscles with the highest positive test results for tightness, while in the female group, the quadriceps (90%) and the tensor fasciae latae (81%) as the muscles with the highest positive test results for tightness.

In a study review by Gleim which looked at flexibility and its effects on sports injury performance, it concluded that basic scientific studies have verified the relationship of musculotendinous stiffness as a mechanism of muscle injury but that clinical studies have yielded conflicting findings about these relationships (Gleim and McHugh, 1997).

A study by Witvrouw (Witvrouw *et al.*, 2003) looked at muscle flexibility as a risk factor to developing injury in elite soccer players. They observed the quadriceps, hamstrings, calf muscles and adductor muscles (all included in the UKIBIPS) and stated that there was a significant correlation between players with decreased flexibility in the hamstring group (SLR less than 90º) and the occurrence of a hamstring muscle injury. They also stated that decreased flexibility of the quadriceps is a factor for developing a quadriceps injury (p 0.63). Overall, they identified a significant difference between the injured and uninjured players in quadriceps (P0.047) and hamstring (P0.02) muscle flexibility and therefore concluded that the injured group of players showed a significantly lower mean flexibility. Cumps reported that players who did not stretch before games were 2.6 times more likely to injure an ankle compared to those who did (OR2.62 95% CI 1.01 to 6.34) (Cumps, Verhagen and Meeusen, 2007).

A number of studies have tested for muscle tightness and associated injury. There are a high number of positive tests for tightness in the quadriceps, hamstrings and TFL recorded in this study. These muscles and their inflexibility have been shown to be associated with muscle injury in scientific research. The relationship between muscle hypertonicity and injury will be discussed later in Chapter 6.

Two orthopaedic tests were used in this assessment. Leg Length Discrepancy and Trendelenburg Tests were used in this study as they are common orthopaedic tests used in clinical settings when assessing back, hip and lower extremity pain or dysfunction. The Trendelenburg Test is used to check for weakness in the gluteus medius. Gluteus medius weakness can reduce athletic performance and precipitate a number of lower extremity injuries (Presswood *et al.*, 2008). Weakness in gluteus medius is linked to injuries in the lower extremity (Beckman and Buchanan, 1995; Fredericson *et al.*, 2000; Friel *et al.*, 2006). In this study, the results show that male and female players had similar percentages of positive Trendelenburg Tests. Trendelenburg Tests for male players were recorded as follows: right side positive 45.45% (m30), left side positive 53.03% (m35) and bilateral positive tests at 31.81% (m21). In the female players, they were recorded as right side positive 45.45% (f20), left side positive 36.36% (f16) and 29.54% (f13) with bilateral positive tests. As this test is a measure of weakness in the muscle these results need to be considered when looking at non-contact injuries in Chapter 6.

In this study, the Leg Length Discrepancy (LLD) Test was included as a simple test and was easy to perform. The number of positive tests was higher in the female group with

24.45% (f9) and 13.63% (m9). In 1991, a study by Shamburg looked at structural measures as predictors of injury in basketball players and reported that players who sustained lower extremity injury had a greater side to side difference in quadriceps (Q) angle with 2.71 (1.4)^{o} v 1.26 (1.1^{o}) in the injured and uninjured groups respectively. Greater LLD was also reported in the injured group of players however units of measurement were not provided by the author (Murphy, Connolly and Beynnon, 2003). He concludes that cutting in the direction opposite the limb with a leg length inequality will extenuate the valgus knee, foot pronation, tibial torsion and sacroiliac strain and thus be expected to cause knee and ankle injuries over foot injuries. Again this test, which is a frequently used test by physiotherapists and other health care professionals, has value if we can see any relationship between a positive LLD and non-contact injuries.

The test selected to assess players fitness was the Bleep Test. Normative values for Bleep Test scores have been discussed earlier. In the U14 male age group, the mean Bleep Test score was 8.04 ±0.60 shuttle level. A test level of between 7.6 and 8.8 is considered a good level of fitness for this age group (based on normative data calculation table by Topend Sports). The U16 male group had a mean score of 8.98 ±1.06 shuttle level which falls between Average and Good fitness level scores of Average 7.5 – 8.9 and Good 8.10 – 9.8. In the U18 male group, the mean achieved was 9.12 ±1.62 shuttle level which demonstrates a Good level of fitness compared with normative levels of 9.10 – 11.13 for this age group. In the 18-25 year old male group, the mean test score was 10.59 ±1.66 shuttle level, which shows a Good level of fitness when compared with normative levels of 10.2 – 11.5 for this age group. In the 26-35 age groups, the mean score was 8.34 ±2.61 shuttle level which is an Average level when compared with normative levels between 7.10 – 8.9 for this age group. In the remaining players between the ages of 36-45 years old the mean score reached was 9.22 ±1.73 shuttle level which is rated as a Very Good level of fitness compared with normative levels of 8.10 – 11.3 in players of the same age group. No player scored in the Poor level of fitness and the highest levels of fitness were recorded in older players aged between 36 and 45. The 26-35 year old male age group scored an Average level of fitness in this study, which for the competition level they play at may expose them to a greater chance of injury.

In the female U16 group, the mean level achieved was 8.38 ±1.57 shuttle level or Good when compared with normative data (7.6 – 8.7) for this age group. In the U18 female group, the mean score was 7.37 ±1.35 shuttle level, which was an Average score compared with the normative level (7.2 – 8.4) in this age group. In the 18-25 year old group, the mean score was 8.32 ±1.06 (Average) when compared with the normative score (7.3 – 8.6) of the same age. And in the final age group tested, the 25-36 year old female players achieved a score of 8.02 ±0.73 which was a Good rate of fitness when compared with normative levels of 7.8 – 9.4 in the same age group. As fitness has been identified as a risk factor for injury in basketball, the U18 female players along with the 18-25 year old female players average fitness levels must be considered a concern for players competing at an elite level. As previously stated, the level and tempo of the game has increased over time and consequently, the fitness levels required to play at an elite level have also increased. The results in the female group are similar to the results of elite female basketball players in the UK, who have also tested lower levels of fitness compared to basketball players tested in other countries (Berdejo-del-Fresno and Gonzalez Rave, 2013).

The tests selected for the pre-participation assessment phase of this study returned a high level of positive tests. The accuracy of these tests as injury predictors can only be seen when analysed in conjunction with the player injury data. It is possible that the parameters or cut-off points of some of these tests need to be adjusted to provide a more accurate picture of the performance of the players.

There were no injuries to any players during any of the pre-participation assessments. All members of the assessment team performed efficiently and provided important data for analysis in the research. All data collected was inputted into an Excel sheet and encrypted for security. The inclusion of the Move2Perform analysis algorithm was very beneficial and allowed for easy analysis of data collected from the FMS and Y-Balance Test. The results and relationship of the team pre-season assessment and data collected on risks will be discussed in Chapter 6.

Chapter 6 – Injury Prevalence and Risk Factors from 2013-2015 in Ireland and the UK

6.1. Introduction

Sports injury prevention is important for any athlete at any level. If injury can be prevented, this will potentially reduce time off work and the associated cost burden for the player. Basketball has the highest incidence of injury of all non-contact sports with a rate of 3-6 injuries per 1000 hours of play with a conservative estimated annual cost of €500 million per year in European basketball. This works out at approximately 720,000 injuries per competition year (Luig *et al.*, 2010).

Before injury prevention strategies can be effectively implemented, it is first necessary to fully understand the nature and scope of the problem. Injury prevention programmes are promoted constantly by different groups responsible for the training, coaching and medical care of the sporting individual. The basketball fraternity is no different to other sports in the promotion of this ideal. Sports injury prevention programmes are designed to decrease acute and overuse injuries which may be avoidable. General or sports-specific components included in programmes that have led to positive effects in reducing injury are uncertain (Mugele *et al.*, 2018). In the past, trainers may have incorporated elements of injury prevention or strength & conditioning programmes that they observed in other sports rather than designing one specifically for their training needs. Mugele *et al.*, in their review, stated that despite not knowing the benefits of using a sports-specific injury prevention programme, players and coaches prefer specialised rather than ad-hoc adaptation for their needs. They concluded that the effectiveness of specific sports injury prevention programmes was un-investigated to date (Mugele *et al.*, 2018).

Where much research has focused on rates and risk factors (Deitch *et al.*, 2006), (Hosea, Carey and Harrer, 2000), (Meeuwisse, Sellmer and Hagel, 2003) and (McKay *et al.*, 2001a), many conclude with the need for the establishment of injury prevention strategies. Only a small group of researchers, such as Eils (Eils *et al.*, 2010), offer specific injury prevention protocols. Eils used a multi-station propreoceptive exercise programme in an attempt to prevent injuries in basketball. In the study, 232 players participated and were randomly assigned into two groups, a control group and a training group. 21 injuries occurred to the control group whereas 7 injuries occurred in the training group. He concluded that the risk of injury was significantly reduced in the training group by approximately 65% backing up the hypothesis that appropriate training influences the rate of occurrence of injury.

There is a lack of research data on basketball injuries occurring in Ireland and the UK and how these might be prevented. Central to the United Kingdom and Ireland Basketball Injury Prevention Study – Injury Surveillance System (UKIBIPS-ISS) study was to gather data on injuries specifically occurring in basketball in this region. The questionnaire embedded in the online system was created to identify rates, risks and type of injuries occurring. Injury risk factors identified in other research studies include player position (Cumps, Verhagen and Meeusen, 2007), Kostopoulos, 2010) and (Leanderson, Nemeth and Eriksson, 1993); shoe type (McKay *et al.*, 2001a); previous injuries (Meeuwisse, Sellmer and Hagel, 2003), (McKay *et al.*, 2001a), (Agel *et al.*, 2007b), (Murphy, Connolly and Beynnon, 2003), (Kostopoulos, 2010) and (Cumps, Verhagen and Meeusen, 2007) and court location (Meeuwisse, Sellmer and Hagel, 2003) and (Kostopoulos, 2010). Basketball is considered a non-contact sport, but anyone who has played or seen the game being played will know that the game has become very physical (Starkey, 2000) and (Drakos *et al.*, 2010). In a study by Luig and Henke (Luig *et al.*, 2010), they reported that there are approximately 144,000 severe knee injuries which require surgery at an average direct medical cost of € 2,300 per knee injury. Between €100 – 200 million is spent per year in knee injury treatment costs. They concluded that the average cost per treatment of all other injuries was €700.

A Spanish study by Caparrós reported statistics for the 2007-2014 seasons. The mean number of practices for the team across each season was 286 practices and the mean number of games was 79. The average number of exposure hours was 4667 hours, with a mean game exposure of 247 hours across each season. The average training exposure hours was reported as 4420 hours. They reported a mean of 23 injuries across each season which was further broken down into training injuries (mean 13) and game (mean 10) injuries. The total injury incidence rate was calculated as 5 per 1000 hours of player exposure. In training, the mean incidence of injury was 5 per 1000 hours of player exposure and game mean incidence of injury at 40 per 1000 hours of game exposure (Caparrós *et al.*, 2016).

The UKIBIPS-ISS, described in detail in Chapters 3 and 4, recorded and stored data collected during the 2013-2014 and 2014-2015 seasons in UK and Irish basketball leagues. Pre-season testing of players was carried out in conjunction with the 2013-2014 season. Throughout this research, the importance of establishing the type and mechanism of injury occurring in basketball players has been to the forefront. This data collection is relevant in order to contribute towards the development of injury prevention programmes and strategies to reduce injury, cost burden of treatments and time off work from preventable injuries. Data collected from pre-season testing when viewed with data collected on injuries would provide important information for the development of strategies to reduce non-contact injuries in the sport. The knowledge gained on injuries and pre-season testing in the study may be of use to scientists, physiotherapists, trainers and coaches when incorporating specific exercises to reduce injury risk. The identification of suitable pre-season tests which may have highlighted players of increased risk of non-contact injury that could also be employed by the non-professional management team would also prove beneficial.

6.2. AIMS

This aims of this chapter are:

- Identify injuries observed in elite basketball players in Ireland and the UK over two seasons using the UKIBIPS-ISS.
- Describe the type, mechanism and risk factors for injuries occurring in the leagues.
- Identify potential relationships between tests used to test intrinsic modifiable personal injury risks in players and any injuries sustained during the season.
- Extract from the data analysed, what variables help identify athletes at a higher risk of injury.
- Demonstrate how the collected data may be used as part of a case study examining the variables that identify players at increased risk of non-contact ankle injuries.
- Demonstrate how statistical modelling and machine learning can be used to identify risk factors for players at increased risk of injury.

6.3. Methodology

The UKIBIP-ISS developed for the purpose of collecting data on this research study has been described previously in Chapters 3 and 4. The system was used to collect data prospectively over two competitive seasons (2013/14 and 2014/15). It recorded all injuries occurring in participating basketball players during this time. The system proved reliable and capable of collecting, storing and exporting data for analysis.

All players were provided detailed information on the injury surveillance study by their clubs and coaches. The project was approved and supported by the governing bodies of basketball in England, Ireland, Scotland and Wales respectively. All conditions were met as set out by the University of Glasgow Ethics Committee who gave approval for the study on 8 July 2013. After testing the system with a pilot group, the injury surveillance system was launched and went live in July 2013. At the time of initial registration, all players gave their consent to participate and were advised that their participation was voluntary and that a player could opt out of the research study at any time if they chose to do so.

Data collected on the UKIBIPS-ISS can be used to analyse both contact and non-contact injuries with a large variety of injury risk variables. The pre-participation tests results discussed in Chapter 5 will be considered as part of the reflection on the injuries that occurred and analysed to try and help identify athletes who may potentially be at an increased risk of injury.

Ankle injury is the most common injury to the lower extremity in basketball players and this has been well-documented in the literature. Pre-season testing data and in-season data collected on each player allowed the Principal Investigator to create a statistical model to establish if any relationship exists between the pre-season tests and ankle injuries. The purpose was to identify variables that could be used to identify athletes at an increased risk of non-contact ankle injury. Non-contact ankle injuries were chosen as they represented the highest proportion of non-contact injuries recorded thereby giving the most power in terms of the number of events available for all statistical analyses. The statistical approach proposed can be used for an injury type comparison. Non-contact injuries were considered as information available prior to a game may be informative in terms of player preparation and readiness to avoid such an injury.

The approach used was to first carry out an analysis of each variable separately to identify variables that may carry predictive power. Following this, a multivariable statistical model was fitted that can accommodate all relevant variables, adjust for multicollinearity accordingly and any hierarchical structures in the data such as clustering (e.g. playing position) and within correlation due to repeated measures at the athlete level.

All data collected were encrypted and stored securely. Data management and cleaning was done using Microsoft Excel, SPSS was used for preliminary statistical analyses and R was used for statistical modelling. For categorical variables, the Chi squared test of association (using a significance level of 0.05) was used if the underlying assumption relating to the expected values was deemed appropriate; otherwise Fishers Exact Test was used. For binary variables, comparisons of proportion based on the Normal approximation to the Binomial distribution were used as necessary. The two-sample t-test (not assuming equal variance) was used to compare continuous variables where the normality assumption was justified; otherwise the Mann-Whitney test for the comparison of medians was used.

Two multivariable models were used to identify potential risk factors for non-contact injury. As the response variable is binary (contact injury coded as yes or no) a logistic regression model is appropriate. The inclusion of explanatory variables for this model was guided by the results of the separate analysis of each variable against the response. Given the large number of potential explanatories a logistic ridge regression was also used to penalise the size of the regression coefficient for explanatory variables that demonstrated multicollinearity. A classification tree, using binary recursive partitioning, was also fitted to identify potential pathways in the data to injury occurrence.

6.4. Results

Graphical and numerical summaries are provided for all response variables of interest from the 270 players (161 males and 99 females) that participated in this study. Player demographics, combined over the two seasons, can be seen in Table 6-1.

Table 6-1: Demographics for 2013 – 2015 Basketball Seasons

	2013 - 2015					
Total Players	**M161**			**F99**		
Age	**Mean**	**StDev**	**Range**	**Mean**	**StDev**	**Range**
	19.77	±7.51	11.82 - 48	20.48	±5.19	12.97 – 42.95
U14	13.09	±0.62	11.82 – 13.96	12.97	±0	0
U16	15.04	±0.61	14 – 15.94	15.39	±0.31	14.80 – 15.77
U18	16.67	±0.52	16 – 17.60	17.03	±0.50	16 – 17.97
U20	18.35	±0.53	18 – 19.52	18.36	±0.54	18 – 19.69
Senior	30.62	±6.51	21.27 – 48	25.02	±4.64	20 – 42.95
Height (cm)	**Mean**	**StDev**	**Range**	**Mean**	**StDev**	**Range**
	182.85	±12.56	142 – 208	173.94	±8.21	140 - 191
U14	162.50	±10.61	142 – 183	140	±0	0
U16	178.71	±9.76	155 – 193	172.78	±7.63	163 – 188
U18	187.43	±8.53	173 – 208	174.66	±8.32	152 – 191
U20	184.05	±11.33	167 – 204	174.69	±7.71	163 – 191
Senior	190.30	±7.35	177 – 206	174.43	±7.03	160 – 185
Weight (Kgs)	**Mean**	**StDev**	**Range**	**Mean**	**StDev**	**Range**
	75.11	±16.54	38 – 117	66.95	±7.93	39 – 86
U14	50.90	±10.38	38 – 73	39	±0	0
U16	65.22	±12.47	41 – 104	60.14	±7.50	50 – 76
U18	78.00	±9.26	52 – 97	66.14	±8.04	52 – 86
U20	76.94	±10.24	57 – 92	68.30	±4.67	59 – 75
Senior	90.76	±10.67	62 – 117	69.86	±6.19	57 – 80
Race	**M**			**F**		
Black	5 (3.10%)			1 (1.01%)		
Hispanic	1 (0.62%)					
Mixed	12 (7.45%)			0 (0%)		
White	143 (88.81%)			98 (98.98%)		
Player Pos'	**M**			**F**		
Point Guard	38 (23.60%)			22 (22.22%)		
Shooting Guard	39 (24.22%)			28 (28.28%)		
Center	20 (12.42%)			13 (13.13%)		
Forward	49 (30.43%)			27 (27.27%		
All- Round	15 (9.31%)			9 (9.09%)		

6.4.1. Exposure to Injury

The hours participating in training and games was recorded over the two seasons. For the 2013-2014 season, the system collected data on the number of weeks training and matches played. For 2014-2015, the system collected data for hours training and matches played. To allow for combination analysis for the two seasons, exposure data collected in weeks was converted based on an average team training session lasting 2 hours and the average game lasting for 1.5 hours in regular time.

Total exposure time for all basketball activity over the two seasons was 22895 hours (12852m / 10043f). Total exposure time in games was 1822 (956m / 866f) and 21072 in training (11895m / 9177f). See Table 6-2 for a full breakdown of these figures. The hours of exposure per player for all activity was 88 (79.8m / 101.4f), comprised of 7 game hours per player (5.9m / 8.7f) and 80.7 training hours (73.9m / 92.7f).

Table 6-2: Player Exposure Times over 2 Seasons

Player n	Total Activity Exposure (hours)	Total Activity Exposure per player (hours)	Training Exposure (hours)	Training Exposure per player (hours)	Games Exposure (hours)	Games Exposure per player (hours)
Male 161	12852	79.8	11895	73.9	956	5.9
Female 99	10043	101.4	9177	92.7	866	8.7
Total 260	22895	88	21072	80.7	1822	7

6.4.2. Total Number of Injuries Recorded

38% of all the players participating in this study sustained an injury (34% of males and 44% of females). This represents a total of:

- 0.66 total injuries per player per season (0.63 injuries per male player and 0.71 injuries per female player).
- 0.38 injuries per player per season in training (0.36 injuries per male player and 0.42 injuries per female player).
- 0.28 injuries per player per season in games (0.27 injuries per male player and 0.29 injuries per female player) respectively.

The total injuries and injury rate figures are provided in Table 6-3.

Table 6-3: Total Number of Injuries Recorded by Activity

Players (n)	Total Injuries (n)	Injuries in Training (n)	Injuries in Games (n)	Injury rates per player training	Injury rates per player games	Injury rates per player per season
Male 161	102	58	44	0.36	0.27	0.63
Female 99	71	42	29	0.42	0.29	0.71
All Players 260	173	100	73	0.38	0.28	0.66

6.4.3. Incidence of Injury

The incidence of injury calculated as "*total number of injuries / total exposure (unit) *1000"* is normally between 3 and 6 for the sport of basketball in Europe. In this study, the overall incidence of injury for all players was 7.56 per 1000 playing hours (7.94m / 7.06f). The incidence of injury for training for all players was 4.75 per 1000 training hours (4.88m / 4.58f). The incidence of injury during games for all players was 40.07 per 1000 playing hours (46.03m / 33.49f). The incidence of injury in training was similar for males and females. However male players had a higher incidence of injury in games compared to female players (Table 6-4).

The relative risk of injury in games was 9 times higher than in training for males and 7 times higher for females, despite the fact that both cohorts of players spent substantially more time in training than in games respectively (ratio of training:games: males 12:1; females 10.5:1).

Table 6-4: Incidence of Injury per 1000 hours

Players	Activity	No of injuries	Exposure time	Incidence of Injury per 1000h
Males	Training	58	11895	4.88
Females		42	9177	4.58
Total		100	21072	4.75
Males	Games	44	956	46.03
Females		29	866	33.49
Total		73	1822	40.07
Males	Total	102	12852	7.94
Females		71	10043	7.06
Total		173	22895	7.56

6.4.4. Injury by Anatomical Location

A total of 173 new injuries (102m / 71f) were recorded. Simple terminology was used in the injury section of the questionnaire to identify the various body parts that may be injured. Injuries were divided into three subgroups – upper extremity, lower extremity and other body parts. In the male players, 69 (68%) injuries occurred in the lower extremity, 19 (19%) in the upper extremity and 14 (14%) in other body regions. In female players, the lower extremity also recorded the highest level of injuries with 50 (70%), upper extremity had 10 (14%) and other body parts 11 (15 %) respectively (see Table 6-5).

In the male group, the top three injuries suffered were 23 (23%) to the ankle, 22 (22%) to the knee and 15 (15%) to the thigh, while in the female group the top three injury sites were 21 (30%) to the ankle, 13 (18%) to the knee and 8 (11%) to the lower leg (see Table 6-5).

The ankle was the most frequently injured site for both groups with a higher percentage of injury (30%) in female players compared to their male counterparts (23%). The knee was the second highest injured body part in both groups with male players suffering a higher percentage of knee injury (22%) over their female counterparts (18%). The third highest injury location differed between both groups with 15% thigh injuries in males and 8% lower leg injuries in female players. The pattern of injuries was very similar across the two cohorts. See Table 6-5 for a summary of all injuries by anatomical location. Additional data on anatomical location and injury type can be found in Appendix 11.

Table 6-5: Injuries by Anatomical Location

Total Participants	**N=260**	
	Male n=161	**Female n=99**
Total Players Injured	55 (34.16%)	44 (44.44%)
Total Players With No Injury	106 (65.83%)	55 (55.55%)
Total New Injuries	**N=173**	
	Male n=102	**Female n=71**
Injury Regions		
† Upper extremity	19 (43.13%)	10 (14.08%)
‡ Lower extremity	69 (67.64%)	50 (70.42%)
Other body regions	14 (13.72%)	11 (15.49%)
Body Region Injured		
Head	1 (0.98%)	1 (1.40%)
Face	3 (2.94%)	0 (0%)
Eyes	0 (0%)	2 (2.81%)
Neck	1 (0.98%)	0 (0%)
Shoulder	5 (4.90%)	5 (7.04%)
Upper arm	3 (2.94%)	0 (0%)
Elbow	1 (0.98%)	0 (0%)
Wrist	4 (3.92%)	0 (0%)
Hand	0 (0%)	0 (0%)
Thumb	2 (1.96%)	2 (2.81%)
Finger	4 (3.92%)	3 (4.22%)
Upper back	1 (0.98%)	1 (1.40%)
Ribs	0 (0%)	2 (2.81%)
Lower back	7 (6.86%)	3 (4.22%)
Pelvis	0 (0%)	2 (2.81%)
Hip	2 (1.96%)	1 (1.40%)
Thigh	15 (14.70%)	3 (4.22%)
Knee	22 (21.56%)	13 (18.30%)
Lower leg	4 (3.92%)	8 (11.26%)
Ankle	23 (22.54%)	21 (29.57%)
Foot	3 (2.94%)	4 (5.63%)
Abdomen	1 (0.985)	0 (0%)

6.4.5. Types of Injury

The types of injury are divided into 10 subgroups; cuts, contusions/bruising, fractures, dislocations, subluxations, muscle, ligament, cartilage, nerve and tendon injuries. The most common injuries that occurred overall were ligament sprains (60, 35%) particularly to the ankle and knee (21% of total male injuries; 28% of total female injuries), muscle strains (52, 30%) particularly to the thigh and lower leg, and tendon injuries (14, 8%) as shown in Figure 6-1. The pattern of injury types was very similar for both male and female players for all types of injuries except for dislocation, subluxation, fractures and bruising which occurred more in female players. The severity of the injury was significantly associated with the body region injured, with more serious injuries in the lower limb than other body regions. Ligament sprains are divided into three grades. A grade 1 sprain can cause the athlete to miss between 1-3 weeks, a grade 2 sprain may take 3-6 week recovery time and a grade 3 sprain can take several months and possibly require surgery (Maughan KL and Ivins D, 2006).

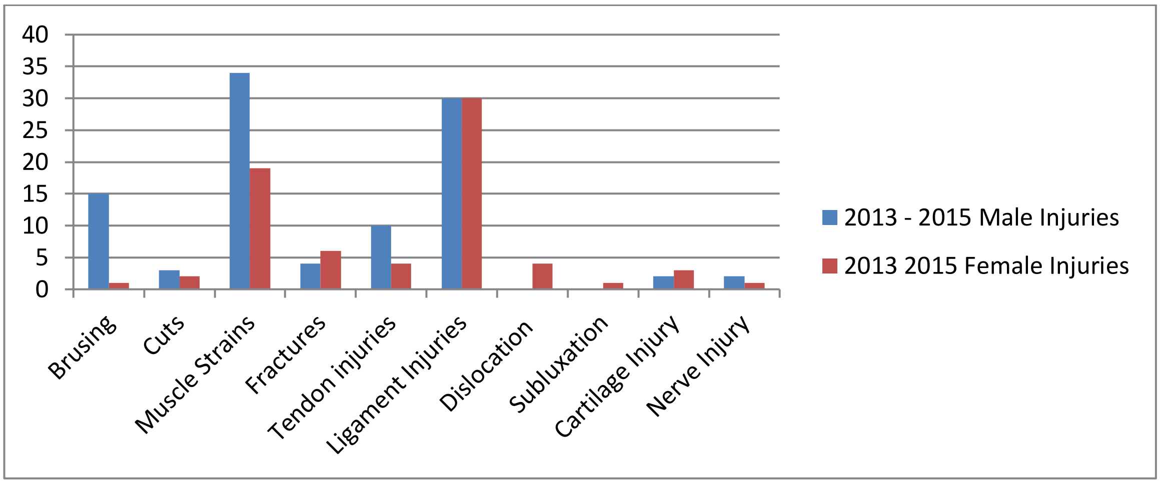


Figure 6-1: Injury Types in Male & Female Basketball Players (2013 – 2015)

6.4.6. Risk Factors for Injury

6.4.6.1. Playing Position

Players were divided into five categories according to their playing position and the distribution of positions was similar between genders: Point guards (24% male, 22% female), shooting guards (24% male, 28% female), centers (12% male, 13% female), forwards (30% male, 27% female) and all-round players (9% male, 9% female).

The distribution of injury by position is shown in Figure 6-2. With the exception of dislocation, nerve, and cartilage injuries, the forward players sustained the highest proportion of injuries for each category and had a significantly higher proportion of ligament strain injuries than other players ($p<0.001$).

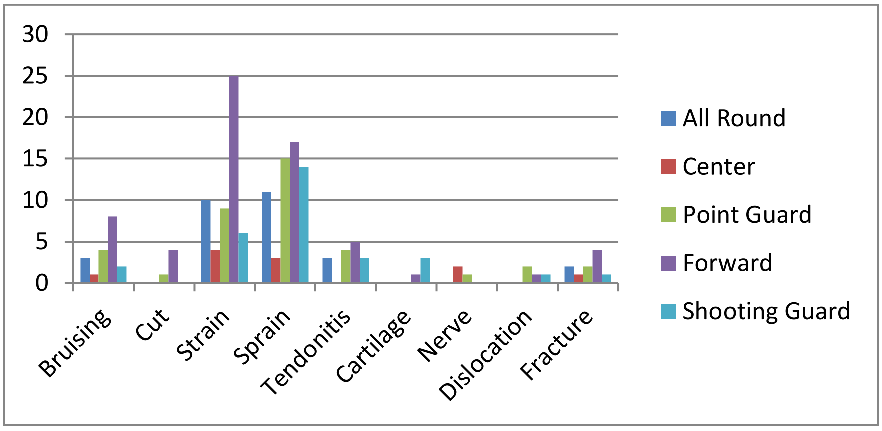


Figure 6-2: Playing Position and Injury Number

6.4.6.2. Footwear

The choice of footwear (a risk factor for basketball injury) worn by male and female players was recorded as follows – hi-top shoes (25% male, 25% female), mid-cut shoes (54% male, 44% female), and low-cut shoes (21% male, 30% female). Although hi-top shoes were the preferred shoe amongst the two cohorts, a greater proportion of female players chose to wear mid-cut shoes. Figure 6-3 presents a breakdown of shoe type and sole type worn by players. The vast majority of players chose to wear rubber sole shoes (69% for males and 76% for females) as compared to air cushion, gel cushion, or composite soles.

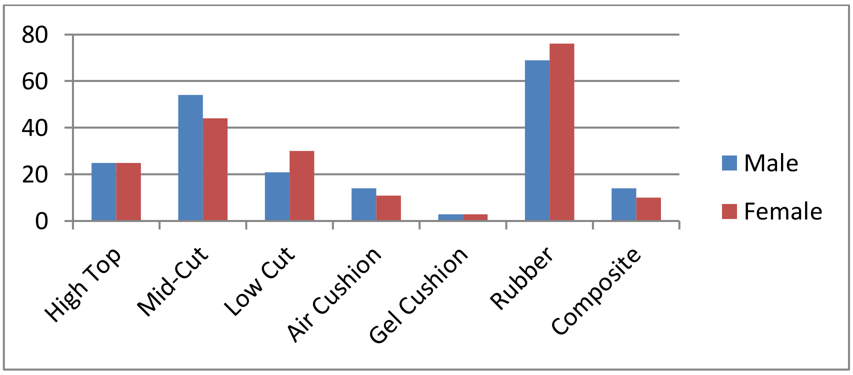


Figure 6-3: Shoe and Sole types worn by Players (%)

Despite the majority of players preferring to wear mid-cut shoes, the distribution of injury shows that players wearing hi-top shoes had a significantly higher proportion of injuries in each of the three injury locations (upper body, lower body and other injuries). This holds true for both for males and females as shown in Table 6-6. While fashion and player endorsement still guide players when selecting their shoes, more players are choosing to select shoes based on grip and traction properties. Regardless of the shoe type, ankle sprains continue to be one of the most common injuries. For many players in the past, hi-top shoes were the footwear of choice as it was believed that they offered more support than other styles, however the results of this study would not agree with that opinion.

Table 6-6: Injury Location by Shoe Type and by Gender (%)

Shoe Type / Injury Location	Low Cut	Mid Cut	High Top
Upper Extremity			
Males	11%	11%	77%
Females	20%	0%	80%
Lower Extremity			
Males	20%	6%	74%
Females	20%	0%	80%
Other			
Males	17%	0%	83%
Females	14%	14%	72%

6.4.6.3. Age and Injury

The average age of male players was 19 years ±7.5 years and ranged from 12 years – 48 years, while in the female group the average age was 20 years ±5 years ranging from 13 years – 43 years respectively. The players were categorised according to age groups: U14, U16, U18, U20, and Senior. The top three injuries for each of the age categories are shown in Table 6-7 below.

Table 6-7: Top 3 Injury Sites by Age Group and Gender

Age Classification	Injury Site
U14 Male Players (n10)	Knee (4), Shoulder (2), Thigh (2) Ankle (2)
U16 Male players (n=13)	Knee (7), Ankle (4) and Wrist (3)
U16 Female Players (n=10)	Ankles (4), Foot (3) and Fingers (3)
U18 Male Players (n=20)	Ankle (9), Thigh (7) and Knee (6)
U18 Female Players (n=14)	Ankles (10), Knees (6) and lumbar spine (2), Shoulder (2) and Low Leg (2)
U20 / Senior Male Players (n=12)	Ankle (8), Thigh (5) and Knee (5)
U20/ Senior Female players (n=20)	Ankles (7), Knees (6) and lower leg (4)

The U18 male and female age group have the highest rate of ankle injury across all age groups. Basketball players in this age group are often specialising in their sport of choice. In Ireland, U18 players can also play U20 and Senior club basketball during the same season. While many are still in school they will also have league and cup competitions. Additionally, some of the players are elite athletes and may also play U18, U20 and in Senior panels. In total, a player may participate in over 7 competitions. The U14 group have a lower level of ankle injuries but this may be because they have not yet been exposed to the more aggressive, competitive style of play seen in older age groups. It may be suggested that the number of hours played by an age group presents a higher risk of injury rather than the physical age of those athletes. McKay *et al*. also concluded that age was not significantly related to the occurrence of ankle injuries.

6.4.6.4. Playing Other Sports and Injury

When asked if they played other sports, 75 male players (47% of total players) and 38 female players (38%) indicated that they participated in more than one sport. The most popular sports other than basketball were football, rugby, and golf for the male players, while in the female group the top three sports, other than basketball, were camogie, volleyball and swimming (Table 6-8).

Table 6-8: Study Participants Playing More Than One Sport

	2013 – 2015	
Total Players	**Male n=161**	**Female n=99**
Players Competing in Other Sports	**Male n=75**	**Female n=38**
Number of Sports Played by Individual Players	**Male n= 75**	**Female n=38**
Participates in 1 extra Sport	**42**	**33**
Participates in 2 extra Sports	**26**	**3**
Participate in 3 ≥ sports	**7**	**2**
Other Sports played		
Outdoor Field Sports		
Camogie	**46**	**20**
Cricket		
Football		
Rugby		
Hockey		
Outdoor Individual Sports		
Athletics	**22**	**4**
Running		
Cycling		
Golf		
Horse Riding		
Tennis		
Water Sports		
Swimming	**10**	**5**
Surfing		
Kit Surfing		
Indoor Team sports		
Volleyball	**5**	**7**
Netball		
Ice Hockey		
Olympic Handball		
Individual Indoor Sports		
Squash	**10**	**4**
Badminton		
Ten pin Bowling		
Table Tennis		
Darts		
Combat Sports		
Boxing	**8**	**0**
Karate		
Tae Kwan do		
Extreme sports		
Rock climbing	**3**	**0**
Mountain Biking		
Conditioning		
Olympic Weight lifting	**4**	**3**
Keep fit/Circuit Training		
Winter Sports		
Skiing	**2**	**0**
Snowboarding		
Other	**1**	**3**

A total of 49 injuries occurred in players who participated in more than one sport. In the U14 age group, 7 male players suffered a total of 8 injuries. Players in this age group participated in 1-2 other sports, mainly soccer and rugby union. All U14 players were Welsh. The U16 age group (m7/f5) suffered 19 injuries (11 injuries in males who played between 1-2 sports, mainly soccer and rugby union) and (7 injuries in females who played between 1-3 sports, mainly football). All female players were from Ireland. In the U18 group there were a total of 10 players (m6/f4) who participated in more than one sport. In this group, male players tended towards individual sports outside basketball. There were a total of 16 injuries in the male group and 8 injuries occurred in the female group. Four of the injuries in the female group occurred in one player who played in three extra sports. In the U20 group, three players (m2/f1) played in 1-2 extra sports. There were a total of three injuries in this group, each player suffering one injury. In the Senior age group, eleven players (m4/f7) played in more than one sport, five of which were Irish (m2/f3). A total of 23 injuries occurred in this group. 14 injuries occurred in males with 6 of these in a single player who participated in 4 sports. There were 9 injuries reported in the Senior female group, all playing one extra sport, with most players coming from Ireland (f3) and Wales (f3). The age group and injury details are provided by nationality in Table 6-9.

Table 6-9: Injury for Multi-Sport Athletes by Age Group, Gender and Nationality

Age Group	Male	Male Injuries	Female	Female Injuries
U14	n=7	8 injuries	n=0	
U16	n=7	11 injuries	n=5	7 injuries
U18	n=6	16 injuries	n=4	8 injuries
U20	n=2	2 injuries	n=1	1 injury
Senior	n=4	14 injuries	n=7	9 injuries

Seventy-eight players participated in more than one sport of which 62% of players suffered an injury. 43% of all injuries occurred in players who participated in more than one sport. Players from Wales and Ireland appear to have more multi-sport participants than any other country. This may be attributed to the population size of each country and the demand for elite athletes to play in more than one sport. Players from the U18 group are playing at a higher competition and intensity level and should take this into consideration when playing in other sports with increased exposure to injury.

6.4.6.5. Previous Injury

Previous injury in basketball players has been identified as a major risk factor for injury. During the 2013-2015 seasons, a total of one hundred and forty players (m81/f59) reported having an injury prior to the commencement of the season. A total of 257 previous injuries (m135/f122) were recorded by players with the breakdown given in Table 6-10.

Table 6-10: Previous Injuries per Season by Gender

Players Season	Male	Female	Total injuries Male	Total Injuries Female
2013-2014	54	48	83	93
2014-2015	27	11	52	29
2013-2015	81	59	135	122

The top 3 injury sites recorded by players for an injury prior to the study period are given in Table 6-11. The most frequently occurring previous injury in male and female players was to the ankle followed by the knee. Thigh and shoulder injuries were the third most common for male and female players respectively.

Table 6-11: Top 3 Injury Sites by Season and Gender

Players		Injury site (n) & (%)	Injury site	Injury site
2013 - 2014	Male	Ankle (26) (31%)	Knee (16) (19.27%)	Finger (5) (6.024%) Thigh (5) (6.024%)
2013 - 2014	Female	Ankle (29) (31.18%)	Knee (16) (17.20%)	Thigh (9) (9.67%)
2014 - 2015	Male	Ankle (18) (34.61%)	Knee (6) (11.53%)	Fingers (5) (9.61%)
2014 - 2015	Female	Ankle (7) (24.13%)	Knee (7) (24.13%)	Shoulder (4) (13.79%)
Total 2013 - 2015	Male	Ankle (44) (32.59%)	Knee (23) (17.03%)	Fingers (10) (7.40%)
Total 2013 - 2015	Female	Ankle (36) (29.50%)	Knee (20) (16.39%)	Thigh (10) (8.19%)

In this study, the relationship between the incidence of previous and reoccurring new injuries was looked at. The incidence of previous and reoccurring injuries for the current study is given in Table 6-12. Of the 161 male players studied, 81 recorded having a previous injury. 34 of these players suffered a new injury during their time of observation and 21 players suffered a re-occurrence of an old injury. In female players (n=99), a total of 59 players reported having suffered a previous injury. 30 of these players suffered a new injury during their time of observation and 21 reported a recurrence of an old injury.

Table 6-12: Incidence of New and Recurring Injury with Previous Injury Recorded

Total Players 260			
Total Male Players n=161	Players with previous Injuries	Players with previous and new injury	Players with repeat Injury
Total Male (n=161)	81 (50.31%)	34 (21.11%)	21(13.04%)
U14 players (n=20)	5(3.10%)	4 (2.480%)	3 (1.86%)
U16 players (n=35)	7 (4.34%)	3 (1.86%)	2 (1.24%)
U18 players (n=46)	29 (18.01%)	17(10.55%)	8 (4.96%)
U20 players (n=17)	10 (6.21%)	3 (1.86%)	3(1.86%)
Snr players (n=43)	30 (18.63%)	7 (4.34%)	5 (3.10%)
Total Female Players n=99	Players with previous Injuries	Players with previous and new Injury	Players with repeat Injury
Total Players n=99	59 (%)	30 (%)	21 (21.21%)
U14 players (n=1)	0	0	0
U16 players (n=14)	11 (11.11%)	9 (9.09%)	6 (6.06%)
U18 players (n=27)	15 (15.15%)	6 (6.06%)	7 (7.07%)
U20 players (n=13)	5 (5.05%)	3(3.03%)	3 (3.03%)
Senior players (n=44)	28 (28.28%)	12(12.12%)	5 (5.05%)
Total Male and Female combined	140 (53.84%)	64 (24.61%)	42 (16.15%)

The U18 male and female players suffered the highest amount of reoccurring injuries in players (m8/f7). Overall, there were 42 (16.5%) reoccurring injuries across all groups with a greater number observed in the female group. The greatest proportion of reoccurring injuries were non-contact ones, but the higher proportion of new injuries was contact injuries as shown in Figure 6-4: Reoccurring Injury by Injury Type.

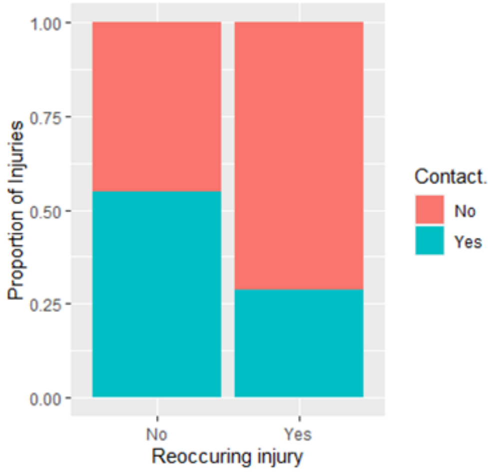


Figure 6-4: Reoccurring Injury by Injury Type

A summary of reoccurring injuries by contact in either game or training scenarios is provided in Figure 6-5 Reoccurring Injuries by Contact and Activity.

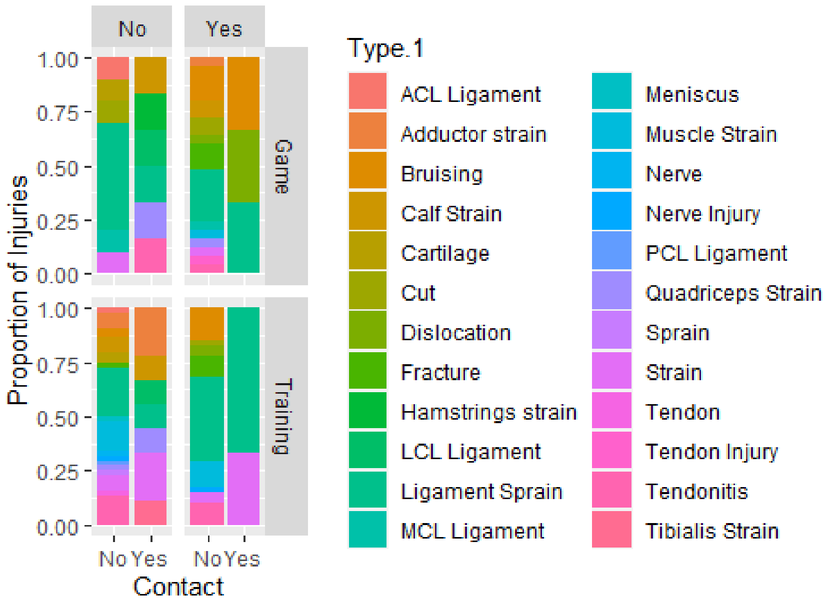


Figure 6-5 Reoccurring Injuries by Contact and Activity

6.4.6.6. Injury and Activity

More injuries occurred in training than in games. The proportion of injuries according to activity was 58% in training and 42% in games respectively. The pattern of injury distribution was very similar for the two groups. Of all the injuries sustained by male players, 57% were training injuries and 43% were game injuries while in female players, 59% of total injuries occurred in training and 41% in games respectively (Figure 6-6).

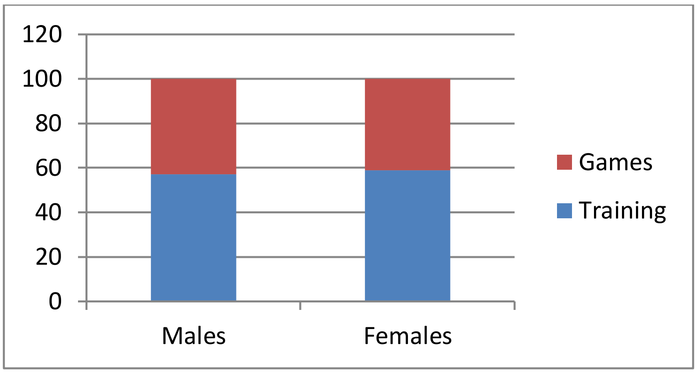


Figure 6-6: Distribution of Injury According to Activity

Injuries to the lower body were more frequent in training (39%) than in games (30%), and similarly for upper body (13% training, 4% in games) and 'other' injuries (9% training, 5% in games). The pattern of lower body and 'other' injuries for games and training was similar for males and female players, however upper body injuries were more prevalent in games for female players and in training for male players (Table 6-13).

Table 6-13: Injury Location & Activity (%)

Players	Activity	Lower Body (%)	Upper Body (%)	Other (%)
Male	Games	32	1	3
	Training	36	18	10
Female	Games	27	9	7
	Training	43	5	9
All	Games	30	4	5
	Training	39	13	9

6.4.6.7. Timing of Injuries

The timing of injuries in games and training is displayed in Table 6-14. Training injuries were not reported according to time unless there were games as part of a training session. The majority of game injuries occurred in the first half of games (70%) for all players; with significantly more injuries occurring in the second quarter of games than any other time period for both males (40%) and females (46%) respectively ($p<0.05$).

Table 6-14: Injuries & Timing within Activity

Activity	Training	1st Q	2nd Q	3rd Q	4th Q
Training					
Males	72%	8%	19%	0	0
Females	93%	3%	3%	0	0
Total	81%	7%	12%	0	0
Games					
Males	12%	35%	40%	12%	3%
Females	0%	20%	46%	10%	24%
Total	7%	29%	41%	11%	11%

6.4.6.8. Court Area

Specific areas on a basketball court have been identified as having a greater risk of injury for players and have been discussed earlier in this study. Table 6-15 and Figure 6-7 provide a breakdown of injuries per court area. The Key area was the site of most injuries with 25 (56.81%) occurring in male players and 18 (62.06%) in female players.

Table 6-15: Court Area & Player Injury by Gender (%)

Court location	Male Players (n=44)	Female Players (n=29)
Key	25 (56.81%)	18 (62.06%)
Inside 3 point Line	5 (11.36%)	3 (10.34%)
Outside 3 point line	3 (6.81%)	2 (6.89%)
Half Court	9 (20.45%)	1 (3.44%)
Baseline	2 (4.54%)	5 (17.24%)

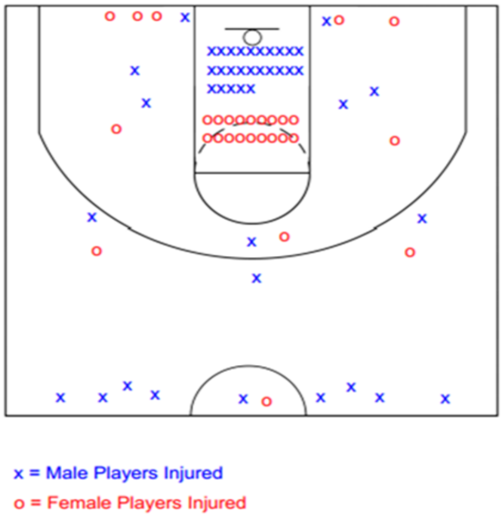


Figure 6-7: Court Area Locations of Injury 2013 – 2015

6.4.6.9. Contact and Non-Contact Injuries

There was a significantly higher proportion of contact injuries (76%) compared to non-contact injuries (24%) for all players ($p<0.005$). The distribution was similar for males (79% contact and 21% non-contact) and females (72% contact and 28% non-contact) respectively. The pattern of injuries by anatomical region and type of injury was similar for contact and non-contact injuries (Figure 6-8) with the majority of injuries represented by ligament injuries to the ankle and knee.

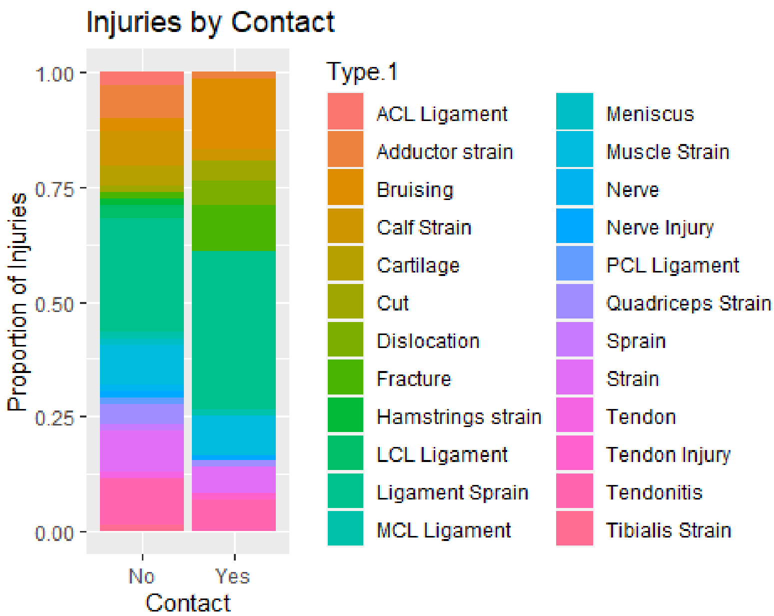


Figure 6-8: Pattern of Injuries by Anatomical Region and Type for Contact and Non-Contact Injuries

6.5. Injury Risk Reduction Modelling: Contact: Non-Contact Injuries

The preliminary analysis of each explanatory variable using non-contact injury as the response identified a number of significant ($p<0.05$) variables as candidate predictors such as the numbers of training hours, the total games played during the season, reoccurring injury, and basketball-specific activities such as running on defence, rebounding offence and defence (Table 6-16 and Figure 6-9).

Table 6-16: Contact and Non-Contact Injury

Variable	Non- Contact	Contact	P value
Age	18.7 (5)	17.8 (4.4)	0.271
Weight	69.6 (14.4)	71 (12.4)	0.557
Height	177 (12.4)	180 (10.2)	0.151
Reoccurring Injury			0.046
No	78.3%	91.7%	
Yes	21.7%	8.3%	
Training days per week	4.35 (1.52)	4.67 (1.32)	0.187
Total training sessions	62 (58.3)	93.7 (75.6)	0.006*
Total games played	6.54 (6.33)	9.28 (7.70)	0.022*
Landing from shooting			0.070*
No	97.1%	87.5%	
Yes	2.9%	12.5%	
Running on Offence			1.00
No	88.4%	87.5%	
Yes	11.6%	12.5%	
Running on Defence			0.033*
No	87.0%	70.8%	
Yes	13.0%	29.2%	
Rebounding Offence			0.018*
No	88.4%	70.8%	
Yes	11.6%	29.2%	
Rebounding Defence			0.067
No	88.4%	75.0%	
Yes	11.6%	25.0%	

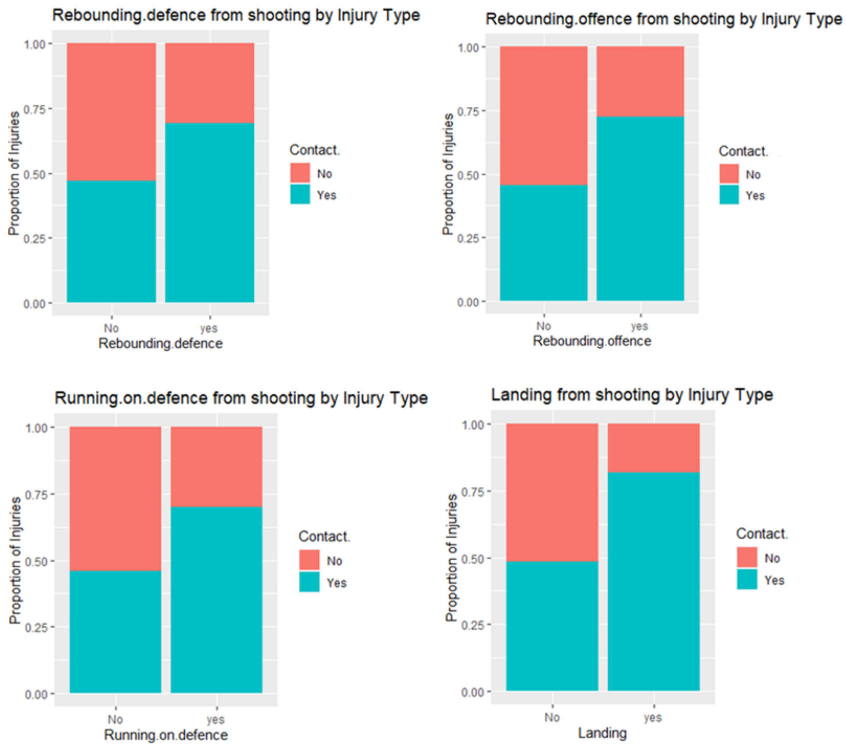


Figure 6-9: Contact and Non-Contact Injury by Activity

A more focused analysis was then conducted on non-contact ankle injuries – the most frequently occurring injury observed for both male and female players, particularly ankle ligament sprains.

The injury surveillance data were combined with pre-season fitness assessments in an injury risk prediction model. The ankle injuries were classified as contact and non-contact injuries. A summary of the individual variables included in the model and a comparison of each variable across the two levels of the response variable (i.e. non-contact ankle injury 'yes' or 'no') is presented in Table 6-17.

Table 6-17: Injury Risk Modelling for Ankles

Variable	Contact Injury	Non-contact	P value
Age	19.9 (6.77)	18.1 (4.09)	0.043
Weight	69.7 (15.3)	69.8 (11.2)	0.947
Height	178 (12.4)	177 (11.0)	0.419
Gender Females Males	 58 (38.7%) 92 (61.3%)	 20 (60.6%) 13 (39.4%)	0.035

Shoe type High top Low cut Mid cut	 31 (20.7%) 35 (23.3%) 84 (56.0%)	 1 (3.03%) 8 (24.2%) 24 (72.7%)	0.597
Shoe age	6.63 (4.15)	6.33 (3.73)	0.690
Position All Round Centre Forward Point Guard Shooting Guard	 20 (13.3%) 18 (12.0%) 43 (28.7%) 32 (21.3%) 37 (24.7%)	 2 (6.06%) 1 (3.03%) 10 (30.3%) 11 (33.3%) 9 (27.3%)	0.308
Total.days.training.per.week	3.87 (1.72)	4.70 (1.40)	0.005
Total.training.sessions	39.9 (59.9)	76.5 (76.8)	0.014
Total.games.played	4.79 (6.83)	8.33 (7.21)	0.013
FMS.total.score	9.29 (7.82)	10.0 (8.29)	0.653
Positive4.test.for.risk.injury Negative Positive	 121 (80.7%) 29 (19.3%)	 31 (93.9%) 2 (6.06%)	0.113
LEG.LENGHT.DISCREPENCY.RIGHT.LONG: Negative Positive	 134 (89.3%) 16 (10.7%)	 31 (93.9%) 2 (6.06%)	0.536
LEG.LENGHT.DISCREPENCY.LEFT.LONG: Negative Positive	 138 (92.0%) 12 (8.00%)	 30 (90.9%) 3 (9.09%)	0.736
TRENDELENBURG.TEST..RIGHT: Negative Positive	 106 (70.7%) 44 (29.3%)	 27 (81.8%) 6 (18.2%)	0.278
TRENDELENBURG.TEST..LEFT: Negative Positive	 106 (70.7%) 44 (29.3%)	 26 (78.8%) 7 (21.2%)	0.467
TRENDELENBURG.TEST.Right.and.LEFT Negative Positive	 119 (79.3%) 31 (20.7%)	 30 (90.9%) 3 (9.09%)	0.193
ANKLE.DORSIFLEXION.SUPINE.RIGHT Negative Positive	 69 (46.0%) 81 (54.0%)	 16 (48.5%) 17 (51.5%)	0.947
ANKLE.DORSIFLEXION.SUPINE.Left Negative Positive	 70 (46.7%) 80 (53.3%)	 16 (48.5%) 17 (51.5%)	0.947
ANKLE.DORSIFLEXION.SUPINE.right.and.left Negative Positive	 72 (48.0%) 78 (52.0%)	 17 (51.5%) 16 (48.5%)	0.862
SINGLE.LEG.BALANCE.TEST.LEFT: Negative Positive	 98 (65.3%) 22 (66.7%)	 52 (34.7%) 11 (33.3%)	1.000

SINLGE.LEG.BALANCE.TEST.RIGHT: Negative Positive	 62 (41.3%) 88 (58.7%)	 17 (51.5%) 16 (48.5%)	0.382
SINLGE.LEG.BALANCE.TEST.RIGHTand.LEFT: Negative Positive	 101 (67.3%) 49 (32.7%)	 22 (66.7%) 11 (33.3%)	1.000
Bleep test Average Good Fair Very good	 23 (25.6%) 30 (33.3%) 21 (23.3%) 16 (17.8%)	 10 (50.0%) 5 (25.0%) 3 (15.0%) 2 (10.0%)	0.239
YBT.test Below Standard Pass	 86 (97.7%) 2 (2.27%)	 20 (100%) 0 (0.00%)	1.000
PSOAS Negative Positive	 97 (64.7%) (2.27%)	 24 (72.7%) 9 (27.3%)	

The analyses presented in the two tables consider each variable separately. In order to explore the risk profiling of injuries collectively, and potential risk prevention, a logistic regression model was fitted (with contact and non-contact injury as the response variable) in order to identify potential modifiable risk factors. Potential useful predictors that were identified included lower hamstrings fibres test and training time (Table 6-18).

Table 6-18: Injury Modelling: Ankle Injury

	Estimate	Standard Error	Odds Ratio	z value	Pr(>|z|)
(Intercept)	-2.9478	0.7381		3.994	6.5e-05 ***
total.days.training.per.week	0.2924	0.1548	1.34	1.888	0.0590
LOWER.HAMSTRING..FibresPositive	1.5342	0.7709	4.64	-1.990	0.0466 *

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 estimates are log odds.

According to the model the odds of a non-contact ankle injury increase by 1.34 per unit increase in total days training and similarly the odds of non-contact ankle injury increase by 4.62 for those with a positive Lower Hamstring Fibres test. The ridge regression model and a classification tree (pruned using cross validation) identified the same set of risk factors as those identified from the preliminary analysis. In order to explore the relationship between the set of explanatory variables and the response in more detail, an unpruned classification tree was built to see what other pathways to a non-contact ankle injury were identified. This is shown in Figure 6-10. These results are very exploratory in nature as the tree is overfitted where the pathways identified are likely to be more reflective of the sample on which the tree was built rather than the population as a whole.

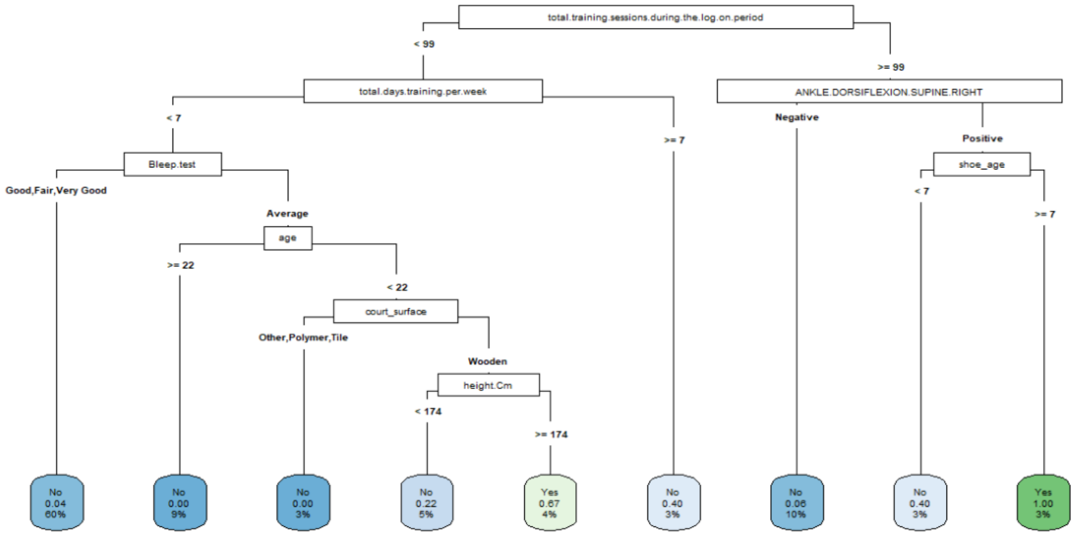


Figure 6-10: Unpruned Classification Tree for Risk Factor Identification

Contributory variables or possible injury predictors are identified through the relationships shown on the tree. These variables are the training load, the results of the ankle dorsiflexion test, the athlete's age, the age of their shoes and the court playing surface. These contributory variables are in line with other research.

With regards to shoe age, Lowe stated that runners are advised to replace their shoes every 350-500 miles, adding the average runner will take up to 66 hours to accumulate 500 miles. The average high school or college player will work out easily 72 hours per month, so therefore the same advice on footwear replacement should stand for a basketball player. Shoe materials such as eva or polyurethane have fatigue factors which can affect the stress on the joint and soft tissues. NBA players change shoes on average every 7-10 days to reduce injury risk (Lowe, 2012).

Basketball as a sport is played by smaller squads, with high training loads, back-to-back competition and long seasons (Weiss *et al.*, 2017). With high training and match loads, players have an increased risk of injury. Weiss stated that basketball players are susceptible to the risk of lower extremity injuries and this is inherently higher than in other team sports. Further, he stated that ankle and knee problems are the most common in basketball with knee problems having the greatest impact due to time loss from sport. Training load as a variable is under the control of the coach who can adjust the sessions to address the specific needs of the players.

Reduced ankle dorsiflexion in basketball players and its relation to injury has been discussed in detail in previous chapters. Backman and Danielson stated that basketball players with a dorsiflexion range of less than 36.5 degrees had a 18.5 to 29.4% risk of developing patellar tendinopathy compared to a 1.8 to 2.1% risk for athletes with dorsiflexion greater than 36.5 degrees (Backman and Danielson, 2011). Reduced ankle dorsiflexion and its effects on lower extremity injury have also been discussed by Mason-Mackay *et al.*, who concluded that dorsiflexion may alter landing mechanics and predispose athletes to injury. They further recommended that screening players' ankle flexibility may identify those at an increased risk of lower extremity injury (Mason-Mackay, Whatman and Reid, 2017). The Ankle Dorsiflexion Test is a relevant and easy to perform test which can be carried out in a time and cost efficient manner throughout the season.

The playing surface of the court has been further identified as a contributory variable for injury in the classification tree. The common belief by players and coaches is that a wooden playing surface can provide better force attenuation compared to other court surfaces. In a previous study by Kong *et al.*, their findings suggested that players can experience greater impact forces on the toes and medial forefoot when performing basketball activities on the more compliant wooden court than asphalt courts (Kong *et al.*, 2018). The American Academy of Podiatric Sports Medicine differed in opinion stating "Different playing surfaces can also have an effect on injuries. Indoor wooden courts offer the most shock absorption and are considered the safest courts, while outdoor courts of asphalt are more dangerous" (Podiatry, 2021). There are many factors that can affect the quality and traction of the playing surface such as dust, age, air circulation/extractions and condensation. Floor surface is an important variable to include in research. At the very least, it may be used to monitor the number of injuries occurring in gyms/courts with a view to identifying courts where the risk of injury is higher. These courts could be removed as a venue for competition to improve athlete safety.

A player's age has also been identified in the relationship tree as a potential predictor for injury. Some studies in the NBA stated player demographics such as age, were not correlated with injury rates (Drakos *et al.*, 2010). Andreoli *et al.*, stated the probability of injury to the hands, fingers and wrist is the same for children, teenagers and professional adults. In the category of children and adolescents, there was a higher prevalence of head and neck injuries compared with the other categories. For professionals, there was a higher prevalence of trunk and spine injuries (Andreoli *et al.*, 2018). Age may be a potential confounder as it is associated with the player's exposure time playing in their sport. The age of the athlete and their time playing may also be affected by the total numbers of years training or playing, competition levels, previous injuries, training methods with different coaches and whether or not they have been exposed to coaching which has got injury prevention strategies built into the programmes. The classification tree has provided details on what other pathways may identify a non-contact ankle injury.

6.6. Discussion

This research has for the first time provided injury-related data and pre-participation screening data for the UK and Ireland. A lot of questions have been answered in relation to the type, frequency and mechanism of injury occurring to players.

The total number of injuries recorded was 173 (102m / 71f) of which 100 were in training (58m / 42f) and 73 in games (44m / 29f). 38% of all the players participating in this study sustained an injury (34% of males and 44% of females). Aspects of training sessions are controlled by the coach or trainer. Factors that are within their control are the length of the training session, number of sessions, intensity of effort by drill selection and breaks. However, in games there are a number of uncontrollable factors to be cognisant of such as opposition aggressiveness, level of competition, unsportsmanlike fouls, overtime and control/management of the game by referees. In this study, more injuries occurred during training than games, so there is opportunity to reduce injuries in this cohort by concentrating on the training sessions.

Significant indicators of interest identified through Chi-square and logistic regression modelling during this research on injuries were the number of training hours, the total games played during the season, reoccurring injuries and basketball-specific activities such as transition on defence and rebounding, some of which are controllable for a coach. For example, a coach could reduce unnecessary player fatigue during pre-and in-season training sessions by avoiding repetitive drills, sometimes used in a punitive manner, which expose players to overuse injuries.

Females had a higher rate of injury than their male counterparts in both training and game injuries per season with 0.42 injuries per female player in training and 0.29 injuries in games, compared to 0.36 and 0.27 injuries per male player in training and games respectively. These findings support previous research that identified a greater risk of injury in female players over their male counterparts (Deitch *et al.*, 2006; Hosea, Carey and Harrer, 2000; Fuller and Drawer, 2004; Hickey, Fricker and McDonald, 1997; Emery *et al.*, 2007; Murphy, Connolly and Beynnon, 2003; Hewett, 2000; Zelisko, Noble and Porter, 1982).

There is a concern when looking at these results in the overall context of the game of basketball that there is not enough work being invested into reducing injury in female players. This may be due to a lack of funding or deficiency in coaching skills/ knowledge when creating training programmes aimed at reducing/preventing modifiable injuries. Other consequences of this higher rate of injury may be a drop-off in basketball participation where females change to another sport that seems to have better injury prevention programmes or are perceived as being safer to participate in.

In previous research, the large body of evidence shows that basketball players are more likely to suffer an injury to the lower extremity than any other anatomical region (Cumps, Verhagen and Meeusen, 2007), (Meeuwisse, Sellmer and Hagel, 2003), (Kostopoulos, 2010), (Hammig, Yang and Bensema, 2007), (McKay *et al.*, 2001a), (McKay *et al.*, 2001b), (Borowski *et al.*, 2008) and (Dick *et al.*, 2007a). This study found that injuries to the lower extremities were most frequently reported and accounted for 68% of all injuries in male players and 70% in female players.

More specifically, ankle ligament sprain and muscle strains are two of the most common injuries in basketball. McKay *et al*. reported injury to the ankle joint as the most common and most serious injury (1.25/1,000 participations), followed by the calf and knee. They also stated that the rate of serious ankle injury was 2.6 times the rate of the second most frequently sustained serious injury (calf/anterior leg 0.48/1,000) (McKay *et al.*, 2001b). The results of this two-season study are in line with and support conclusions from previous research studies about the type, frequency and seriousness of injury to the lower extremity.

Injuries to the lower extremity are often the most serious in basketball players and necessitate long periods away from training. The cost burden of these injuries has been discussed earlier. Elis has shown the benefits of a simple propreoceptive programme in reducing ankle injuries in players (Eils *et al.*, 2010). This type of training needs to be embedded into both pre-season and regular training sessions. Players participating in this study who wore hi-top shoes were more likely to suffer an injury than those who wore mid-cuts or low-cut shoes.

This finding is different to other studies that concluded that shoe-cut did not contribute to a greater risk factor of injury (Cumps, Verhagen and Meeusen, 2007; Barrett *et al.*, 1993). There is not enough research carried out to provide for an informed decision on shoe type to reduce injury. The AAPSM reported that NBA players choose a wide variety of shoe styles to wear stating 68% of the players utilise a high top shoe, 15% utilise a 3/4 top shoe, and only 10% will use a low top basketball shoe for regular play (Lowe, 2012). Players who use hi-tops are more likely to continue using them as they feel more support and are confident that they will offer protection in the event of an ankle roll.

Reporting of injuries like cuts and bruises was low, possibly due to the players accepting this as part of the natural contact and aggressiveness of the game. As a consequence, they did not put a value on this type of injury as they can continue playing through it. The other injury types such as ligament sprains, fractures, muscle strains and tendon injury have a greater impact on the player's ability to play. Although the system was designed to collect data on all injury types, ligament and muscle strain injuries were the highest type reported in this study. This is similar to the findings reported by McKay in their study (McKay *et al.*, 2001a).

Regardless of what the players report, the ability to capture data on the more significant types of injury occurring in the sport has been demonstrated as a keystone to creating and implementing an injury prevention programme with the aim of reducing modifiable injury occurrence.

From the data gathered using the UKIBIPS-ISS system, a statistical model using logistic regression was created to help identify a relationship between risk factors and injury for this study. Ankle injuries are reported with the highest rate of incidence in general, and this is true in this research, so it was the obvious injury choice for use in the data model in this instance. The statistical model created used the data collected during pre-season testing to highlight the risk factor of a player with a tight lower hamstring having a potentially higher risk of ankle injury occurring. In testing terms, these players had failed the muscle hypertonicity test for hamstrings. This is a pass/fail test that is easy to perform and could be observed during part of a team warm up. This demonstrates the trinity between injury, risk factor and tests that can identify a potential weakness in an athlete that may contribute to an injury. This model could be applied in other research studies to present results for other injuries of interest.

The research study provides the sports management team with a new tool to collect data to help answer their research questions in the sport of basketball. The model used in the analysis of non-contact ankle injury is just one example of how the data collected may be analysed.

The statistical model and classification tree analyses presented identify how classical statistical modelling and machine learning approaches can be used given the richness of data collected and how they have been curated into an accessible athlete management system. The benefit of the statistical model used is that the role of each explanatory can be assessed (unlike the tree), in particular modifiable risk factors that should be targeted as part of training and rehab.

The accuracy and power of any statistical modelling (or tree based) approach when considering a binary outcome is dependent on the number of events, in this case injuries. As more data become available more robust models can be fitted for other injuries not considered in the analysis section of the study. The results of these analyses can be used to create an early warning system to identify players at increased risk of injury and the necessary changes made. The injury selected here is a non-contact ankle injury. This approach could be applied for any injury reported. However, the data will lack power due to the number of injuries recorded in this study, but the methods proposed will scale up (in terms of accuracy, power and precision) as the dataset grows.

Chapter 7 – Final Discussion and Conclusions

7.1. Summary of Aims and Findings

The United Kingdom and Ireland Basketball Injury Prevention Study has been carried out over two competitive seasons (2013/14 & 2014/15) of basketball in both the UK and Ireland and offers an insight into associated injuries and pre-participation testing that has up to now not been available for the sport. The overall aims of the UKIBIPS study were to:

1. Identify (Scope Review) existing Injury Surveillance Systems and describe their characteristics and establish what factors may be appropriate to this research study.
2. Develop a basketball Injury Surveillance System for use in Ireland and the UK.
3. Undertake a pilot study to understand how this system could be used to:
    a. Monitor injury incidence.
    b. Understand risk factors for injury that exist in the Ireland and the UK and may contribute to further research on injury prevention strategies.

The key findings of the study are:

- The UKIBIPS research study has provided a new robust and reliable Injury Surveillance System that can be used for the collection, storage and analysis of data in the sport of basketball.
- Using clinical tests in combination with standard pre-participation sports testing has the ability to identify players at increased risk of intrinsic personal non-contact injuries.
- Using cluster analysis the similarities between the tests used for various risk factors were established, thus allowing a judicious selection of tests to be used by the practitioner for both pre-participation and in-season testing while reducing the time and financial burdens associated with regular, ongoing testing.
- Simple pass/fail/binary field tests may be used by a team trainer (non-qualified practitioner) to identify players at increased risk of injury on a continuous basis during the season who may then be referred to the relevant specialists.

- The forward position carries the greatest risk of injury for players on the court.
- Ankle injury is the most frequently occurring injury.
- More injuries occur in training than in games.

The research study has achieved its aims and offers, at the very least, to the scientific community, a new robust Injury Surveillance System, previously unknown information on basketball injury in Ireland and the UK, as well as data on PPE testing which may be used to identify basketball players at increased risk of injury. This data collection tool can also be used by a variety of sports-based researchers and the resultant data can assist in providing answers to their specific research questions.

7.2. Discussion and Conclusions

Basketball is a fast tempo game and, regardless of the varied definitions and opinions, is a contact sport. The multi-directional aspects and attacking nature of the game make it exciting for the audience and tests the skill and physical abilities of the players. There are many benefits in playing a team sport such as basketball. However, research identifies the sport as having a high rate of injury. Injuries have always been accepted as a negative side effect of sports participation.

The cycle of play, injury, recovery and return to play is something that many players go through in their basketball careers whether they are amateur or professional, old or young. Injuries may be minor or career-ending. Although injuries can be treated by healthcare professionals, there is a need to address the prevention aspect of injury management more seriously. The cost burden of injury may put necessary treatments beyond the reach of many, and the possible enforced time off work and the associated loss of salary may lead players to discontinue playing or give up physical activity. In the current climate where health, exercise and sports participation are being promoted, the risk of injury to basketball players must be confronted and solutions sought.

Luig *et al*. cited the incidence of injury in European basketball as being 3-6 injuries per 1000 exposures and having a collective associated cost burden of over €500 million per year. It has been estimated that there are 720,200 basketball-related injuries in the European Union each year (Luig *et al*., 2010). The goal of clinicians and scientists must be to use evidence-based knowledge to help reduce avoidable injury in sports, and to educate and design strategies that are effective, efficient and cost beneficial for all members of the basketball community. However, the responsibility does not just lie with the clinicians, scientists and trainers. The individual must also take personal responsibility for their own health by looking at many facets such as fitness, nutrition, rest and preparation to play. They need to understand that part of their role as a player is to engage with research in injury prevention, and subsequently participate in prescriptive injury prevention programmes. Where do we begin?

Van Mechelen in his research has presented a model for injury prevention with four main steps: 1) identify and establish the extent of the sport injury problem in a sport, 2) establish the aetiology and mechanisms of injury, 3) introduce injury prevention strategies and 4) assess the effectiveness of these strategies by reviewing the first stage in the model (Van Mechelen *et al*., 1992).

Using this 4 step process as a reference model, the Principal Investigator, as a physiotherapist, former player and international basketball head coach, identified there was a lack of research data on basketball injuries occurring in Ireland and the UK and considered how this might be addressed. In order to progress this, there was a need to systematically monitor and collect injury incidence data in basketball in the Ireland and the UK. Following the collection and analysis of this data, a body of knowledge could be made available to assist others in the basketball community in developing science-based programmes to prevent modifiable basketball injuries.

In order to carry out the research and provide meaningful data, the first stage was to identify a method for collecting data which had the ability to deal with a large number of participants. While paper questionnaires were available, easy to design and used by many researchers (Cumps, Verhagen and Meeusen, 2007; Meeuwisse, Sellmer and Hagel, 2003; Kofotolis and Kellis, 2007; McKay *et al.*, 2001a) in their work, there are problems associated with the process of posting out questionnaires and finding a person as a point of contact for following up with their team to input data on a consistent basis and return completed questionnaires.

Electronic systems have been more frequently used in sports injury research studies in Canada, America and Australia. The flexibility of using this type of data collection suited the needs of the Principal Investigator. One aim of the research study was to carry out a scope review of Injury Surveillance Systems presently being engaged worldwide to establish if they would be appropriate and available to use in this study. This is presented in Chapter 2.

The easiest and most efficient approach to data collection was to utilise a pre-existing system such as the Datalys Injury Surveillance System that is used by the NCAA. Unfortunately, on enquiry, this system and others employed by different countries were geographically constrained and had restrictive licensing agreements preventing their use in this study. For this reason, it was determined that a bespoke system needed to be designed and developed. This was achieved through collaboration with staff and students from the Galway-Mayo Institute of Technology which allowed for the development of a sports-specific application in a timely and cost-effective manner.

While there were difficulties for the Principal Investigator and the software development team due to their differing areas of expertise, 2013 saw the launch of the first injury surveillance software in Ireland and the UK (UKIBIPS). The system enabled the collection of data from 183 participants over the 2013-2015 seasons, despite the potential numbers of players available to participate being over 2000. There were no other technologies required for the system to function and fulfil its role in achieving the data collection aim of the research.

The system successfully operated throughout the time period of the study with no technical issues for players. It stored the data safely and eliminated the time-onerous task of chasing down and collecting hard copy questionnaires. A total of 77 players logged on and registered for the 2014-2015 season.

The Principal Investigator had met with, spoke and presented to the national governing bodies in Ireland and the UK. With their endorsement, information packs with simple language documents were sent to clubs and, social media platforms were utilised to engage and recruit participants. Finally, follow up emails were sent to every National League club in the Ireland and the UK in a bid to maximise the number of players participating. Despite this effort, only 10% of the available population participated in this study.

Unlike US-based studies using Datalys, registration in this study was on a voluntary basis and thus the number of participants was outside the control of the Primary Investigator. The low participation rate was disappointing, especially when considering the approval received from basketball governing bodies.

In the first season of study, sign up at the pre-season testing was high. There was no pre-season testing in the second phase of study, so this may have influenced the number of players registered in 2014-2015. For the 2014-2015 season, there were no technical difficulties managing the system, and with additional functionality the Principal Investigator could export data directly into Excel for analysis. Player adherence to the system improved in the second year of observation with system usage by male players going from (9.33 ±12.23 to 19 ±13.04 weeks) and in female players from (12.06 ±12.70 to 20 ±12.91 weeks).

The problem faced by the Primary Investigator, as well as many others researchers, continues to be maximising the number of participants in a research study. With better engagement/adherence by participants, there is potential for integrated data 'curation' to address big epidemiology issues for the UK and Ireland. This will only be possible when governing bodies make participation mandatory in the interests of player welfare.

This is in sharp contrast to the US, where the Injury Surveillance System (ISS) has enabled the National Collegiate Athletic Association (NCAA) to collect and report on injury trends over extended periods of time, with a key difference being that it is a requirement that sports and athletes of the NCAA must participate in the ISS program. This requires athletic trainers or team therapists to upload information on their players weekly during the season. Agel, in her 2007 study was able to access records on all college basketball teams participating over a 16 year period (Agel *et al*., 2007b). In an NCAA report into college sports participation rates, there were 35,325 (m18,816/f16,509) registered college basketball players. In Dicks 2007 study, there were 997 teams and 16,028 male players participating across the three divisions (Dick *et al.*, 2007a), but again, participation was compulsory for all teams due to NCAA regulations.

Retrospectively, one strategy which may have increased participation and adherence would have been to offer an incentive to participants who registered and updated the system for the duration of the study, i.e. VIP tickets to a FIBA European final championship event.

Luig *et al*., in their sports injury report looking at the burden of sports injuries across the European Union, concluded that "without information about types of injuries and dominantly affected persons, no target prevention is possible". They also recommended that sports clubs and their federations at national as well as European level are invited to establish meaningful statistics for their own purposes (Luig *et al*., 2010). Luig previously made the recommendation to have all national associations include an injury prevention module in their education curriculums. In addition, they should designate an official staff member as “safety promotion ambassador” for the federation. They concluded that all injuries should be reported to club trainers and coaches. The coaches need to systematically record the data: 1) to help identify individual and situational risk factors, 2) to monitor injury trends and 3) to evaluate measures that have been put into place to reduce future injuries.

This author believes that the responsibility lies with FIBA Europe and national governing bodies to make participation in similar and future research studies an official requirement for all member countries. It is also recommended that the European Championships held yearly across all age groups is the ideal setting to instigate a European-wide injury surveillance protocol that could filter through to other levels of competition.

On reflection, the UKIBIPS-ISS is a data collection mechanism that is easy to use for both players and researchers. It encourages player engagement through timely automatic reminders by text and email. It is cost-effective to set up for any level of competition, adaptable to multiple sports and activities and provides the researcher with a way to analyse data without third-party intervention. It is a tool that allows the researcher to focus on their fieldwork and analysis rather than the mechanism of data collection to be used. The research study was not constrained by the ISS in any way. The system has demonstrated a proof of concept and returned all data inputted correctly. With better adherence, the UKIBIPS has the potential for that integrated data ‘curation’ necessary for a large scale epidemiology study.

The second part of the Van Mechelen model is to establish the aetiology and mechanisms of injury. The embedded questionnaire in the UKIBIPS-ISS was designed to collect data on rates, types and incidences of injury over a two year period. The rate of injury in this study per situation (Game/Training) was similar to other basketball research studies despite the low participant numbers. Total exposure time for all basketball activity over the two seasons was 22895 hours (12852m / 10043f). Total exposure time in games was 1822 (956m / 866f) and 21072 in training (11895m / 9177f). The overall incidence of injury calculated for all players was 7.56 per 1000 playing hours (7.94m / 7.06f). The incidence of injury for training for all players was 4.75 per 1000 training hours (4.88m / 4.58f). The incidence of injury during games for all players was 40.07 per 1000 playing hours (46.03m / 33.49f).

The incidence of injury in training was similar for males and females. However, male players had a higher incidence of injury in games compared to female players. The relative risk of injury in games was 9 times higher than in training for males and 7 times higher for females, despite the fact that both cohorts of players spent substantially more time in training than in games respectively (ratio of training:games was 12:1 m and 10.5:1 f). In training sessions and considering the total number of injuries (m+f) there is a higher level of contact injuries (93.7 or 75.6%) over non-contact injuries (62 or 58.3%) with P<0.006.

In two studies by Dick and Agel, they reported that the rate of injury in a game was almost two times higher than in training at 7.68 versus 3.99 per 1000 athlete exposures with a rate ratio of 1.9, 95% confidence interval 1.9, 2.0 (Dick *et al.*, 2007a; Agel *et al.*, 2007a). Many injuries in games are of a sudden onset nature with player contact the highest cause of injury. These injuries are not modifiable injuries.

In contrast, the evidence in this study describes a greater number of injuries at training than in games. While coaches demand a high level of commitment during training sessions and try to recreate game situations, they may inadvertently be contributing to player's injuries by not establishing controlled aggression within players. The coach needs to reflect on their sessions and how to get the best out of their players while still maintaining a high level of competition. The training session is a more controlled environment than a game. Therefore, it offers the best opportunity to introduce and embed basketball specific injury prevention programmes.

Additionally, in games, there is a higher level of contact injury occurring with 9.28 (7.70 incidence rate) compared to non-contact of 6.54 (6.33 incidence rate) and P< 0.022. This is similar to other studies which cite a greater number of contact versus non–contact injuries in games. As discussed previously, there are a number of uncontrollable factors to be cognisant of during games, such as opposition aggressiveness, level of competition being played, unsportsmanlike fouls, overtime and control/management of the game by referees. These contact injuries are an unfortunate but inevitable part of the game. Proper strength, conditioning and core programmes will better prepare the player for the known contacts that will happen in a game. This player conditioning is the only modifiable element in a non-modifiable injury situation and may alter the negative outcome from this type of contact.

As discussed earlier, the lower extremity is the most common region for injuries to occur in basketball players (Deitch *et al.*, 2006; Bove *et al.*, 2019; Cumps, Verhagen and

Meeusen, 2007). This study has reported similar findings with lower extremity injuries accounting for 68% of all injuries in males and 70% of all injury in females. The ankle was the most frequently injured site for both groups with a higher percentage of injury (30%) in female players compared to their male counterparts (23%). The knee was the second highest injured body part in both groups with male players suffering a higher rate of knee injury (22%) over their female counterparts (18%). The third highest injury location differed between both groups with 15% thigh injuries in males and 8% lower leg injuries in female players. The pattern of injuries was very similar across the two cohorts.

The most common injuries that occurred overall were ligament sprains (35%) particularly to the ankle and knee (21% of total male injuries, 28% of total female injuries), muscle strains (30%) particularly to the thigh and lower leg, and tendon injuries (8%). It has been estimated (Luig *et al.*, 2010) that the average cost of treatment for an injury is €700 euro which in turn would put an estimated cumulative cost of €30,800 on treatment of ankles alone. It has also been estimated that severe knee injuries have approximately €2,300 direct medical costs per case.

The UKIBIPS study concluded, in line with other international results, that the lower extremity, specifically the ankle, is most at risk of injury. It also finds that, unlike other geographical areas, there are more injuries during training time in Ireland and the UK. It has confirmed for Ireland and the UK that the “big men” in the Key area are the most susceptible to injury.

Eils *et al*. have shown that a simple propreoceptive programme can reduce the incidence of ankle injuries (Eils *et al.*, 2010). Riva stated that the introduction of systematic propreoceptive activity in a training routine resulted in a statistical reduction in the occurrence of ankle sprains by 81% from the first to the third biennium ($p<0.001$). They concluded that improvements in propreoceptive control in a single leg stance may be a key factor for effective reduction in ankle sprains, knee sprains and lower back pain (Riva *et al.*, 2016). The Single Leg Balance Test can be used to identify ankle instability and implementing a simple propreoceptive programme to improve balance can help reduce injury.

This author, in his experience, has found that one of the reasons that teams do not implement injury prevention programmes is a lack of resources, specifically time and money. Both the Single Leg Balance Test and a propreoceptive exercise programme require no equipment and could be used by any team with minimal impact on budget and training time. Therefore, this combination is one that could serve as a basic, low-cost, low-time injury prevention programme for teams at every level.

Pre-season team assessments were carried out prior to the commencement of the 2013-2014 season. The lower extremity was the focus of the assessment as this area has been identified as the most injured region among basketball players. Prior to this, there were no other studies in Ireland or the UK which provided data on pre-season testing. Fitness, balance, functional movement, muscle tightness and orthopaedic special tests were included. The test results returned a high rate of failure among the players. These tests are indicators of injury. However, when these players test results were compared with their injuries sustained over a season, it did not show a strong relationship between the number of failed tests and the total number of injuries to the relevant body part for that test. This may be as a result of the low numbers involved and may not represent the true predictive value of the testing with a much larger cohort. Regardless of the results of the tests individually, the testing data gathered did present an analysis opportunity to examine potential relationships between the tests themselves.

The subsequent cluster analysis carried out provided a dendogram which identified relationships that existed between tests. As discussed in detail in Chapter 5, the relationships between the tests mean that a subset could be chosen by the qualified practitioner to have maximal coverage of risk factors being tested at any given time. The tests included in the study are binary in the nature of their results. This means that a non-qualified person could test the players in an unobtrusive way during the season after the qualified practitioner has selected the most appropriate tests for that team.

While there is a preponderance of factors contributing to player injury, we can more effectively address a structured research question on a clearly defined type of injury that may have controllable risk factors like the previously discussed intrinsic modifiable personal injury risk variables. The study provided useful data from the model designed to look at an ankle injury. Information attained from injury and test data in this cohort would allow the sports management team to introduce simple pre-season conditioning strategies on balance, hamstring flexibility and gluteal strengthening to reduce ankle injuries.

Other research questions on other specific injuries sustained may also be addressed through similar methods using the same model matrix. A practitioner with information on useful predictors of ankle injury has the ability to guide individual training needs for the player. The research gathered on PPE testing shows that non-professional management personnel can use valid simple field tests to identify players for further injury risk evaluation. Simple single leg balance tests, gluteal strengthening and lower fibre hamstring flexibility can be integrated into a team's training and would ensure that certain musculoskeletal needs were being addressed as part of a weekly training session without being perceived as an interference by a coach who has time burden constraints. Reflecting on the results of this study, including simple training exercises could lead to a reduction in modifiable non-contact injuries sustained.

The work presented in this study highlights for the first time data on incidence rates and types of injury occurring across all age groups and genders in Ireland and the UK. The newly designed UKIBIPS-ISS software was efficient and reliable in meeting the data collection requirements of the Principal Investigator. The role of injury prevention is the responsibility of all stakeholders in the game of basketball. The technology now exists to gather data on injury in Ireland and the UK. Governing bodies need to establish injury prevention strategies and include them in their policies. A recommendation to move this process forward would be to create a policy group made up of a dedicated team of researchers across the four home nations. They would be best positioned to establish policies on injury surveillance and injury prevention. These changes would allow researchers to collect data which could be supplemented with further studies and then used to inform coaches, trainers, players, and the sport's governing bodies. With this knowledge, changes can occur in all levels of the game, whether it is adjusting training sessions, methods of conditioning or, most importantly, educating players on their responsibility as part of a personal injury prevention programme. The key to these recommendations being implemented lies with the governing bodies.

This study has produced an athlete data management system to enable statisticians to work with high-quality data. The case study on ankle injuries gives a brief glimpse of the type of data that can be generated using the UKIBIPS-ISS. A high-quality Injury Surveillance System can be used to build a high-quality injury prevention programme to extend playing careers and contribute to a healthy and safe participation across the life span.

Appendices

Appendix 1: Risk Factors in Basketball Studies over 30 Years

Author	Study	Player position	Footwear	Age of footwear	Court location	Games	Practice	Length of season	Time of injury	Protective gear	Landing	Warm up	Not Stretching	Seasons played	Player contact	Rebounding	Facilities	Competition level	Preseason training
1. Meeuwisse et al	2003	✓			✓	✓									✓				
2. McKay et al	2001		✓								✓		✓						
3.Agel, et al	1988-2004					✓	✓	✓			✓				✓				
4.Borowskiet et al	2008					✓					✓					✓			
5. Messina, et al	1999					✓													
6. Murphy et al	2003					✓													
7. Agel, et al	2005																		
8. Yeh et al	2012																		
9. Krosshaug et al	2007																		
10. Deitch et al	2006					✓	✓										✓		
11. Trojian et al	2006																		
12. Hosea et al	2000																	✓	
13. NCAA ISS	2001-2001																		
14.Hewett,	2000																		
15. McKay	2001																	✓	
16. Barrett et al	1993		✓																
17. Witvrouw et al	2001																		
18. Kofotolis et al	2007	✓			✓										✓				
19. McGuine et al	2000																		
20. Randal	2007					✓									✓				✓
21 Cumps et al	2007	✓									✓								
22 Bastos et al	2014																		
23 Bastos et al	2013	✓																	

Author	Study	Age	Weight	Height	Gender	Race	Flexibility	Previous injury	Skill level	Laxity	Limb alignment	Strength	Hormonal differences	Balance
1. Willem H. Meeuwisse et al	2003							✓						
2. G D McKay	2001							✓						
3. Julie Agel, et al	1988-2004							✓						
4. Borowskiet al	2008				✓									
5. Messina,	1999				✓									
6. Murphy et al	2003				✓			✓						
7. Agel, et al	2005				✓									
8. Yeh et al	2008		✓											
9. Krosshaug	2007				✓					✓				
10. Deitch et al	2006		✓	✓							✓	✓	✓	
11. Trojian et al	2006					✓								
12. Hosea et al	2000								✓					
13. NCAA ISS	2001 - 2002				✓									
14. Hewett el al	2000				✓									
15. McKay, et al	2001				✓									
16. Barrett et al	1993						✓	✓		✓				
17. Witvrouw et al	2001						✓	✓		✓				
18. Kofotolis et al	2007							✓						
19. McGuine et al	2000													✓
20. Randal	2007													
21 Cumps et al	2007							✓						
22. Bastos et al	2014	✓												
23 Bastos et al	2013													

Appendix 2: South African Rugby Union Injury Prevention Data Capture Sheet

NAME: ______________________**AGE:** _____ **SQUAD:** __________ **POSITION:** ___________

DETAILS	**TEST 1**		**TEST 2**		**TEST 3**	
ANTHROPOMETRY	Date:		Date:		Date:	
Height (cm)						
Weight (kg)						
SKINFOLDS(mm)						
Bicep						
Tricep						
Subscapula						
Suprailiac						
Abdominal						
cm up leg for thigh measurement						
Thigh						
Calf						
CIRCUMFERENCES (cm)						
Mid thigh						
Calf						
Forearm						
FLEXIBILITY	R	L	R	L	R	L
Sit & Reach (cm)						
SLR						
Illiopsoas						
Quadriceps						
POWER	Reach height	Jump height	Reach height	Jump height	Reach height	Jump height
Vertical Jump (cm)						
Standing broad jump (cm)	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2

SPEED	Trial 1		Trial 2		Trial 1		Trial 2		Trial 1		Trial 2	
	10	40	10	40	10	40	10	40	10	40	10	40
10 & 40M speed (sec)												
AGILITY	Trial 1		Trial 2		Trial 1		Trial 2		Trial 1		Trial 2	
Illinois agility (sec)												
MUSCLE STRENGTH	Wt		Reps		Wt		Rep		Wt		Rep	
Bench Press (kg)												
Parallel Squat (kg)												
MUSCLE ENDURANCE												
Pull ups (max)												
Flexed arm hang (sec)												
Push ups (60 sec)												
Sit ups (120 sec)												
Sit ups (60 sec)												
CARDIORESPIRATORY FITNESS	Test 1				Test 2				Test 3			
Multistage shuttle run (shuttles)												
3km time trial (minutes and seconds)												
REPEAT SPRINT ABILITY												
5m shuttle run	Test 1				Test 2				Test 3			
Run1												
Run2												
Run3												
Run4												
Run5												
Run6												

Appendix 3: Scope Review Email Query

To whom it may concern,

By way of introduction my Name is Michael Lynch and I am presently reading for my PhD at the University of Glasgow.

My area of research interest is in sports injury surveillance, pre-participation screening and injury prevention.

As part of my present work I am carrying out a scope review of Injury surveillance systems in use in team ball sports. I am looking to collect information on the following.

- Is Injury Surveillance carried out by the governing body/ senior professional league in your sport?
- Is data collected through paper reports or through an electronic?
- What are the variables/queries included in your system?
- Who records the data and how often?
- How is data collected on injury expressed when analyzed –i.e. athletic exposure or per 1000hrs?
- Is there a possibility to allow me access your system via a link to view or try it?

If possible I would be grateful if you were in a position to provide me with any of the above information, or if possible advise me on who may be best positioned to help me with my queries. Thank you for taking the time to consider the above.

<u>My Supervisors</u>

Professor Jason Gill
Professor of Cardiometabolic Health (Institute of Cardiovascular & Medical Sciences)
Associate (Institute of Health & Wellbeing)
Associate (School of Life Sciences)
University of Glasgow

Dr John MacLean
Director of the National Sports Injury Clinic, Hampden National Stadium
Clinical Senior Lecturer in Sport and Exercise Medicine, University of Glasgow
Kind Regards

Appendix 4: ATS Injury Surveillance System Pricing List

ATS Pricing & Purchase Options

Current Pricing

One-Time Cost(s)**			
ATS Suite	1 User	$	695.00
	2+ Users	$	995.00

Includes All Current Modules

Hosting/Support/Maintenance		
Number of Users*	Annual Fees	
Single	$	300.00
2-8	$	640.00
9-15	$	900.00
16-25	$	1,500.00
26-35	$	2,000.00
36-50	$	2,750.00
51-80	$	3,600.00
81-120	$	5,200.00
121-150	$	6,500.00
151-200	$	8,500.00
201-250	$	11,000.00
250+	Call	

Startup cost breakout

Number of Users*	1-Time Purchase	Annual Fees	Total Starting Cost
Single	$ 695.00	$ 300.00	$ 995.00
2-8	$ 995.00	$ 640.00	$ 1,635.00
9-15	$ 995.00	$ 900.00	$ 1,895.00
16-25	$ 995.00	$ 1,500.00	$ 2,495.00
26-35	$ 995.00	$ 2,000.00	$ 2,995.00
36-50	$ 995.00	$ 2,750.00	$ 3,745.00
51-80	$ 995.00	$ 3,600.00	$ 4,595.00
81-120	$ 995.00	$ 5,200.00	$ 6,195.00
121-150	$ 995.00	$ 6,500.00	$ 7,495.00
151-200	$ 995.00	$ 8,500.00	$ 9,495.00
201-250	$ 995.00	$ 11,000.00	$ 11,995.00
250+	$ 995.00	Call	$995 + Call

Notes:
- **Annual Support is included in the hosting fee**
- **On-site installation is not**
- **Customers outside of the United States must "Self Assess" and pay any applicable taxes**
- **Initial purchase includes 2 hours of training via a GoTo meeting**
- **One-time purchase price is non-refundable**

* **For ATS purposes; a "billable user" is defined as someone entering or updating information.
This typically includes athletic trainers and strength/conditioning coaches;
It does not include anyone with read-only access rights, students or doctors.**
Note: Graduate Assistants working in an outreach program are considered billable users

** **1-time purchase is a license to use the ATS Software as long as the annual fees are maintained**

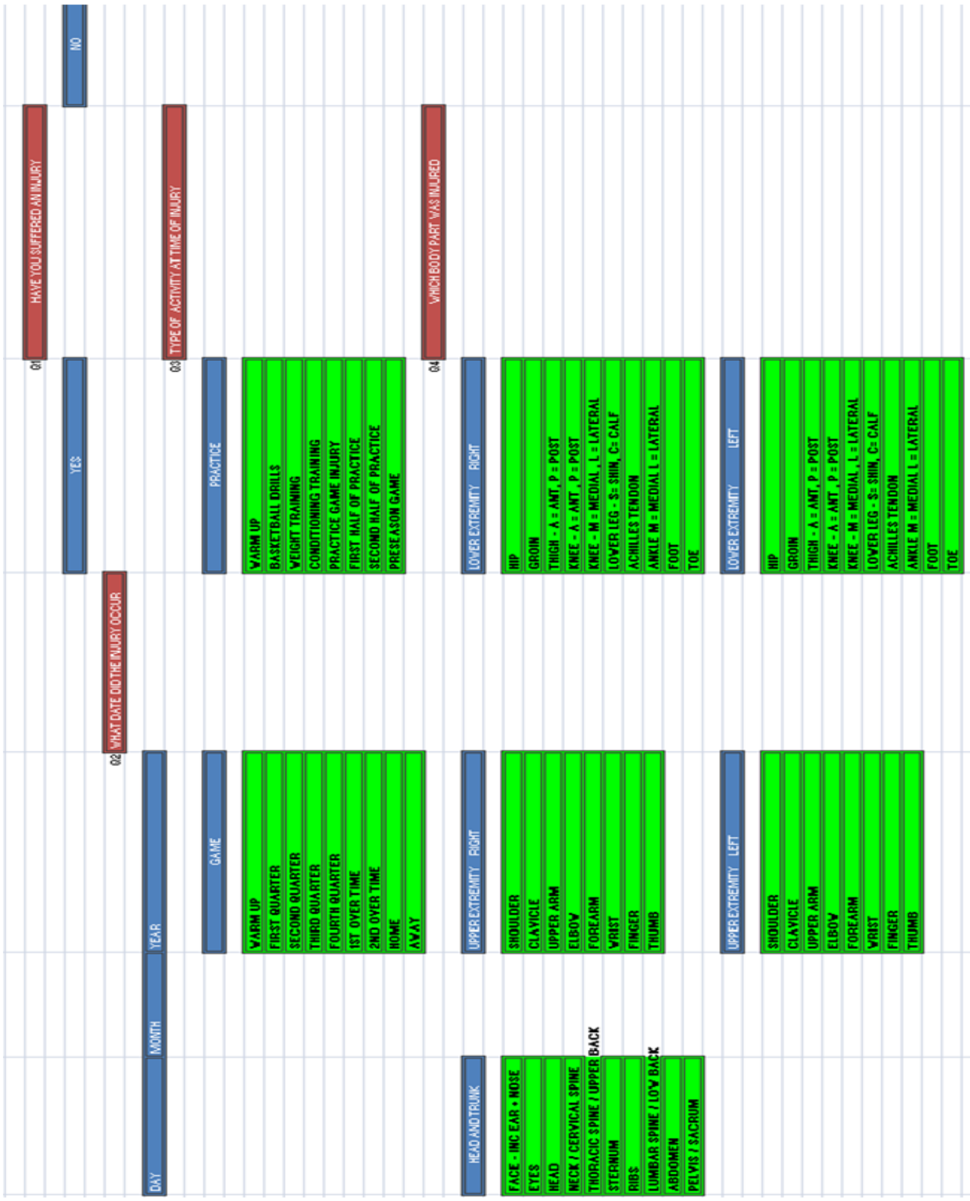
*** **Annual fees shown are for our standard database configuration. Having the database encrypted "at rest" is an option and doubles the annual fee.**

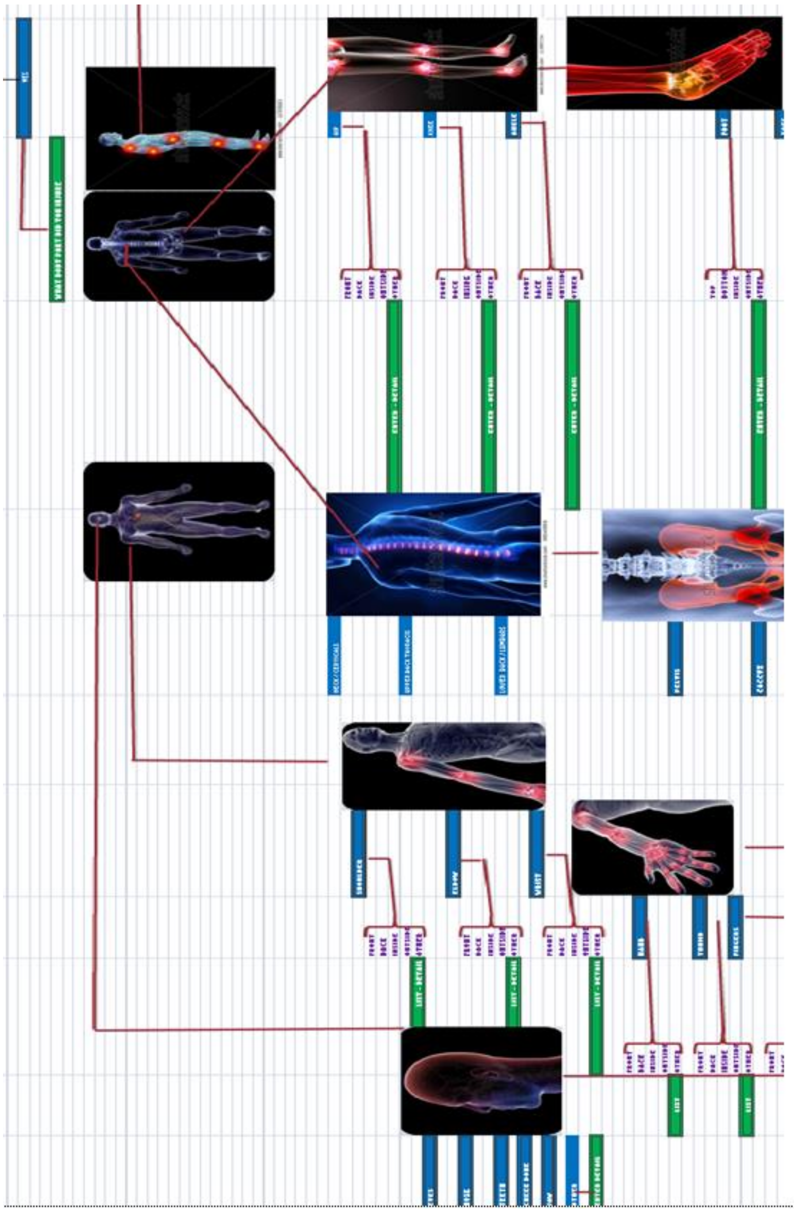
Prices are in US Dollars and are subject to change

Appendix 5: Orchard Sports Injury Classification System

https://www.johnorchard.com/resources/OSICS10version1.pdf

Appendix 6: GMIT Questionnaire Collaboration





Appendix 7: Participant Information Sheet

University of Glasgow | College of Medical, Veterinary & Life Sciences

PARTICIPANT INFORMATION SHEET

The United Kingdom and Ireland Basketball Injury Prevention Study (UKIBIPS) (Part I)

Investigators: Michael Lynch, Dr John Maclean, Dr Jason Gill

You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

What is the purpose of the study?

Basketball has the highest incidence of injury of all non-contact sports (3 – 6 injuries per 1000 hours of play with a conservative estimated annual cost of € 500 million per year in European basketball). However, there is a lack of research data on basketball injuries occurring in Ireland and the UK and how these might be prevented. The aim of Part I of the UKIBIPS: (a) to systematically monitor injury incidence in basketball in the UK are Ireland and (b) determine whether screening procedures can help to identify players at increased risk of injury.

Once Part I of the UKIBIPS is completed, we aim, in Part II of the UKIBIPS to develop and implement new injury prevention programmes in players identified to be at high injury risk.

Why have I been chosen?

The study is being carried out with the players of the National / Super Leagues and underage International Basketball Teams in the UK and Ireland. You (or your child) have been selected as a potential participant for this study as you are player from one of these teams. The Basketball Associations of Ireland, Scotland, England and Wales support this research.

Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part, you are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will not affect the standard of care you receive.

What will happen to me if I take part?

We will ask you to log on and register to the UKIBIPS online injury surveillance system. Once you are registered, you will receive an email or text message once per week asking you to log on once per week from the start of pre-season training until the end of the competitive season to log any injuries that you have suffered. You will be guided through a list of questions to provide specific details of any injuries.

Players from some teams will also be asked to participate in a pre-season injury risk assessment session. The assessment circuit is made up of 7 stations: 1] Bleep test, 2] muscle tightness, 3] single leg balance test, 4] Functional movement testing, 5] Y balance testing, 6] ankle joint range of movement testing, and 7] Optojump test. The tests will involve you performing a variety of exercises, mostly involving jumps balance tests, and a fitness test, which will be carried out by a qualified team of assessors.

What are the possible disadvantages and risks of taking part?

There are no risks associated using the online injury surveillance systems.

There may be very small risks of injury associated with the testing phase of the study as you will be asked to undertake exercise test to determine if any dysfunctional movement patterns exist. However, these risks are no greater than you would encounter in a normal training session or game.

Any player suffering from an injury at the time of the assessment will not be asked to participate in the study. Michael Lynch, a qualified physiotherapist, or another suitably qualified individual, will be on site when all injury risk assessments are taking place.

What are the possible benefits of taking part?

There may be no direct benefits to you but the findings will help research into how we can prevent injuries in basketball. The results of Part I of the UKIBIPS will be used to help design new injury prevention programmes in players identified to be at high injury risk.

Will my taking part in this study be kept confidential?

All information that is collected about you as a player during the course of the research will be kept strictly confidential. You will be identified by an ID number and any information about you will have your name and address removed so that you cannot be recognised from it. All the information will be stored safely and protected through encrypted coded programmes and passwords in line, with the Data Protection Authority's requirements.

What will happen to the results of the research study?

The findings of this study will help us to better understand to prevent injuries in basketball and will be presented at medical conferences and published in medical journals. All Basketball Associations participating in the study will be provided with a report which will be available to each club. No individual player team or club will be identifiable in any report or publication.

Who is organising and funding the research?

This project is being carried out by Michael Lynch, MSc, who is a PhD Student at the Institute of Cardiovascular Medicine and Medical Sciences, at the University of Glasgow. Michael's PhD is being supervised by Dr John MacLean (Director of the National Sports Injury Clinic, Hampden National Stadium and Clinical Senior Lecturer in Sport and Exercise Medicine, University of Glasgow) and Dr Jason Gill (Reader in Exercise Science, University of Glasgow). The project has not received any external funding.

Who has reviewed the study?

This study has been reviewed and approved by the College of Medical, Veterinary and Life Sciences Ethics committee at the University of Glasgow.

Contact for Further Information

Any questions about the procedures used in this study are encouraged. You will be given a copy of this information sheet and a signed consent form to keep for your records. If you have any doubts or questions, please ask for further explanations by contacting either:

Michael Lynch, MSc, (Principal Investigator) - m.lynch.2@research.gla.ac.uk

Dr John MacLean, (Supervisor) - John.MacLean@SportsMedicineCentre.Org

Dr Jason Gill (Supervisor) - Jason.Gill@glasgow.ac.uk

Thank you for your time, effort and valuable contribution to this research study.

Appendix 8: Application Form For Ethical Approval

University of Glasgow | College of Medical, Veterinary & Life Sciences

College of Medical, Veterinary & Life Sciences Ethics Committee for Non-Clinical Research Involving Human Subjects

APPLICATION FORM FOR ETHICAL APPROVAL

NOTES:

THIS APPLICATION FORM SHOULD BE TYPED NOT HAND WRITTEN.

ALL QUESTIONS MUST BE ANSWERED. "NOT APPLICABLE" IS A SATISFACTORY ANSWER WHERE APPROPRIATE.

PROJECT CODE:

Project Title: The United Kingdom & Ireland Basketball Injury Prevention Study (UKIBIPS). Part I

Has this application been previously submitted to this or any other ethics committee?

No

If 'Yes', please state the title and reference number

Is this project from a commercial source, or funded by a research grant of any kind?

No

If 'Yes',

a) **Has it been referred to Research & Enterprise?**
   Has it been allocated a project Number?
b) **Give details, and ensure that this is stated on the Informed Consent Form.**

Insurance Restrictions:

The University insurance cover is restricted in certain, specific circumstances, e.g., the use of hazardous materials, work overseas and numbers of participants in excess of 5000. All such projects must be referred to Research and Enterprise before ethical approval is sought.

Date of submission: 11/06/2013

Name of all person(s) submitting research proposal:

Michael Lynch

Dr Jason Gill

Dr John McLean

Position(s) held:

PhD Student

Reader in Exercise Science

Honorary Clinical Senior Lecturer in Sports Medicine

School/Group/Institute/Centre:

Institute of Cardiovascular and Medical Sciences

Address for correspondence relating to this submission:

BHF Glasgow Cardiovascular Research Centre

Institute of Cardiovascular and Medical Sciences

College of Medical, Veterinary and Life Sciences

University of Glasgow

Glasgow

G12 8TA

Email address: m.lynch.2@research.gla.ac.uk

Name of Principal Researcher (if different from above, e.g., Student's Supervisor):

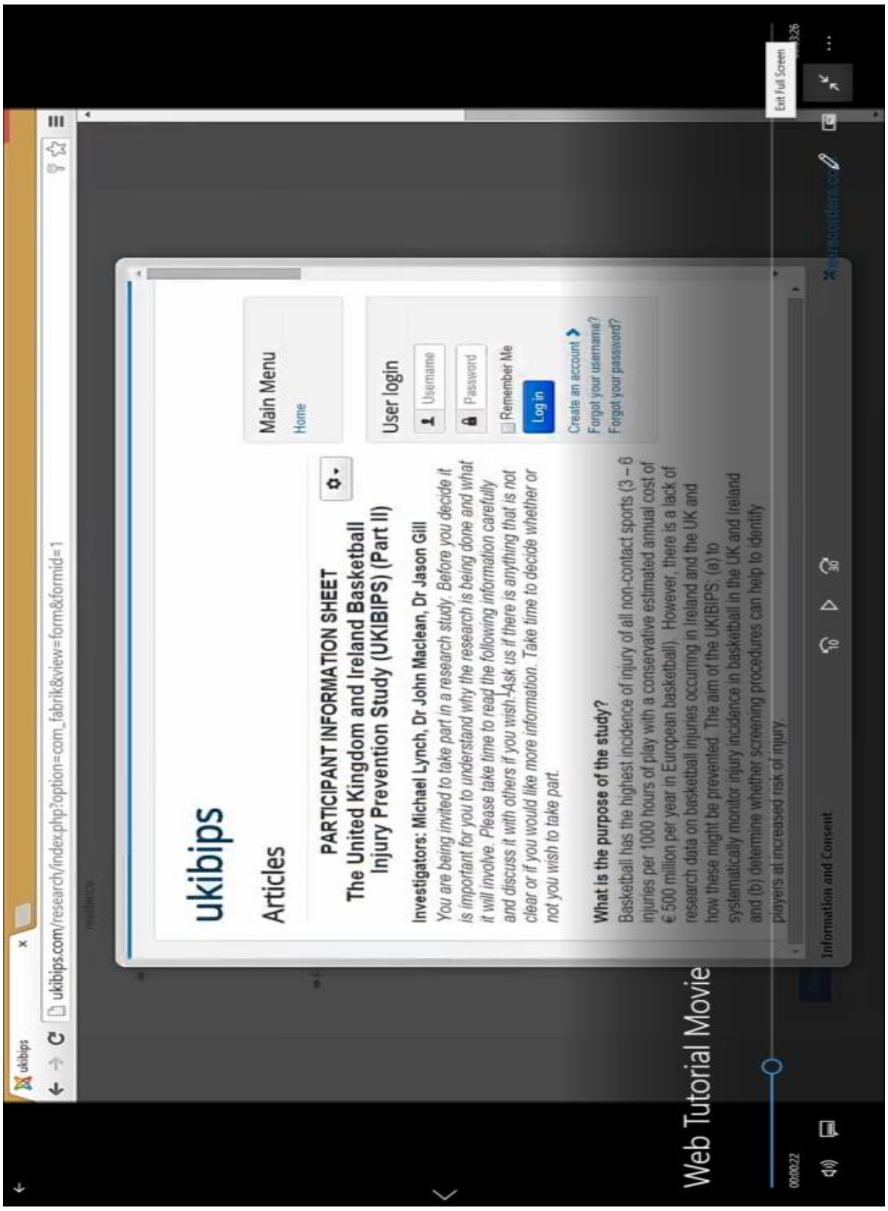
Position held:

Undergraduate student project: No

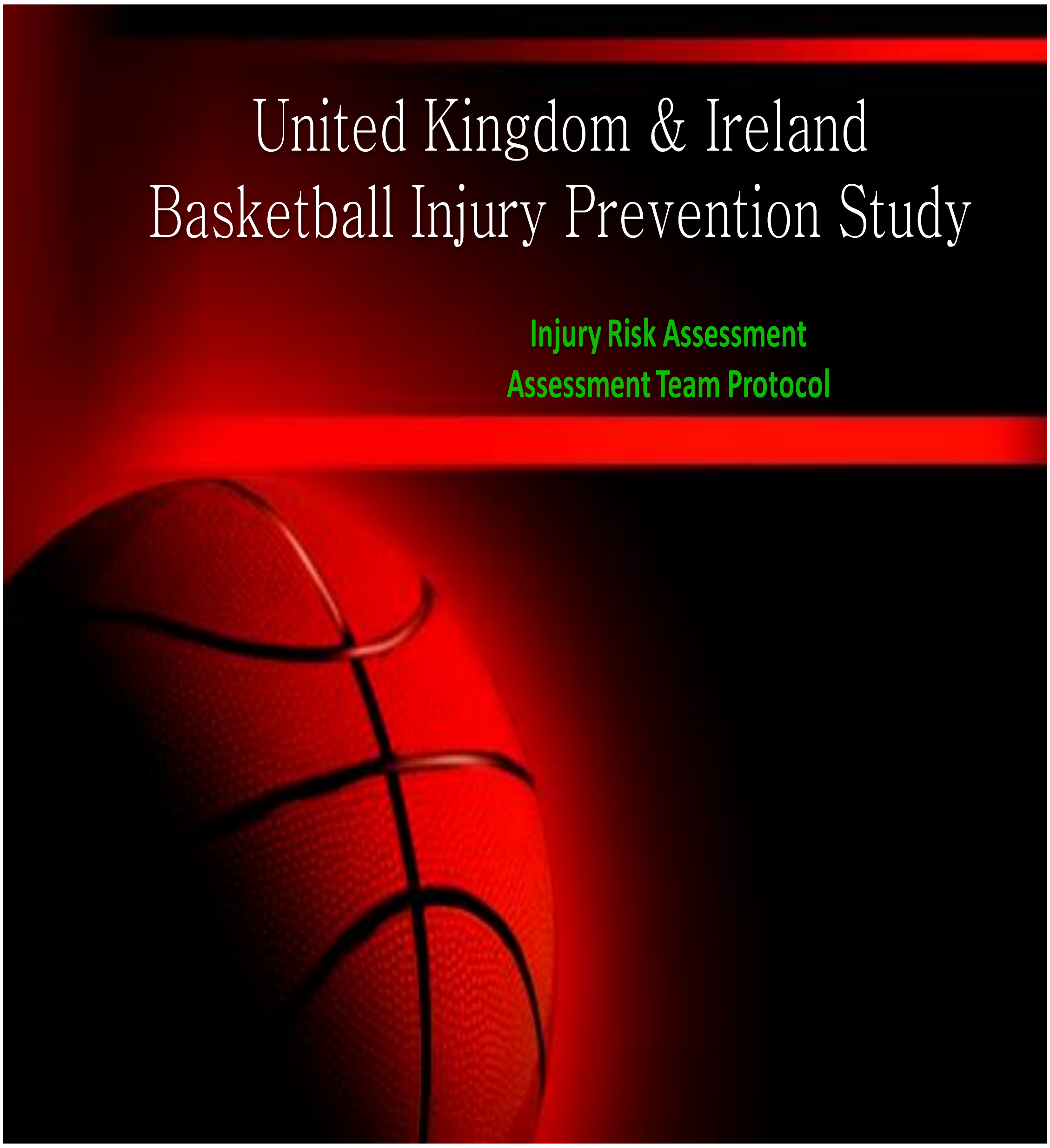
If 'Yes', please state degree being undertaken: **NA**

Postgraduate student project: Yes

Appendix 9: Participant Informed Consent 2014 - 2015



Appendix 10: UKIBIPS Assessment Manual



The following document has been prepared for the UKIBIPS injury risk assessment team. Each assessment station has been described in detail. We will ask each assessor on the day of testing to record the results of the players test scores on both a hard copy as well as electronic equipment where indicated. All players participating will be registered on arrival and will display their name and registration number on an ID tag. Before commencing the assessment, the assessor will be asked to check the players name and number against the registration sheet at their station.

All results will be stored in a folder at each station until the end of the testing session and the test records will be handed over to the Principal Investigator, who will then check this data against the data collected electronically. All records must be written in black ink.

Thank you for your valuable assistance and time with this research study.

Kind regards

Dr John MacLean
Director of the National Sports Injury Clinic, Hampden National Stadium
Clinical Senior Lecturer in Sport and Exercise Medicine, University of Glasgow

Dr Jason Gill
Reader in Exercise Science, University of Glasgow

Michael Lynch, MSc
PhD student, University of Glasgow
Director of Galway Physical Therapy Clinic
Principal Investigator, UKIBIPS

Test 1

Functional movement screening [FMS]

Seven tests in total with two clearing tests. Begin by measuring the height of the tibia tuberosity from the ground of the player in a standing position. Record the length of the hand from the top of the middle finger to the wrist. The (FMS) consists of a four- point scale system.

3 points = perfect performance

2 points = minor deficits or perfect performance with modifications

1 points = inability to perform the exercise

0 points = in all tests, prevalence of <u>pain</u> indicates a zero

Protocol –

- Three attempts are performed for each test, with the highest score recorded
- If a score of 3 is scored on any test no further repetitions are required
- For the tests that are divided for a left or right score the lower of the two scores is used for the final score
- The maximum score is 21

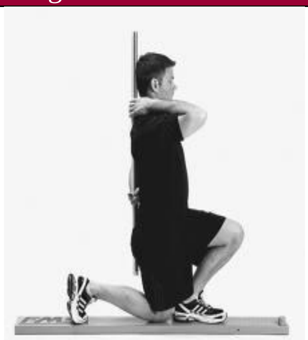
1. Deep Squat

Deep Squat	3 points	2 points	1 point	0 points
	Upper Torso is parallel with tibia or towards vertical Femur below horizontal Knees aligned with the feet Dowel aligned within footprint	Upper Torso is parallel with tibia or towards vertical Femur below horizontal Knees aligned with the feet Dowel aligned within footprint *with modification	Upper Torso and tibia are not parallel Femur is not below horizontal Knees are not aligned over the feet Lumbar flexion is noted	Pain experienced during test

2. Hurdle Step

Hurdle Step	3 points	2 points	1 point	0 points
	Hips, knees and ankles remain aligned in the sagittal Minimal to no movement is noted in lumbar spine Dowel and hurdle remain parallel	Alignment is lost between hips, knees and ankles Movement is noted in lumbar spine Dowel and hurdle do not remain parallel	Contact between and hurdle Loss of balance is noted	Pain experienced during test

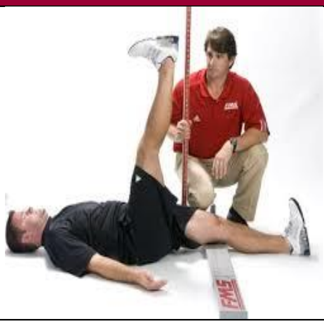
3. Lunge

Lunge	3 points	2 points	1 point	0 points
	Dowel contacts remain with L-spine extension No torso movement is Noted Dowel and feet remain in sagittal plane Knee touches board behind heel of front foot	Dowel contacts do not remain with L-spine Extension Movement is noted torso Dowel and feet do not remain in sagittal plane Knee does not touch board behind heel of front foot	Loss of balance is noted	Pain experienced during test

4. Shoulder Mobility Test

Shoulder mobility test	3 points	2 points	1 point	0 points
	Fists are within one hand length	Fists are within one and a half hand lengths	Fists are not within one and a half hand lengths	Pain experienced during test

5. Active SLR

Active SLR	3 points	2 points	1 point	0 points
	Ankle/dowel reside between mid-thigh and ASIS	Ankle/dowel reside between mid-thigh and mid patella/ joint line	Ankle/dowel reside below mid patella/ joint line	Pain experienced during test

6. Trunk Stability Press-Up

Trunk Stability Press-Up	3 points	2 points	1 point	0 points
	Males perform 1 repetition with thumbs aligned with the top of the forehead Females perform 1 repetition with thumbs aligned with chin	Males perform 1 repetition with thumbs aligned with the chin Females perform 1 repetition with thumbs aligned with clavicle	Males are unable to perform 1 repetition with thumbs aligned with the chin Females are unable to perform 1 repetition with thumbs aligned with clavicle	Pain experienced during test

7. Rotatory Stability Test

Active SLR	3 points	2 points	1 point	0 points
	Performs 1 correct unilateral repetition while keeping spine parallel to board Knee and elbow touch in line over the board	Performs 1 correct diagonal repetition while keeping spine parallel to board Knee and elbow touch in line over the board	Inability to perform diagonal repetition	Pain experienced during test

<u>Impingement clearing test</u>

The athlete puts a palm on the opposite shoulder and lifts the elbow as high as possible while keeping the palm touching the shoulder. If pain is present a positive is recorded.

<u>Posterior rocking clearing test</u>

The athlete starts on hands and knees and rocks back to touch buttocks to heels and chest to thighs. Hands remain in front of the body stretched out as far as possible. If pain is present, a positive test is recorded.

Push up clearing test

The athlete performs a press-up in which they push their upper body off of the ground, but keeps their quadriceps on the ground. If pain is present, a positive is recorded

FMS testing chart

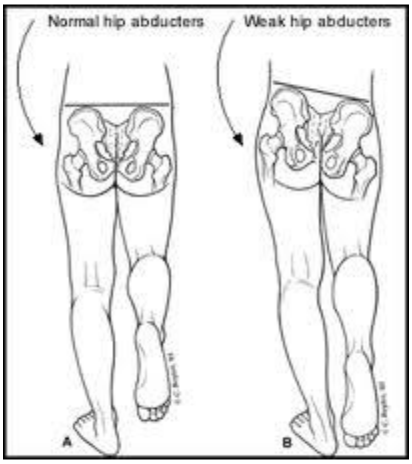
Name	Height			Weight			Hand leg dominance
FMS	FMS			FMS			FMS
Test	Raw Test Score Left			Raw Test Score Right			Final test Score
Deep Squat							
Hurdle step							
Lunge							
Shoulder Mobility Test							
Impingement clearing Test							
Active SLR							
Trunk stability Press Up							
Press up clearing test							
Rotary stability Test							
Posterior rocking clearing test							
Hand length							
Tib tuberosity height							

Test 2

Muscle Hypertonicity Testing & Orthopaedic Tests

This station consists of 13 muscle tests

1. Trendelenburg test: Positive if the PSIS on unsupported side drops.



2. Tensor fascia late (TFL) test: Player sideling knee flexed to 90 degrees and ankle supported by assessor. If knee remains in this position or fails to drop toward table consider the TFL muscle positive for tightness.

3 + 4. Psoas and Rectus Femoris muscle test

The player is tested in the supine position. If the hip remains in a flexed position consider the psoas muscle positive for tightness. In this test position consider rectus femoris positive if the knee is held in greater than 90 degrees of extension.

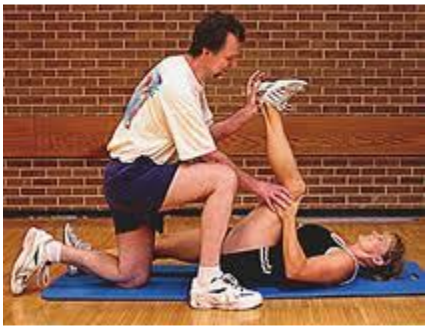
5. Vasti group test: Player prone position. Assessor brings the heel of the player passively towards the glutes. An inability to touch the heel with the glutes [Excluding muscle opposition} may be considered a positive test for tightness

6 + 7. Gastro + Soleus: player supine test position. Soleus tested with knee in flexion and considered positive for tightness if the assessor is unable to achieve passive dorsiflexion past 90 degrees. The gastrocnemius is tested with the player in a supine position with the knee in full extension. If the assessor is unable to achieve passive dorsiflexion past 90 degrees consider the Gastrocnemius positive for tightness.

8. Upper Hamstring fibers test: Player in a supine position. Assessor lifts the players fully extended leg with the opposite leg flat on the floor. An inability to achieve 90 degrees indicates tightness in the upper fibers of hamstrings.

9. Lower hamstring fibre test: Player in a supine position. Assessor brings the players knee toward the player's chest and holds it in this position. At the same time the

assessor tries to bring the players knee into extension. An inability to reach 90 degrees of extension indicates tightness in the lower fibers of the hamstring.



10. Medial hamstring fibers muscle test: Player supine. Assessor brings hip into abduction. An inability to achieve 45 degrees of abduction or greater is an indication of tightness in the medial fibers of the hamstrings.

11. Adductor muscle group: As with the medial hamstrings the player is tested in a supine position. Assessor brings hip into abduction, and lets the lower leg into 90 degrees of flexion off the table. An inability to achieve 45 degrees of abduction or greater with the knee in flexion is an indication of tightness in the adductor muscles.

12. Piriformis muscle: Player is tested in a supine position. Align the payer by asking them to flex their knees and bring both ankles together while keeping their feet flat

on the table, then lift their buttocks off the table for a moment and then return again. Ask player to fully extend both knees. The assessor lifts both legs off the table and gently lets the feet fall back to the table. If one or both feet go into an externally rotated position consider the piriformis muscle to be tight.

13. Leg length discrepancy test: Player in a supine test position. Align the player by asking them to flex their knees and bring both ankles together while keeping their feet flat on the table. If there is a difference in height between both knees we must consider a longer tibia on the higher side. If one knee is more anterior than the other we must consider a longer femur.

    A second method is to measure the player from their A.S.I.S to the medial malleolus and see if there is a difference in this measurement indicating a possible leg length discrepancy. Finally with equal traction on both ankles compare both the left and right malleolus to see if they are in alignment. If not consider a leg length discrepancy.

Testing chart for muscle + orthopaedic testing

Muscle + Orthopaedic test	Left /Positive/-negative	Right / Positive/-negative
Trendelenburg test		
Tensor fascia late		
Psoas		
Rec fem		
Vasti group		
Gastro		
Soleus		
Hamstrings lower fibers		
Upper hamstrings fibers		
Medial hamstring fibers		
Piriformis		
Adductors		
Leg length discrepancy test		

<u>Test 3</u>

Single leg balance test:

The Single Leg Balance test can be defined as standing on one foot without shoes with the contralateral knee bent and not touching the weight bearing leg; the hips remain level to the ground; the eyes open and fixed on a spot marked on the wall; and then the eyes are closed for 10 seconds. The athlete reports any sense of imbalance. The investigator notes if the athlete's legs touched each other, the feet moved on the floor, the foot touches down, or the arms moved from their start position. If the athlete has a positive test (fails to remain balanced or described a sense of imbalance) during their first trial, a second trial is carried out, with the results of the second trial counting (positive or negative) for analysis. Both legs are tested. An SLB test is considered positive if the athlete was unable to carry out the test on either or both legs.

Single leg balance test card

Single leg balance test	Left /Positive/-negative	Right / Positive/-negative
First test		
Second test		
Final Result		

Test 4

Y balance Test

Players practice six trials on each leg in each of the three reach directions prior to formal testing. The subjects are tested within 20 minutes of practicing. All subjects are not to wear shoes during the performance of the test. The subjects stand on one leg on the center foot plate with, the most distal aspect of the foot at the starting line. While maintaining single leg stance, the subject is asked to reach with the free limb in the anterior, posteromedial and posterolateral directions in relation to the stance foot.

Testing protocol

The testing order involves three trials standing on the right foot reaching in the anterior direction
(Right anterior reach) followed by three trials standing on the left foot reaching in the anterior direction. This procedure is repeated for the posteromedial and the posterolateral reach directions.

The maximal reach distance is measured by reading the tape measure at the edge of the reach indicator, at the point where the most distal part of the foot reached. The trial is discarded and repeated if the player:

5) Fails to maintain unilateral stance on the platform (e.g. touches down to the floor with the reach foot or fell off the stance platform)

6) Fails to maintain reach foot contact with the reach indicator on the target area while it was in motion (e.g. kicked the reach indicator),

7) Uses the reach indicator for stance support (e.g. places foot on top of reach indicator)

8) Fails to return the reach foot to the starting position under control. The starting position for the reach foot is defined by the area immediately between the standing platform and the pipe opposite the stance foot.

Lower leg length

Ask the player to lie supine on a plinth. On a mat table with the subject supine, the subject lifted the hips off the table and returned them to starting position. Then, the examiner passively straightens the legs to equalise the pelvis. The subject's right limb length is then measured in centimetres from the anterior superior iliac spine to the most distal portion of the medial malleolus with a cloth tape measure.
Since reach distance is related to limb length, reach distance is normalised to limb length. To express reach distance as a percentage of limb length, the normalised value is calculated as reach distance divided by limb length then multiplied by 100. Composite reach distance was the sum of the three reach directions divided by three times limb length, and then multiplied by 100

Greater than 4 cm right/left difference in anterior direction: > 2.5 times more likely to be injured

The Move 2 Perform software system will be used to analyse the data to see if player is at risk of lower leg injury

Score Sheet for Y Balance Test & Limb Length

Movement	Left	Right	Difference	Right leg length
Anterior				
Posteriomedial				
Posteriolateral				

*** Difference should be less than 4 cm. for return to sport and pre-participation

Composite Score = (Anterior + Posteriomedial + Posterolateral) (3 x Limb Length) x 10

Test 5

Ankle Dorsiflexion Test

Reduced ankle dorsiflexion has been identified as a risk factor for lower leg injuries. The player will be measured with runners and will be tested, both weight bearing and prone and supine.

<u>Test Option 1</u>

<u>Bubble inclinometer</u>

Ask player to lie down supine on the plinth

Place the bubble Inclinometer on the sole of the foot, set at zero

Dorsiflex the ankle and read the result

Player to wear basketball shoes as readings are more accurate.

Player will also be tested in a standing position

Test option 2

<u>Goniometer</u>

The goniometer will also be used to measure the joint movement. When using the goniometer the lateral malleolus, fibula head and fifth metatarsal will be used as the anatomical landmarks for joint range of motion testing.

<u>Test chart for dorsiflexion of ankle</u>

Movement	Standing bubble inclinometer	Supine bubble inclinometer	Prone Dorsiflexion	Supine Dorsiflexion
Right ankle				
Left ankle				

Low ankle dorsiflexion range is a risk factor for developing injury in basketball players. In the studied material, an ankle dorsiflexion range of 36.5° or less was found to be the most appropriate cut off point for prognostic screening.

TEST 6

The Bleep Test

The Bleep Test, also known as the multi-stage fitness test or shuttle run test, is used by sports coaches and trainers to estimate an athlete's maximum oxygen uptake better known as VO2 Max.

Test procedure:

The test involves running continuously between two points that are 20metres apart. These runs are synchronised with a pre-recorded audio tape, CD or laptop which plays beeps at set intervals. As the test proceeds, the interval between each successive beep reduces, forcing the athlete to increase velocity over the course of the test, until it is impossible to keep in sync with the recording.

For this station, we will use the *Bitworks* Software system.

Bleep test score card

Bleep Test	Level	Shuttle	VO2 Max

<u>**UKIBIPS Injury Risk Assessment Recording Forms**</u>

Name /ID number			Height			Weight	Hand leg dominance
-------------------------------------			-------------------------			-------------------------------	-------------------------
FMS	FMS			FMS			FMS
Test	Raw Test Score Left			Raw Test Score Right			Final test Score
Deep Squat							
Hurdle step							
Lunge							
Shoulder Mobility Test							
Impingement clearing Test							
Active SLR							
Trunk stability Press Up							
Press up clearing test							
Rotary stability Test							
Posterior rocking clearing test							
Hand length							
Tib tuberosity height							

Muscle + Orthopaedic test	Left /Positive/-negative	Right / Positive/-negative
Trendelenburg test		
Tensor fascia late		
Psoas		
Rec fem		
Vasti group		
Gastro		
Soleus		
Hamstrings lower fibers		
Upper hamstrings fibers		
Medial hamstring fibers		
Piriformis		
Adductors		
Leg length discrepancy test		

Single leg balance test	Left /Positive/-negative	Right / Positive/-negative
First test		
Second test		
Final Result		

Ankle Dorsiflexion test	**Standing bubble inclinometer**	**Supine bubble inclinometer**	**Prone Dorsiflexion**	**Supine Dorsiflexion**
Right ankle				
Left ankle				

Y balance test	Left	Right	Difference	Right leg length
Anterior				
Posteriomedial				
Posteriolateral				

Bleep Test	Level	Shuttle	VO2 Max

Assessment Team

Assessment Station	Assessor
FMS	
Y Balance Test	
Muscle and Special orthopaedic Tests	
Ankle Dorsiflexion Measurement	
Single leg balance Test	
Bleep Test	

Team representative ______________________________

Principal Investigator______________________________

Date ________________________

Appendix 11: New Injuries Data Tables 2013 - 2015

	2013 - 2014		2014 – 2015		2013 – 2015	
Total Participants	N=183		N=77		N=260	
	Male n=105	**Female n=78**	**Male n=56**	**Female n=21**	**Male n=161**	**Female n=99**
Total Players Injured	44 (41.90%)	41 (52.56%)	11 (19.64%)	3 (14.28%)	55 (34.16%)	44 (44.44%)
Total Players With No Injury	61 (58.09%)	37 (47.43%)	45 (80.35%)	18 (85.71%)	106 (65.83%)	55 (55.55%)
Total New Injuries	N=141		N=32		N=173	
	Male n=74	**Female n=67**	**Male n=28**	**Female n=4**	**Male n=102**	**Female n=71**
Injury Regions						
† Upper extremity	14 (18.91%)	10 (14.92%)	5 (17.85%)	0 (0%)	19 (43.13%)	10 (14.08%)
‡ Lower extremity	50 (67.56%)	46 (68.65%)	19 (67.85%)	4 (100%)	69 (67.64%)	50 (70.42%)
Other body regions	10 (13.51%)	11 (16.41%)	4 (14.28%)	0 (0%)	14 (13.72%)	11 (15.49%)
Body Region Injured						
Head	1(1.35%)	1 (1.49%)	0 (0%)	0 (0%)	1 (0.98%)	1 (1.40%)
Face	2 (2.70%)	0 (0%)	1 (3.57%)	0 (0%)	3 (2.94%)	0 (0%)
Eyes	0 (0%)	2 (2.98%)	0 (0%)	0 (0%)	0 (0%)	2 (2.81%)
Neck	1 (1.35%)	0 (0%)	0 (0%)	0 (0%)	1 (0.98%)	0 (0%)
Shoulder	4 (5.40%)	5 (7.46%)	1 (3.75%)	0 (0%)	5 (4.90%)	5 (7.04%)
Upper arm	1 (1.35%)	0 (0%)	2 (7.14%)	0 (0%)	3 (2.94%)	0 (0%)
Elbow	1 (1.35%)	0 (0%)	0 (0%)	0 (0%)	1 (0.98%)	0 (0%)
Wrist	4 (5.40%)	0 (0%)	0 (0%)	0 (0%)	4 (3.92%)	0 (0%)
Hand	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Thumb	1 (1.35%)	2 (2.98%)	1 (3.75%)	0 (0%)	2 (1.96%)	2 (2.81%)
Finger	3 (4.05%)	3 (4.47%)	1 (3.75%)	0 (0%)	4 (3.92%)	3 (4.22%)
Upper back	1 (1.35%)	1 (1.49%)	0 (0%)	0 (0%)	1 (0.98%)	1 (1.40%)
Ribs	0 (0%)	2 (2.98%)	0 (0%)	0 (0%)	0 (0%)	2 (2.81%)
Lower back	5 (6.75%)	3 (4.47%)	2 (7.14%)	0 (0%)	7 (6.86%)	3 (4.22%)
Pelvis	0 (0%)	2 (2.98%)	0 (0%)	0 (0%)	0 (0%)	2 (2.81%)
Hip	2 (2.70%)	1 (1.49%)	0 (0%)	0 (0%)	2 (1.96%)	1 (1.40%)
Thigh	11 (14.86%)	3 (4.47%)	4 (14.28%)	0 (0%)	15 (14.70%)	3 (4.22%)
Knee	15 (20.27%)	12 (17.91%)	7 (25%)	1 (25%)	22 (21.56%)	13 (18.30%)
Lower leg	2 (2.70%)	6 (8.95%)	2 (7.14%)	2 (50%)	4 (3.92%)	8 (11.26%)
Ankle	17 (22.9%)	20 (29.85%)	6 (21.42%)	1 (25%)	23 (22.54%)	21 (29.57%)
Foot	3 (4.05%)	4 (5.97%)	0 (0%)	0 (0%)	3 (2.94%)	4 (5.63%)
Abdomen	0 (0%)	0 (0%)	1 (3.75%)	0 (0%)	1 (0.985)	0 (0%)

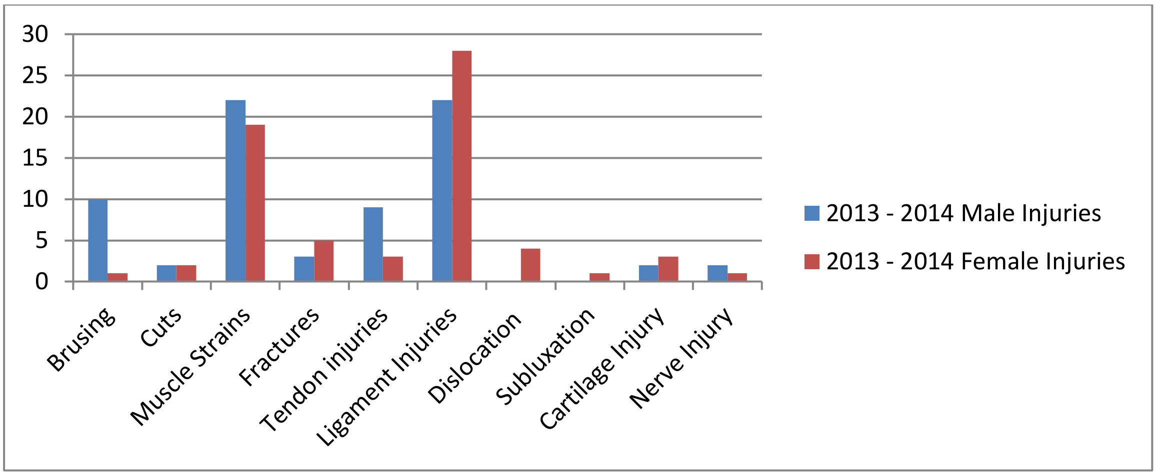
Table 6.8 New Injury types by anatomical location 2013 – 2014 Season

N (141)	Total New Injuries			Men (N=74) (52.48%)			Women (N=67) (47.51%)				
Male injuries (74)		**Bruising**	**Cuts**	**Muscle strains**	**Fractures**	**Tendon injuries**	**Dislocations**	**Ligament strains**	**Nerve injury**	**Cartilage injury**	**Subluxation**
Head	(1)	1									
Face (lips)	(2)		2								
Neck/cervicals	(1)			1							
Shoulder	(4)			3		1					
Upper Arm	(1)	1									
Elbow	(1)				1						
Wrist	(4)					1		3			
Thumb	(1)	1									
Finger	(3)	1					2				
Upper back	(1)	1									
Low back	(5)			4		1					
Hip	(2)	1				1					
Thigh	(11)	2		8					1		
Knee	(15)	2		2		5		3	1	2	
Lower Leg	(2)			2							
Ankle	(17)				1			16			
Foot	(3)			2	1						
Sum		**(10)**	**(2)**	**(22)**	**(3)**	**(9)**	**(2)**	**(22)**	**(2)**	**(2)**	
Female Injuries (67)		**Bruising**	**Cuts**	**Muscle strains**	**Fractures**	**Tendon injuries**	**Dislocations**	**Ligament strains**	**Nerve injury**	**Cartilage injury**	**Subluxation**
Head	(1)		1								
Face (lips)	(0)										
Eyes	(2)	1	1								
Neck	(0)										
Shoulder	(5)			3		1	1				
Thumb	(2)						1	1			
Finger	(3)						1	2			
Upper back	(1)			1							
Ribs	(2)				2						
Low back	(3)			2				1			
Pelvis	(2)				1				1		
Hip	(1)			1							
Thigh	(3)			3							
Knee	(12)			1	1		1	5		3	1
Lower Leg	(6)			6							
Ankle	(20)					1		19			
Foot	(4)			2	1	1					
Sum		**(1)**	**(2)**	**(19)**	**(5)**	**(3)**	**(4)**	**(28)**	**(1)**	**(3)**	**(1)**

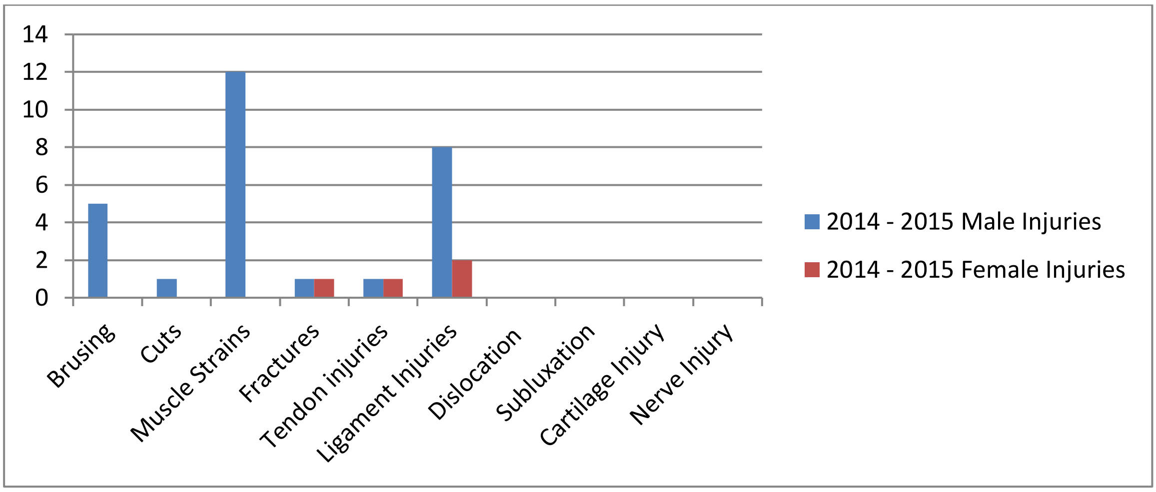
Table 6.9 New Injury types by anatomical location 2014 – 2015 Season

N (32)	Total New Injuries			**Men (N=28)** (%)		**Women (N=4)** (%)					
Male injuries (28)		Bruising	Cuts	Muscle strains	Fractures	Tendon injuries	Dislocations	Ligament sprains	Nerve injury	Cartilage injury	Subluxation
Jaw	**(1)**		1								
Shoulder	**(1)**							1			
Upper Arm	**(2)**	1			1						
Thumb	**(1)**							1			
Finger	**(1)**	1									
Low back	**(2)**			2							
Abdomen	**(1)**			1							
Thigh	**(4)**			4							
Knee	**(7)**	2		3		1		1			
Lower Leg	**(2)**			2							
Ankle	**(6)**	1						5			
SUM		**(5)**	**(1)**	**(12)**	**(1)**	**(1)**		**(8)**			
Female Injuries (4)		Bruising	Cuts	Muscle strains	Fractures	Tendon injuries	Dislocations	Ligament strains	Nerve injury	Cartilage injury	Subluxation
Knee	**(1)**							1			
Lower Leg	**(2)**			1	1						
Ankle	**(1)**							1			
SUM				**(1)**	**(1)**			**(2)**			

Injury Type



30
25
20
15
10
5
0
Brusing
Cuts
Muscle Strains
Fractures
Tendon injuries
Ligament Injuries
Dislocation
Subluxation
Cartilage Injury
Nerve Injury
2013 - 2014 Male Injuries
2013 - 2014 Female Injuries



14
12
10
8
6
4
2
0
Brusing
Cuts
Muscle Strains
Fractures
Tendon injuries
Ligament Injuries
Dislocation
Subluxation
Cartilage Injury
Nerve Injury
2014 - 2015 Male Injuries
2014 - 2015 Female Injuries

	2013 – 2014				2014 – 2015				2013 – 2015			
Total Players	**Male n= 105**		**Female n= 78**		**Male n= 56**		**Female n=21**		**Male n=161**		**Female n=99**	
Players Injured	**Male n=44**		**Female n=41**		**Male n=11**		**Female n=3**		**Male n=55**		**Female n=44**	
Player Position	**(Male)**	**(Male Injured)**	**(Female)**	**(Female Injured)**	**(Male)**	**(Male Injured)**	**(Female)**	**(Female Injured)**	**(Male)**	**(Male Injured)**	**(Female)**	**Female Injured)**
Point Guard	25	13 (12.38%)	19	11 (14.10%)	13	3 (5.35%)	3	0 (0%)	38	16(9.93%)	22	11 (11.11%)
Shoot' Guard	23	7 (6.66%)	22	9 (11.53%)	16	2 (3.57%)	6	0 (0%)	39	9 (5.59%)	28	9 (9.09%)
Forward	32	4 (3.80%)	9	4 (%)	17	4 (7.14%)	8	2 (9.52%)	49	8 (4.96%)	17	6 (6.06%)
Center	12	12 (11.42%)	19	11 (14.10%)	8	0 (0%)	4	1 (4.47%)	20	12 (7.45%)	23	12 (12.12%)
All Round	13	8 (7.61%)	9	6 (7.69%)	2	2 (3.57%)	0	0 (0%)	15	10 (6.21%)	9	6 (6.09%)
U14 Players	**(Male)**	**(Male Injured)**	**(Female)**	**(Female Injured)**	**(Male)**	**(Male Injured)**	**(Female)**	**(Female Injured)**	**(Male)**	**(Male Injured)**	**(Female)**	**(Female Injured)**
Point Guard	9	5 (55.55%)	0	0 (0%)	0	0 (0%)	0	0 (0%)	9	5 (55.55%)	0	0 (0%)
Shoot' Guard	2	1 (50%)	1	1 (100%)	0	0 (0%)	0	0 (0%)	2	1 (50%)	0	0 (0%)
Forward	2	1 (50%)	0	0 (0%)	0	0 (0%)	0	0 (0%)	2	1 (50%)	0	0 (0%)
Center	0	0 (0%)	0	0 (0%)	0	0 (0%)	0	0 (0%)	0	0 (0%)	0	0 (0%)
All Round	7	3 (42.85%)	0	0 (0%)	0	0 (0%)	0	0 (0%)	7	3 (42.85%)	0	0 (0%)
U16 PLAYERS	**(Male)**	**(Male Injured)**	**(Female)**	**(Female Injured)**	**(Male)**	**(Male Injured)**	**(Female)**	**(Female Injured)**	(Male)	(Male Injured)	(Female)	Female Injured)
Point Guard	6	4 (66.66%)	6	5 (83.33%)	3	1 (33.33%)	0 (0%)	0 (0%)	9	5 (55.55%)	6	5 (83.33%)
Shoot' Guard	8	2 (25%)	4	2 (50%)	1	0 (0%)	0 (0%)	0 (0%)	9	2 22.22%)	4	2 (50%)
Forward	3	2 (66.66%)	1	1 (100%)	1	0 (%)	0 (0%)	0 (0%)	4	2 (50%)	1	1 (100%)
Center	10	2 (20%)	1	1 (100%)	1	0 (%)	0 (0%)	0 (0%)	11	2 (18.18%)	1	1 (100%)
All Round	2	2 (100%)	2	1 (50%)	0	0 (%)	0 (0%)	0 (0%)	2	2 (100%)	2	1 (50%)
U18 PLAYERS	**(Male)**	**(Male Injured)**	**(Female)**	**(Female Injured)**	**(Male)**	**(Male Injured)**	**(Female)**	**(Female Injured)**	(Male)	(Male Injured)	(Female)	Female Injured)
Point Guard	4	3 (75%)	4	3 (75%)	4	1 (25%)	1	0 (0%)	8	4 (50%)	5	3 (60%)
Shoot' Guard	8	4 (50%)	8	4 (50%)	8	0 (0%)	0	0 (0%)	16	4 (25%)	8	4 (50%)
Forward	2	0 (0%)	3	2 (66.66%)	6	2 33.33%)	10	0 (0%)	8	2 (25%)	13	2 (15.38%)
Center	10	8 (80%)	7	4 (57.14%)	2	0 (0%)	2	0 (0%)	12	8 (66.66%)	9	4 (44.44%)
All Round	1	1 (100%)	1	1 (100%)	1	1 (100%)	0	0 (0%)	2	2 (100%)	1	1 (100%)
U20 PLAYERS	**(Male)**	**(Male Injured)**	**(Female)**	**(Female Injured)**	**(Male)**	**(Male Injured)**	**(Female)**	**(Female Injured)**	(Male)	(Male Injured)	(Female)	Female Injured)
Point Guard	2	0 (0%)	1	0 (0%)	3	0 (0%)	1	0 (0%)	5	0 (0%)	2	0 (0%)
Shoot' Guard	0	0 (0%)	0	0 (0%)	6	2 (33.33%)	3	0 (0%)	6	2 (33.33%)	3	0 (0%)
Forward	1	0 (0%)	1	0 (0%)	1	0 (0%)	3	1 (33.33%%)	2	0 (0%)	4	1 (25%)
Center	2	1 (50%)	2	1 (50%)	1	0 (0%)	1	0 (0%)	3	1 (33.33%)	3	1 (33.33%)
All Round	1	1 (100%)	1	1 (100%)	0	0 (0%)	0	0 (0%)	1	1 (100%)	1	1 (100%)
SENIOR PLAYERS	**(Male)**	**(Male Injured)**	**(Female)**	**(Female Injured)**	**(Male)**	**(Male Injured)**	**(Female)**	**(Female Injured)**	(Male)	(Male Injured)	(Female)	Female Injured)
Point Guard	4	1 (25%)	7	3 (42.85%)	3	1 (33.33%)	1	0 (0%)	7	2 (28.57%)	8	3 (37.5%)
Shoot' Guard	5	0 (0%)	10	3 (30%)	1	0 (0%)	3	0 (0%)	6	0 (0%)	13	3 (23.07%)
Forward	4	1 (25%)	2	1 (50%)	9	2 (22.22%)	4	1 (25%%)	13	3 (23.07%)	6	2 (33.33%)
Center	10	1 (10%)	11	5 (45.45%)	4	0 (0%)	1	1 (100%)	14	1 (7.14%)	12	6 (50%)
All Round	2	1 (50%)	5	3 (60%)	1	1 (100%)	0	0 (0%)	3	2 (66.66%)	5	3 (60%)

Table 6.5 Previous Injury types by anatomical location 2013 – 2014 Season

Total Participants N=183						Male N=105				Female N=(78)		
Total players with previous injuries						Male (N=54)				Female (N= (48)		
N (176)			Total Previous Injuries									
Male injuries (83)		Bruising	Cuts	Muscle strains	Fractures	Tendon injuries	Dislocations	Ligament strains	Nerve injury	Cartilage injury	Subluxation	Nail injury
Head	(1)		1									
Nose	(2)				2							
Shoulder	(3)				1	1	1					
Acromioclavicular joint	(1)				1							
Elbow	(3)		1		2							
Forearm	(1)				1							
Wrist	(2)				1	1						
Hand	(1)				1							
Thumb	(1)				1							
Finger	(1)				1	1	2	1				
Abdomen	(1)			1								
Ribs	(2)	1			1							
Low back	(2)			2								
Thigh	(5)			5								
Knee	(5)			1		4	1	7	1	2		
Lower Leg	(4)			1	1	1		1				
Ankle	(26)	1			5	2		18				
Foot	(1)											1
Sum	(83)	(2)	(2)	(10)	(18)	(10)	(4)	(27)	(1)	(2)		(1)

Female Injuries (93)		Bruising	Cuts	Muscle strains	Fractures	Tendon injuries	Dislocations	Ligament strains	Nerve injury	Cartilage injury	Subluxation	Concussion
Head	(3)		1									2
Face (lips)	(1)		1									
Shoulder	(3)			1		2						
Acromioclavicular joint	(1)				1							
Elbow	(2)				1			1				
Wrist	(5)				4			1				
Thumb	(4)	1			1		1	1				
Finger	(4)				2		1	1				
Low back	(5)			5								
Thigh	(8)			7				1				
Knee	(18)		1			1	1	10		5		
Lower Leg	(5)			5		1						
Ankle	(27)	1			3		2	21				
Foot	(6)			1	2	3						
Sum	(93)	(2)	(3)	(19)	(14)	(7)	(5)	(36)		(5)		(2)

Table 6.6 Previous Injury Types by Anatomical Location 2014 – 2015 Season

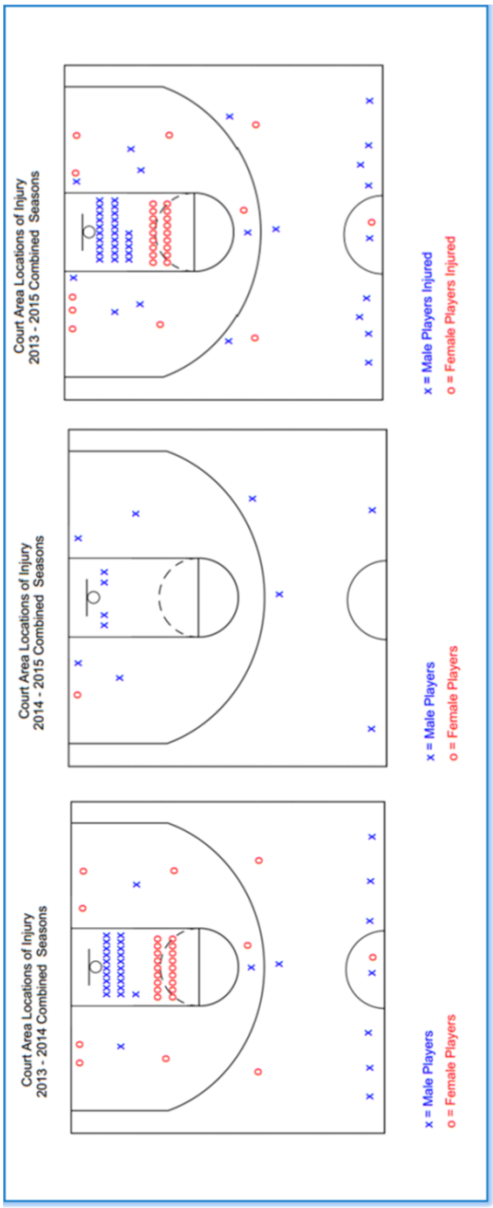
Total Participants N=77	**Male N=(56)**	**Female N= (21)**
Total Players with previous injuries	**Male (N=27)**	**Female (N= (11)**

N (81) Total previous Injuries

Male injuries (52)	Bruising	Cuts	Muscle strains	Fractures	Tendon injuries	Dislocations	Ligament strains	Nerve injury	Cartilage injury	Subluxation	Nail injury	Plantar Fascia
Head (1)				1								
Jaw (1)	1											
Thoracic Spine (1)			1									
Lumbar Spine (2)			1				1					
Elbow (1)						1						
Wrist (3)			1	2								
Hand (1)				1								
Thumb (1)				1								
Fingers (5)	1			2		1	1					
Pelvis (1)							1					
Hip (2)	1								1			
Thigh (4)			3				1					
Knee (6)	1				2		1		2			
Lower leg (1)	1											
Ankle (18)	2		2		2		12					
Foot (4)				1	1		2					
Sum (52)	(7)		(8)	(8)	(5)	(2)	(19)		(3)			

Female Previous Injuries

Female injuries (29)	Bruising	Cuts	Muscle strains	Fractures	Tendon injuries	Dislocations	Ligament strains	Nerve injury	Cartilage injury	Subluxation	Nail injury	Concussion	Disc
Head (2)				1								1	
Lumbar (1)													1
Shoulder (4)			1	1	2								
Wrist (1)							1						
Fingers (2)				1	1								
Hip (2)			1			1							
Thigh (1)			1										
Knee (7)				1		2	2		2				
Lower leg (1)				1									
Ankle (7)	1						6						
Toe (1)				1									
Sum (29)	(1)		(3)	(6)	(3)	(3)	(9)		(2)			(1)	(1)


Court Area Locations of Injury
2013 - 2014 Combined Seasons
x = Male Players
o = Female Players
Court Area Locations of Injury
2014 - 2015 Combined Seasons
x = Male Players
o = Female Players
Court Area Locations of Injury
2013 - 2015 Combined Seasons
x = Male Players Injured
o = Female Players Injured

	2013 - 2014		2014 – 2015		2013 – 2015	
Total Participants	N=183		N=77		N=260	
	Male n=105	**Female n=78**	**Male n=56**	**Female n=21**	**Male n=161**	**Female n=99**
Total Players Injured	44 (41.90%)	41 (52.56%)	11 (19.64%)	3 (14.28%)	55 (34.16%)	44 (44.44%)
Total Players With No Injury	61 (58.09%)	37 (47.43%)	45 (80.35%)	18 (85.71%)	106 (65.83%)	55 (55.55%)
Total New Injuries	N=141		N=32		N=173	
	Male n=74	**Female n=67**	**Male n=28**	**Female n=4**	**Male n=102**	**Female n=71**
Injury Regions						
† Upper extremity	14 (18.91%)	10 (14.92%)	5 (17.85%)	0 (0%)	19 (43.13%)	10 (14.08%)
‡ Lower extremity	50 (67.56%)	46 (68.65%)	19 (67.85%)	4 (100%)	69 (67.64%)	50 (70.42%)
Other body regions	10 (13.51%)	11 (16.41%)	4 (14.28%)	0 (0%)	14 (13.72%)	11 (15.49%)
Game Injuries	N=32	N=28	N=12	N=1	N=44	N=29
Home	12 (37.5%)	13 (46.42%)	9(75%)	1 (100%)	21 (47.72%)	14 (48.27%)
Away	20 (62.5%)	15 (53.57%)	3(25%)		23 (52.27%)	15 (51.72%)
Injuries by quarter	N=32	n=28	N=12	N=1	N=44	N=29
First Quarter	4 (12.5%)	5 (17.85%)	5 (41.66%)		9 (20.45%)	5 (17.24%)
Second Quarter	10 (31.25%)	14 (50%)	2 (16.66%)		12 (27.27%)	14 (58.62%)
Third Quarter	12(37.5%)	4 (14.28%)	3 (25%)	1(100%)	15 (34.09%)	5 (17.24%)
Fourth quarter	6 (18.75%)	4 (14.28%)	2 (16.66%)		8 (18.18%)	4 (13.79%)
Over Time	0(0%)	1 (3.57%)			0 (0%)	1 (3.44%)
Injuries by court location						
Key area	21(65.62%)	18 (64.28%)	4 (33.33%)		25 (56.81%)	18 (62.06%)
Inside 3 point line	3 (9.37%)	3 (10.71%)	2 (16.66%)		5 (11.36%)	3 (10.34%)
Outside 3 point Line	1 (3.12%)	2 (7.14%)	2 (16.66%)		3 (6.81%)	2 (6.89%)
Half court	7 (21.85)	1 (3.57%)	2 (16.66%)		9 (20.45%)	1 (3.44%)
Base Line		4 (14.28%)	2 (16.66%)	1 (100%)	2 (4.54%)	5 (17.24%)

	2013 – 2014 Season		2014 – 2015 Season		2013 – 2015 Season	
Total Players	**N=183**		**N=77**		**N=260**	
	Male n= 105	**Female n= 78**	**Male n= 56**	**Female n=21**	**Male n=161**	**Female n= 99**
Total Players Injured	N=85		N=14		N=99	
	Male n=44	Female n=41	Male n=11	Female n=3	Male n=55	Female n=44
Total Injuries	N=141		N=32		N=173	
	Male n=74	Female n=67	Male n=28	Female n=4	Male n=102	Female n=71
Number of Injuries per player						
1 Injury	28 (63.63%)	22 (23.65%)	3 (27.27%)	2 (66.66%)	31 (56.36%)	24 (54.54%)
2 Injuries	10 (22.72%)	14 (34.14%)	2 (18.18%)	1 (33.33%)	12 (21.81%)	15 (34.09%)
3 Injuries	4 (9.90%)	3 (7.31%)	5 (45.45%)	0 (0%)	9 (16.36%)	3 (6.81%)
4 Injuries	0 (0%)	2 (4.47%)	0 (0%)	0 (0%)	0 (0%)	2 (4.54%)
6 Injuries	1 (2.27%)	0 (0%)	1 (9.09%)	0 (0%)	2 (3.63%)	0 (0%)
8 Injuries	1 (2.27%)	0 (0%)	0 (0%)	0 (0%)	1 (1.81%)	0 (0%)
Injuries By Age Group						
U14	10 (22.72%)	0 (0%)	0 (0%)	0 (0%)	10 (18.18)	0 (0%)
U16	12 (27.27%)	10 (24.39%)	1 (3.57%)	0 (0%)	13 (23.63%)	10 (22.72%)
U18	16 (36.36%)	14 (34.14%)	9 (32.14%)	0 (0%)	25 (45.45%)	14 (31.81%)
U20	2 (4.54%)	2 (4.87%)	3 (10.71%)	2 (50%)	5 (9.09%)	4 (9.09%)
Senior	4 (9.09%)	15 (36.58%)	15 (53.57%	2 (50%)	19 (34.54%)	17 (38.63%)

Glossary of Basketball Terms

A

Advance step: A step in which the defender's lead foot steps toward their man, and their back foot slides forward.

Assist: A pass thrown to a player who immediately scores.

B

Backcourt: The half of the court a team is defending, the opposite of the front court. Also used to describe parts of a team: backcourt = all guards (front court= all forwards and centers).

Back cut: See Cuts, Backdoor cut.

Backdoor cut: See Cuts.

Back screen: See Screens.

Ball fake: A sudden movement by the player with the ball intended to cause the defender to move in one direction, allowing the passer to pass in another direction. Also called "pass fake."

Ball reversal: Passing the ball from one side of the court to the other.

Ball screen: See Screens.

Ball side: The half of the court (if the court is divided lengthwise) that the ball is on. This is also called the "strong side." (The opposite of the help side).

Banana cut: See Cuts.

Bank shot: A shot that hits the backboard before hitting the rim or going through the net.

Baseball pass: A one-handed pass thrown like a baseball.

Baseline: The line that marks the playing boundary at each end of the court. This area can also be called the "end line."

Baseline out-of-bounds play: The play used to return the ball to the court from outside the baseline along the opponent's basket.

Basket cut: See Cut.

Blindside screen: See Back screen.

Block: (1) A violation in which a defender steps in front of a dribbler but is still moving when they collide. This can also be called a "blocking foul." (2) To tip or deflect a shooter's shot, altering its flight so the shot misses. (3) The small painted square on the floor next to the basket just outside the lane.

Block out: To make contact with an opposing player to establish rebounding position between the player and the ball. This can also be called a "box out."

Bounce pass: A pass that bounces once before reaching the receiver.

Box-and-one: A combination defence in which four defenders play zone in a box formation, and the fifth defender guards one player man-to-man.

Box out: See block out.

Box set: This is a formation in which four players align themselves as the four corners of a box. Often used for baseline out-of-bounds plays.

Bump the cutter: To step in the way of a cutter who is trying to cut to the ball for a pass.

C

Center: (1) This is a basketball position in which a player, usually the tallest player on the team, stays near the basket. (2) The player who plays that position.

Center circle: This is the painted circle at midcourt used for the opening jump ball.

Charge: (1) A violation when a player with the ball runs into a defender who is standing still. This is also called a "charging foul." (2) To commit that violation.

Chest pass: An air pass thrown from the passer's chest to a teammate's chest. It can be a one-handed or two-handed pass.

Chin the ball: To hold the ball with both hands under the chin, elbows out, to protect the ball.

Clear-Out Play: A set play designed to clear an area of the court of all offensive players without the ball so the player with the ball can play 1-on-1.

Closing out: This is when a defender sprints to guard a player who has just received a pass.

Combination defence: A defence that is part man-to-man and part zone. This is also called a "junk defence."

Continuity offense: A sequence of player and ball movement that repeats until a good shot is created.

Control dribble: A dribble manoeuvre in which the player keeps their body between the defender's body and the ball.

Crossover dribble: A dribble manoeuvre in which a player dribbles the ball in front of their body so they can change the ball from one hand to the other.

Cross screen: A movement in which a player cuts across the lane to screen for a teammate.

Curl: See Cuts.

Curl pass: A low, one-handed pass made by stepping around the defender's leg and

extending the throwing arm. Also called a "hook pass."
Cut: A sudden running movement to get open for a pass.

- Banana Cut: A wide, curving cut, as opposed to a cut that is a straight line.
- Backdoor Cut: An offensive play in which a player on the perimeter steps away from the basket, drawing the defender with them, and suddenly cuts to the basket behind the defender for a pass. The opposite of a I-cut. Also: Back cut.
- Basket Cut: A cut toward the basket.
- Curl Cut: A cut that takes the player around a screen toward the basket.
- Fade Cut: A cut that takes the player away from the ball. For example after using a baseline screen or on the defenders help Also: Flare cut.
- Flash Cut: A cut that takes the player from the low post to the high post, or in the middle of the paint from behind the defence (mostly used to describe a cut against a zone).
- Flex Cut: A cut from the weak side corner to the ball side low post, using a screen at the weak side low post.
- I-cut: An offensive play in which a player on the perimeter steps toward the basket, drawing the defender with them, and suddenly cuts to the perimeter for a pass. The opposite of a backdoor cut.
- Popout Cut: A cut taken around a screen straight to the ball.
- Shuffle Cut: A cut that takes a player around a screen on the high post to the basket.
- Shallow Cut: A cut from the top of the key to the ball side corner.
- UCLA Cut: A cut that takes the player from the top of the key to the low post over a screen at the high post.
- V-cut (or L-Cut when 90° angle): e.g. The player starts at the low post and cuts to the high post, initiates contact with the defender and then cuts to the wing. It can also be executed from the wing; in this case the player cuts to the low post and comes back out.

D

Defensive rebound: A rebound made off a missed shot at the basket a team is defending.
Defensive slide: The quick "step-slide" movement a defender makes when closely guarding the dribbler.
Defensive stance: The stance used to play defences - knees bent, feet wide, arms out, etc.
Defensive stop: Gaining possession of the ball before the offensive team scores.
Defensive transition: When the team on offense suddenly gives up possession of the ball

and has to convert from offense to defence.

Delay offense: An offense used to take more time with each possession.

Denial defence: A defence in which a defender tries to prevent their man from receiving a pass.

Denial stance: The stance used to play denial defence-body low, knees bent, hand and foot in the passing lane.

Deny the ball: To use a denial stance to keep the offensive player from receiving a pass.

Diamond-and-one: A combination defense in which four defenders play zone in a diamond formation and the fifth defender guards a specific offensive player man-to-man.

Diamond Press: This is a full-court press with a 1-2-1-1 formation.

Dishing: This is a slang term for passing the ball to a player open for a shot, usually after dribble penetration.

Double down: To drop from the perimeter, leaving your man or zone, to double-team a low post player.

Double low stack: When two offensive players set up at one of the blocks to run a play.

Double screen: See Screens.

Double-teaming: A defence in which two defenders guard the same offensive player at the same time.

Down screen: See Screens.

Dribble: (1) This is to advance the ball by bouncing it on the floor. (2) The bounce of the ball caused by a player pushing the ball downward.

Dribble penetration: When a dribbler is able to drive into the lane; she "penetrates" the defence.

Drive: To attack the basket by dribbling hard at it.

Drop step: A low post move when an offensive player with her back to the basket swings one leg around the defender and uses it as a pivot foot to gain inside position.

E

Elbow: The corner made by the intersection of the free throw line and the lane line. Each lane area has two elbows.

End line: See baseline.

Entry: Beginning of a play. It can also be used for Continuous, Set and Special plays. Most popular entries: UCLA Cut, Power, Zipper Cut, Wing Exchange, Horns.

F

Face up: See Square up.

Fade cut: See Cuts.

Fan the ball: When the defence forces the ball toward the sideline.

Fast break: A play in which a team gains possession of the ball (through a defensive rebound, steal, or made shot) and then pushes the ball toward the other basket as fast as possible, hoping to catch the other team off guard and score an easy shot.

Field goal: A 2-or 3-point basket.

Filling the lanes: This is a fast break in which players from the offensive team run up the court in the right lane, middle lane, and the left lane.

Flagrant foul: Excessive physical contact (punching, kicking, etc.).

Flare cut: See Cuts.

Flare Screen: See Screens.

Flash: See Cuts.

Forward: A position usually played by a tall, athletic player. A "small forward" or a "3" plays on the wing, and a power forward or a "4" plays in the high or low post area.

Foul: A violation of the rules.

Foul line: See Free throw line.

Foul shot: See Free throw.

Foul trouble: (1) Player foul trouble occurs when a player accumulates three or four fouls and is in danger of fouling out. (2) Team foul trouble occurs when a team accumulates four or more team fouls in a quarter and is "in the bonus."

Free throw: An uncontested shot taken from the free throw line as a result of a foul. Also called a "foul shot." A successful (made) free throw is worth 1 point.

Free throw line: The line a player stands behind to shoot a free throw. Also called the "foul line."

Free throw line extended: An imaginary line extending from one end of the free throw line to the sidelines.

Front: To guard a player by standing directly in front of him and therefore between him and the ball.

Frontcourt: A team's offensive half of the court. This is the opposite of the backcourt. Also used to describe parts of a team: front court = all forwards and centers, backcourt = all guards.

Full-court press: A man-to-man or zone defence in which the players guard the other team in the frontcourt. Also called a "press."

Funnel the ball: When the defence forces the ball toward the middle.

G

Give-and-go: An offensive play in which the player with the ball passes (gives) to a teammate and cuts (goes) to the basket to receive a return pass. This is one of the game's basic plays.

Goaltending: A violation in which a defender touches a shot as it nears the basket in a downward flight.

Guard: (1) A position on the perimeter. The point guard or "1" brings the ball up the court and begins the offense. The shooting guard or "2" is usually the team's best outside shooter. (2) To defend an offensive player closely.

Guide hand: The shooter's non-shooting hand. See also shooting hand.

H

Half-court line: The line at the center of the court parallel to the sidelines that divides the court in half. This is also called the "midcourt line."

Hand-check: To make hand contact with a dribbler while guarding them.

Hedge: In a pick-and-roll, when the screener's defender steps into the path of the dribbler so the dribbler has to hesitate, giving their defender time to get around the screen.

Help and recover: A defensive move in which a defender leaves her assigned player to guard a teammate's assigned player and then goes back to guard their own player.

Help side: The half of the court (if the court is divided lengthwise) that the ball is not on. This is also called the "weak side." The opposite of the ball side.

Help-side stance: The stance used to guard a help-side offensive player. See also Pistol stance.

Hesitation dribble: A dribble manoeuvre in which the dribbler hesitates, pretending to pick up their dribble, but suddenly continues to the basket. This is also called a "stop-and-go dribble."

High post: The area around the free throw line.

Hook shot: A one-handed shot taken with a sweeping, windmill motion.

I

Inbound: To pass the ball to a teammate on the court from out-of-bounds.

Inbounder: The player who inbounds the ball.

Inside-out dribble: An advanced dribbling move, a fake crossover dribble.

Intentional foul: A foul that occurs when a player makes illegal contact with an opposing player without intending to get the ball.
Isolation play: An offensive play designed to have a specific player attack the basket 1-on-1. This is also called an "iso play."

J

Jab-and-cross: A play in which the offensive player makes a jab step in one direction and then follows it by driving by the defender in that direction.
Jab step: A short (6 to 8 inches) out-and-back step by an offensive player to see how the defender reacts.
Jam the cutter: When a defender steps in the way of a cutter to prevent them from cutting to the ball.
Jump ball: A procedure used to begin a game. The referee tosses up the ball in the center circle between two opposing players, who jump up and try to tip it to a teammate. This is also called the "opening tip."
Jump hook: A variation of the traditional hook shot in which the shooter takes the shot with both feet in the air.
Jump shot: A shot in which the shooter faces the basket and releases the ball after jumping into the air.
Jump stop: The action of coming to a complete stop, legs apart and knees bent when dribbling or running; can be a one-foot or two-foot jump stop.
Jump to the ball: When a defender, after her man passes the ball, changing to a denial position so their man can't cut between her and the ball.
Junk defence: See combination defence.

L

Lane: The rectangular painted area between the baseline, the lane lines, and the free throw line. This can also be called the "paint."
Lane line extended: An imaginary line from the junction baseline and lane line to the same junction on the other half of the court. (This is used to describe a proper spacing in a four-out offense).
Layup: A shot taken next to the basket in which the shooter extends their arm, lifts their same-side knee, and aims the ball at the upper corner of the painted square on the backboard.
Loose-ball foul: A foul committed when neither team has possession of the ball.

Low post: The area on one side of the basket around the block.

M

Man offense: See Man-to-man offense.

Man-to-man defence: A team defence in which each defender guards a specific player or man. This can also be called "player-to-player defence."

Man-to-man offense: A team offense used against man-to-man defence. This is also called "man offense."

Midcourt line: See Half-court line.

Mirror the ball: To follow the movement of the ball with your hands when closely guarding a player who is pivoting.

Moving pick: A violation that happens when a screener leans or moves after setting a screen.

N

Non-shooting foul: A foul committed against a player who is not in the act of shooting.

O

Off-ball screen: See Screens.

Offensive rebound: A rebound at the basket a team is attacking.

Offensive transition: When the team on defence suddenly gives up possession of the ball and has to convert from defence to offense.

On-ball Defence: Defence that occurs when a defender guards the player with the ball.

On-ball screen: See Ball screen.

One-and-one: Free throws awarded to a team once its opponent has committed seven personal fouls. If the shooter's first free throw is successful, they shoot a second free throw.

One-Guard Offense: A team offense used against zones with two-guard fronts (2-3 and 2-1-2 zones).

Open stance: The stance used to play help-side defence-feet apart, body balanced, knees bent, and arms out.

Outlet: (1) This is to pass the ball after a defensive rebound to start the fast break. (2) The player who stays in the backcourt to receive an outlet pass.

Outlet pass: An overhead pass thrown by a defender that starts the fast break.

Overhead pass: A two-handed pass thrown from above the player's head.

Overtime: A 5-minute extra period played when the game is tied at the end of regulation play.

P

Paint: See Lane.

Palming: See Carrying the ball.

Pass fake: See Ball fake.

Passing lane: This is an imaginary line from the player with the ball to a teammate. If a defender is in the way, the passing lane is closed.

Personal foul: A penalty assessed on a player who commits an illegal action.

Pick: See Screen.

Pick-and-roll: A two-person play in which an offensive player sets a screen (pick) on the ball handler's defender and cuts (rolls) to the basket after the ball handler drives by the screen. This is also called a "screen and roll." A common play in college and the pros.

Pistol stance: When a help-side defender is guarding their man, they point one hand at their man and one hand at the ball (as if they're holding a pistol).

Pivot: The action when the player with the ball spins on one foot and steps with their other foot to protect the ball from a defender.

Pivot foot: The foot that the offensive player spins on while pivoting.

Player-control foul: A non-shooting offensive foul.

Player screen: See Off-ball screen.

Player-to-player defence: See Man-to-man defence.

Point guard: (1) This is a basketball playing position played by a team's primary ball handler, the player who brings the ball up the court and begins the offense. Numerically this position is called the "1." (2) The player who plays that position.

Popout cut: See Cuts.

Post: (1) A player who plays in and around the lane area. A center or forward (a "4" or a "5"). (2) An area of the court, as in the low post or the high post.

Post moves: Back-to-the-basket scoring moves made by players near the basket.

Post-up: (1) An offensive move in which an offensive player (usually a forward or a center) positions himself close to the basket with their back toward the basket and the defender behind them so the offensive player can receive a pass. (2) To make that move.

Power forward: A position played by the larger of the forwards on the floor, usually a good scorer and rebounder. A playing position also called the "4." (2) The player who plays that position.

Power layup: A two-footed layup.

Press break: A team offense used against a press defence. This is also called "press offense."

Press offense: See Press break.

Pressure man-to-man defence: An aggressive defence where the defenders stay between their man and the ball.

Primary break: A fast break that involves only a few players from each team.

Pump fake: See Shot fake.

Push pass: A one-handed air pass.

R

Ready stance: The balanced position from which a player is ready to run, jump, slide, or pivot. Their knees are bent, hands are up and out, back is straight, and head is up.

Rebound: (1) A missed shot that comes off the backboard or rim. (2) To fight for and gain control of a missed shot that comes off the backboard or rim.

Rejection: A blocked shot.

Retreat step: A step in which the defender's back foot steps toward the baseline, and the lead foot slides in place.

Runner: A shot that the player shoots while running, without taking the time to set up the shot. This is also called a "floater."

Running clock: When the clock in a game isn't stopped every time the referee blows the whistle to ensure that the game ends on time and the next game can begin when scheduled. This is often used in middle school and AAU games.

S

Safety: The offensive player at the top of the circle.

Sag: A tactic in which a defender leaves their man or zone and drops into the lane to help protect the basket.

Sagging man-to-man defence: A conservative defence in which the defenders stay between their man and the basket.

Screen: A play in which an offensive player runs over and stands in a stationary position next to a teammate's defender to free up the teammate to dribble or to receive a pass. This is also called a pick.

- Ball Screen: Screen on a defender, who is defending the ball carrier.
- Back Screen: Screen in the back of the defender.

- Cross Screen: Screen from one Low post to the opposite Low post.
- Double Screen: Screen set by two players next to each other. This screen is also called Parallel Screen.
- Down Screen: Screen from the wing to the Low post.
- Up Screen: see UCLA Screen.
- UCLA Screen: Screen from the Low post to the Top of the Key.
- Flare Screen: Screen for a player moving away from the ball.
- Off-Ball Screen: A screen set on a defender guarding an offensive player who doesn't have the ball.
- Shot Screen: A screen set for a player to shoot the ball, mostly on the weak side.
- Staggered Screen: two Screens not next to each other set simultaneous for the same cutter.

Screen away: To pass in one direction and set a screen for a teammate in the opposite direction.
Screener: A player who sets a screen.
Sealing the defender: After setting a screen, the screener does a reverse pivot to "seal" the defender-put the defender on her back.
Secondary break: A fast break that involves most of the players from each team.
Set play: A sequence of player and ball movement that has an end.
Shagger: A player who, in a drill, collects loose balls and returns them to the passer.
Shell drills: Defensive drills designed to work on all aspects of defence.
Shooter's roll: When a shot doesn't go through the basket cleanly, but bounces around softly before dropping through.
Shooting foul: This is a violation that happens when a defender fouls the shooter. The shooter is awarded 2 points and a free throw.
Shooting guard: (1) A position played by a perimeter player who is usually the team's best outside shooter. This is also called the "2." (2) The person playing this position.
Shooting hand: The hand used to shoot the ball. See also Guide hand.
Shot clock: The clock used to limit the time allowed for a team to attempt a shot. Shot clocks are used in pro and college games, in some high school leagues, but not in middle school and youth leagues.
Shot clock violation: A violation that occurs when the team with the ball doesn't get a shot off during the allotted time. It results in a change of possession.
Shot fake: A movement in which the player with the ball acts as if they are about to shoot.

It is designed to trick the defender into straightening up, allowing the player with the ball to dribble past them. This is also called a "pump fake."

Sideline: The line at each side of the court that marks the boundary of the playing surface.

Sideline play: This is a play used by the offensive team to put the ball back in play from the sideline.

Sixth man: The first substitute who comes off the bench to replace a starter.

Skip pass: An overhead pass from one side of the court to the other over the defense.

Speed dribble: A dribble manoeuvre in which the player pushes the ball ahead of her and bounces it at chest height.

Special plays: a play for a specific situation and/or a specific player.

Spin dribble: A dribble manoeuvre in which the player does a reverse pivot while bringing the ball around them so it ends up in their other hand.

Split-line: This is an imaginary line between the two baskets. It is mostly used to describe a position for defenders.

Splitting the screen: This is where the screener, seeing her defender hedging, gets out of his/her screening stance and cuts to the basket for a pass.

Splitting the trap- This is when a trapped player steps in between the defenders to pass the ball.

Square up: To pivot so the shoulders and feet face the basket. This can also be called "face up."

Staggered screen: When two players not next to each other set simultaneous screens for the same cutter.

Steal: (1) This is where a player can intercept a pass and gain possession of the ball. (2) The name for the action.

Stop-and-go dribble: See Hesitation dribble.

Stop and pop: An offensive move in which a player comes to a sudden stop, picks up her dribble, and shoots the ball.

Strong side: See Ball side. This is the opposite of "weak side."

Substitute: A player who comes in the game to replace another player. This is also called a "sub."

Swing step: A defensive step in which the defender does a reverse pivot with one foot and stays in her on-ball stance.

Switch: A movement in which two defenders change the offensive player each is playing.

T

Technical foul: A violation, such as a player or coach using profanity that results in the other team getting free throws and possession of the ball. Also called a "T," as in "T him up."

Tip-off: The opening jump ball at the center circle that begins a game.

Trailer: An offensive player, usually a center or a power forward, who trails the first wave of players on the fast break.

Transition: A movement that occurs when a team changes from offense to defense (defensive transition) or from defence to offense (offensive transition).

Trap: A defensive move in which two defenders guard the player with the ball by forming a V with their bodies.

Travelling: This is one of the main violations in basketball that occurs when the player with the ball takes too many steps without dribbling. This is a common occurrence with young players.

Triangle-and-two: A combination defence in which three defenders play zone in a triangle formation and two defenders guard specific players man-to-man.

Triple threat position: The bent knees stance that allows the player three options: dribble, pass, or shoot.

Turnaround jump shot: A shot by a player in the low post in which they catch the ball with their back to the basket, makes a forward pivot so they face the basket, and shoots a jump shot.

Turnover: A loss of possession of the ball caused by a steal, an offensive foul, a held ball, or a poor pass.

Two-Guard Offense: A team offense mostly used against zones with one-guard fronts (1-2-2 and 1-3-1).

Two-shot foul: A violation that occurs when a defender fouls the shooter and the shot misses. The shooter is awarded two free throws.

U

UCLA Screen: See Screens

Up-and-under move: An advanced post move that starts out like a turnaround jump shot, but instead of shooting, the post player "pump fakes," causing the defender to rise out of their defensive stance. The post player steps by the defender and finishes with a layup.

Up screen: See UCLA Screen.

V

V-cut: See Cuts.

W

Weak side: See Help side.

Wing: (1) The area on the court where the 3-point arc meets the free throw line extended. (2) The offensive player who plays in that area.

Z

Zone defence: A team defence in which players are assigned to guard specific areas of the court, rather than players. Most popular zone alignments: 2-3, 3-2, 1-3-1, 1-1-3, 2-1-2

Zone offense: A team offense used against a zone defence.

Zone press defence: Full court zone defence, mostly used to trap the ball. Most popular alignments: 1-3-1, 1-2-1-1 (Diamond), 1-2-2, 2-2-1.

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Appendix 2 OSICS version 10.1

OSICS10 code	Specific	Detail	OSICS9
HXXX	Head injuries	Head injuries	
HHXX	Head/facial bruising/haematoma	Head/facial bruising/haematoma	HH1
HHOX	Eye bruising/haematoma	Eye bruising/haematoma	HHO
HHOO	Eye bruising/haematoma	Periorbital bruising/haematoma	
HHOC	Eye bruising/haematoma	Conjunctival haematoma	
HHSX	Scalp bruising/haematoma	Scalp bruising/haematoma	HHS
HHNX	Nose bruising/haematoma	Nose bruising/haematoma	HHN
HHNE	Nose bruising/haematoma	Epistaxis	HV1
HHNS	Nose bruising/haematoma	Septal haematoma	
HHMX	Mouth bruising/haematoma	Mouth bruising/haematoma	HHM
HHEX	Ear bruising/haematoma	Ear bruising/haematoma	HHE
HHEC	Ear bruising/haematoma	Cauliflower ear (chronic)	
HHJX	Jaw bruising/haematoma	Jaw bruising/haematoma	
HHZX	Other bruising/haematoma not otherwise specified	Other bruising/haematoma not otherwise specified	
HKXX	Head laceration/abrasion	Head laceration/abrasion	
HKXQ	Complication of head laceration/abrasion including infection	Complication of head laceration/abrasion including infection	
HKXS	Head laceration location unspecified/or multiple requiring suturing	Head laceration location unspecified/or multiple requiring suturing	
HKXN	Head laceration location unspecified/or multiple not requiring suturing	Head laceration location unspecified/or multiple not requiring suturing	
HKHX	Forehead laceration/abrasion	Forehead laceration/abrasion	HKF
HKHS	Forehead laceration/abrasion	Forehead laceration requiring suturing	
HKHN	Forehead laceration/abrasion	Forehead laceration/abrasion not requiring suturing	
HKBX	Eyebrow laceration/abrasion	Eyebrow laceration/abrasion	HKB
HKBS	Eyebrow laceration/abrasion	Eyebrow laceration requiring suturing	
HKBN	Eyebrow laceration/abrasion	Eyebrow laceration/abrasion not requiring suturing	
HKLX	Eyelid laceration/abrasion	Eyelid laceration/abrasion	HKE
HKLS	Eyelid laceration/abrasion	Eyelid laceration requiring suturing	
HKLN	Eyelid laceration/abrasion	Eyelid laceration/abrasion not requiring suturing	
HKCX	Cheek laceration/abrasion	Cheek laceration/abrasion	HKC
HKCS	Cheek laceration/abrasion	Cheek laceration requiring suturing	
HKCN	Cheek laceration/abrasion	Cheek laceration/abrasion not requiring suturing	
HKNX	Nose laceration/abrasion	Nose laceration/abrasion	HKN
HKNS	Nose laceration/abrasion	Nose laceration requiring suturing	
HKNN	Nose laceration/abrasion	Nose laceration/abrasion not requiring suturing	
HKMX	Mouth/musocal laceration/abrasion	Mouth/musocal laceration/abrasion	HKM
HLMS	Mouth/musocal laceration/abrasion	Musocal laceration requiring suturing	
HLMN	Mouth/musocal laceration/abrasion	Mucosal laceration not requiring suturing	
HKKX	Lip laceration/abrasion	Lip laceration/abrasion	
HKKS	Lip laceration/abrasion	Lip laceration requiring suturing	
HKKN	Lip laceration/abrasion	Lip laceration/abrasion not requiring suturing	

(*Continued*)

Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
HKTX	Tongue laceration	Tongue laceration	
HKTS	Tongue laceration	Tongue laceration requiring suturing	
HKTN	Tongue laceration	Tongue laceration not requiring suturing	
HKPX	Perforating mouth laceration	Perforating mouth laceration	
HKPS	Perforating mouth laceration	Perforating mouth laceration requiring suturing	
HKJX	Chin laceration	Chin laceration	HKJ
HKJS	Chin laceration	Chin laceration requiring suturing	
HKJN	Chin laceration	Chin laceration/abrasion not requiring suturing	
HKEX	Ear laceration/abrasion	Ear laceration/abrasion	
HKES	Ear laceration/abrasion	Ear laceration requiring suturing	
HKEN	Ear laceration/abrasion	Ear laceration/abrasion not requiring suturing	
HKSX	Scalp laceration/abrasion	Scalp laceration/abrasion	HK1
HKSS	Scalp laceration/abrasion	Scalp laceration requiring suturing	
HKSN	Scalp laceration/abrasion	Scalp laceration/abrasion not requiring suturing	
HKZX	Facial laceration/abrasion not otherwise specified	Facial laceration/abrasion not otherwise specified	HK2
HKZS	Facial laceration/abrasion not otherwise specified	Facial laceration NOS requiring suturing	
HKZN	Facial laceration/abrasion not otherwise specified	Facial laceration/abrasion NOS not requiring suturing	
HMXX	Facial muscle and/or tendon strain/spasm/trigger points	Facial muscle and/or tendon strain/spasm/trigger points	
HMYX	Facial muscle trigger points	Facial muscle trigger points	HY1
HJXX	Facial joint sprain/injury	Facial joint sprain/injury	
HJJX	Jaw sprain/TMJ symptoms	Jaw sprain/TMJ symptoms	HJ1
HDXX	Facial dislocation	Facial dislocation	
HDJX	Jaw dislocation	Jaw dislocation	HD1
HFXX	Head/facial fracture	Head/facial fracture	HF4
HFEX	Orbital fracture	Orbital fracture	HFE
HFEF	Orbital fracture	Orbital floor fracture	
HFEM	Orbital fracture	Medial wall fracture	
HFEZ	Orbital fracture	Other orbital fracture not otherwise specified	
HFZX	Zygoma fracture	Zygoma fracture	HFZ
HFNX	Nasal fracture	Nasal fracture	HF1
HFUX	Maxillary fracture	Maxillary fracture	HFM
HFMX	Mandibular fracture	Mandibular fracture	HF3
HFMC	Mandibular fracture	Compound fractured mandible	
HFSX	Skull/cranial fracture	Skull/cranial fracture	HF2
HFSF	Skull/cranial fracture	Fractured frontal bone	HFF
HNXX	Concussion/brain injury	Concussion/brain injury	
HNCX	Concussion	Concussion	HN1
HNCA	Concussion	Acute concussion	
HNCO	Concussion	Acute concussion with visual symptoms	
HNCC	Concussion	Chronic brain injury	HN3
HNVX	Intracranial bleed	Intracranial bleed	HN2
HNNX	Cranial nerve injury	Cranial nerve injury	HN4
HOXX	Head organ damage	Head organ damage	
HOOX	Eye injury/trauma	Eye injury/trauma	HO1
HOOC	Eye injury/trauma	Eye foreign body – corneal	
HOOJ	Eye injury/trauma	Eye foreign body – conjunctival	

(*Continued*)

Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
HOOP	Eye injury/trauma	Eye foreign body – perforating	
HOOZ	Eye injury/trauma	Eye foreign body – not otherwise specified	HOF
HOOH	Eye injury/trauma	Hyphaema	HOH
HOOU	Eye injury/trauma	Corneal abrasion	HOU
HOOL	Eye injury/trauma	Contact lens displacement	HOL
HOOR	Eye injury/trauma	Retinal detachment	HOR
HOOM	Eye injury/trauma	Eye trauma with multiple lesions	
HOEX	Ear trauma	Ear trauma	
HOED	Ear trauma	Perforated ear drum	HO2
HODX	Dental injury	Dental Injury	HG1
HODF	Dental injury	Fractured tooth	HGF
HODD	Dental injury	Avulsed tooth	HGA
HODL	Dental injury	Subluxed tooth	
HZXX	Head pain/injury not otherwise specified (including headache)	Head pain/injury not otherwise specified (including headache)	
HZEX	Exercise related headache	Exercise related headache	
HZEM	Exercise related headache	Exercise related migraine	
HZNX	Cervicogenic headache	Cervicogenic headache	
HZNM	Cervicogenic headache	Muscular trigger point referred headache	
HZZX	Other head pain/injury not otherwise specified	Other head pain/injury not otherwise specified	HZ1
NXXX	Neck injuries	Neck injuries	
NHXX	Neck soft tissue bruising/haematoma	Neck soft tissue bruising/haematoma	NH1
NKXX	Neck laceration/abrasion	Neck laceration/abrasion	NK1
NKXQ	Complication of neck laceration/abrasion including infection	Complication of neck laceration/abrasion including infection	
NKXS	Neck laceration requiring suturing	Neck laceration requiring suturing	
NKXN	Neck laceration not requiring suturing	Neck laceration not requiring suturing	
NWXX	Whiplash	Whiplash	NJ1
NMXX	Neck muscle and/or tendon strain/spasm/trigger points	Neck muscle and/or tendon strain/spasm/trigger points	
NMSX	Neck muscle strain	Neck muscle strain	NM1
NMYX	Neck muscle spasm/trigger points incl torticollis	Neck muscle spasm/trigger points incl torticollis	NY1
NJXX	Cervical spine facet joint injuries	Cervical spine facet joint injuries	
NJLX	Facet joint/neck ligament sprain	Facet joint/neck ligament sprain	NL1
NJUX	Cervical subluxation/instability	Cervical subluxation/instability	NU8
NJPX	Cervical facet joint pain/chronic inflammation/stiffness	Cervical facet joint pain/chronic inflammation/stiffness	NP1
NCXX	Cervical disc injury	Cervical disc injury	
NCLX	Cervical disc sprain	Cervical disc sprain	
NCLP	Cervical disc sprain	Cervical disc prolapse	NC1
NFXX	Neck fracture	Neck fracture	
NFCX	Cervical fracture/s	Cervical fracture/s	
NFCS	Cervical fracture/s	Stable cervical fracture/s	NF1
NFCU	Cervical fracture/s	Unstable cervical fracture/s	NF2
NFCA	Cervical fracture/s	Avulsion fracture/s cervical spine (eg, spinous process fracture)	NG1
NFLX	Laryngeal fracture	Laryngeal fracture	
NOXX	Neck organ damage	Neck organ damage	
NOLX	Laryngeal trauma	Laryngeal trauma	NO1
NOLF	Laryngeal trauma	Foreign body in larynx	
NNXX	Neurological neck injury	Neurological neck injury	

(*Continued*)

Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
NNNX	Cervical nerve root compression/ stretch (proximal burner/stinger)	Cervical nerve root compression/ stretch (proximal burner/stinger)	NN1
NNSX	Cervical spinal cord injury	Cervical spinal cord injury	NN2
NNSC	Cervical spinal cord injury	Cervical spinal cord concussion	NN4
NAXX	Cervical spinal column degenerative disc disease/arthritis	Cervical spinal column degenerative disc disease/arthritis	
NAFX	Cervical facet joint arthritis	Cervical facet joint arthritis	NA1
NACX	Cervical spinal canal stenosis	Cervical spinal canal stenosis	NN3
NADX	Cervical disc degeneration	Cervical disc degeneration	NC2
NZXX	Neck pain/injury not otherwise specified	Neck pain/injury not otherwise specified	NZ1
SXXX	Neck pain/injury not otherwise specified	Neck pain/injury not otherwise specified	
SHXX	Shoulder soft tissue bruising/ haematoma	Shoulder soft tissue bruising/ haematoma	SH1
SHMX	Shoulder muscle haematoma	Shoulder muscle haematoma	
SHMD	Shoulder muscle haematoma	Deltoid haematoma	SHD
SHMT	Shoulder muscle haematoma	Trapezius haematoma	
SHMR	Shoulder muscle haematoma	Rotator Cuff haematoma	
SHAX	AC joint contusion	AC joint contusion	
SHZX	AC joint contusion	AC joint contusion	
SKXX	shoulder soft tissue laceration/ abrasion	shoulder soft tissue laceration/ abrasion	SK1
SKXQ	Complication of shoulder laceration/ abrasion including infection	Complication of shoulder laceration/ abrasion including infection	
SKXS	Shoulder laceration requiring suturing	Shoulder laceration requiring suturing	
SKXN	Shoulder laceration/abrasion not requiring suturing	Shoulder laceration/abrasion not requiring suturing	
SMXX	Shoulder muscle strain/spasm/trigger points	Shoulder muscle strain/spasm/trigger points	SM1
SMDX	Deltoid muscle injury	Deltoid muscle injury	
SMPX	Pectoralis major muscle injury	Pectoralis major muscle injury	SMP
SMLX	Latissimus dorsi muscle injury	Latissimus dorsi muscle injury	SML
SMRX	Rotator cuff muscle injury	Rotator cuff muscle injury	
SMYX	Shoulder muscle trigger points/ posterior muscle soreness	Shoulder muscle trigger points/ posterior muscle soreness	SY1
SMZX	Other shoulder muscle injury not elsewhere specified	Other shoulder muscle injury not elsewhere specified	
STXX	Shoulder tendon overuse injury/strain	Shoulder tendon overuse injury/ strain	ST1
STSX	Supraspinatus tendon injury	Supraspinatus tendon injury	STS
STST	Supraspinatus tendon injury	Supraspinatus tendinopathy	
STSC	Supraspinatus tendon injury	Calcific tendinopathy	
STSP	Supraspinatus tendon injury	Supraspinatus tendon tear partial thickness	
STSR	Supraspinatus tendon injury	Suprapinatus tendon rupture full thickness	SRS
STSZ	Supraspinatus tendon injury	Other supraspinatus tendon injury not otherwise specified	
STIX	Infraspinatus tendon injury	Infraspinatus tendon injury	STI
STIR	Infraspinatus tendon injury	Infraspinatus tendon rupture	SRI
STIZ	Infraspinatus tendon injury	Other Infraspinatus tendon injury not otherwise specified	
STCX	Subscapularis tendon injury	Subscapularis tendon injury	STU
STCR	Subscapularis tendon injury	Subscapularis tendon rupture	SRU
STCZ	Subscapularis tendon injury	Other subscapularis tendon injury not otherwise specified	

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
STBX	Proximal biceps tendon injury	Proximal biceps tendon injury	
STBT	Proximal biceps tendon injury	Biceps tendinopathy	ST2
STBR	Proximal biceps tendon injury	Long head of biceps tendon rupture	SR2
STBZ	Proximal biceps tendon injury	Other biceps tendon injury not otherwise specified	
STPX	Pectoralis major tendon injury	Pectoralis major tendon injury	
STPR	Pectoralis major tendon injury	Pec major tendon rupture	UR1
STPZ	Pectoralis major tendon injury	Other pec major tendon injury not otherwise specified	
STMX	Multiple tendon injury	Multiple tendon injury	
STMT	Multiple tendon injury	Multiple tendinopathy	
STMS	Multiple tendon injury	Multiple tendon strain/rupture	
STZX	Other tendon injury NOS	Other tendon injury NOS	
SJXX	Acute shoulder sprains/subluxation	Acute shoulder sprains/subluxation	
SJSX	Glenohumeral joint sprains	Glenohumeral joint sprains	SL1
SJSA	Glenohumeral joint sprains	Anteroinferior shoulder subluxation	SUA
SJSL	Glenohumeral joint sprains	Glenohumeral ligament sprain	SLI
SJSP	Glenohumeral joint sprains	Posterior shoulder subluxation	SUP
SJSQ	Glenohumeral joint sprains	Glenohumeral joint sprain with chondral/labral damage (incl SLAP tear)	SCS
SJAX	Acromioclavicular joint sprain	Acromioclavicular joint sprain	SJ2
SJAS	Acromioclavicular joint sprain	Grade 1 AC joint sprain	SJ2
SJAT	Acromioclavicular joint sprain	Grade 2 AC joint sprain	SJ2
SJAD	Acromioclavicular joint sprain	Grade 3 AC joint dislocation	SD2
SJAR	Acromioclavicular joint sprain	Grade 4–6 AC joint dislocation	SD2
SJAF	Acromioclavicular joint sprain	Fracture dislocation AC joint	
SCXX	Shoulder osteochondral lesion	Shoulder osteochondral lesion	SC1
SDXX	Acute shoulder dislocation	Acute shoulder dislocation	SD1
SDAX	Anteroinferior shoulder dislocation	Anteroinferior shoulder dislocation	SDA
SDAL	Anteroinferior shoulder dislocation	Shoulder dislocation with labral bankart lesion	SCB
SDAS	Anteroinferior shoulder dislocation	Shoulder dislocation with SLAP tear	
SDAH	Anteroinferior shoulder dislocation	Shoulder dislocation with HAGL lesion	SCH
SDAG	Anteroinferior shoulder dislocation	Glenohumeral ligament tear	
SDAA	Anteroinferior shoulder dislocation	Shoulder dislocation with axillary nerve injury	
SDAN	Anteroinferior shoulder dislocation	Shoulder dislocation with other or unspecified neurological injury	
SDIX	Inferior shoulder dislocation	Inferior shoulder dislocation	SDI
SDPX	Posterior shoulder dislocation	Posterior shoulder dislocation	SDP
SDPL	Posterior shoulder dislocation	Posterior shoulder dislocation with posterior labral lesion	SCP
SUXX	Chronic shoulder instability	Chronic shoulder instability	SU1
SUAX	Anteroinferior instability of shoulder	Anteroinferior instability of shoulder	
SUAL	Anteroinferior instability of shoulder	Anteroinferior instability with labral lesion incl SLAP	
SUAI	Anteroinferior instability of shoulder	Anteroinferior instability shoulder with RC bruising/impingement	
SUPX	Posterior instability	Posterior instability	
SUBX	SLAP Lesion	SLAP Lesion	
SUCX	AC Joint instability/recurrent sprains	AC Joint instability/recurrent sprains	
SGXX	Shoulder impingement/synovitis	Shoulder impingement/synovitis	
SGSX	Subacromial impingement	Subacromial impingement	
SGSA	Subacromial impingement	Acute subacromial impingement	
SGSI	Subacromial impingement	Instability associated subacromial impingement	

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
SGSP	Subacromial impingement	Posture associated impingement	
SGSC	Subacromial impingement	Other chronic subacromial impingement	
SGIX	Internal impingement of the shoulder	Internal impingement of the shoulder	
SGIA	Internal impingement of the shoulder	Acute anterior internal impingement	STF
SGIP	Internal impingement of the shoulder	Acute posterior internal impingement	STE
SGIC	Internal impingement of the shoulder	Chronic internal impingement	STB
SGCX	Adhesive capsulitis	Adhesive capsulitis	SP1
SGAX	Synovitis AC joint	Synovitis AC joint	
SFXX	Shoulder fractures	Shoulder fractures	SG1
SFCX	Clavicular fracture	Clavicular fracture	SF1
SFCO	Clavicular fracture	Fracture outer third clavicle	SFO
SFCM	Clavicular fracture	Fracture middle third clavicle	SFM
SFCI	Clavicular fracture	Fracture inner third clavicle	SFI
SFCR	Clavicular fracture	Refracture clavicle through callus	SFR
SFSX	Scapula fracture	Scapula fracture	SF2
SFSB	Scapula fracture	Fractured glenoid = bony bankart lesion	SGB
SFHX	Humerus fracture	Humerus fracture	
SFHN	Humerus fracture	Fracture neck of humerus	SF3
SFHT	Humerus fracture	Fracture greater tuberosity humerus	
SFHH	Humerus fracture	Hill sachs compression fracture	SGH
SSXX	Shoulder stress/overuse injuries incl stress fractures	Shoulder stress/overuse injuries incl stress fractures	
SSFX	Shoulder bony stress/over use injury	Shoulder bony stress/over use injury	
SSFS	Shoulder bony stress/over use injury	Stress fracture coracoid process	SS1
SSAX	AC joint stress/overuse injury	AC joint stress/overuse injury	SA2
SSAO	AC joint stress/overuse injury	Osteolysis of distal clavicle	SAO
SSZX	Other bony/overuse injuries not elsewhere classified	Other bony/overuse injuries not elsewhere classified	
SNXX	Shoulder neurological/vascular injury	Shoulder neurological/vascular injury	SN3
SNTX	Thoracic outlet syndrome	Thoracic outlet syndrome	
SNBX	Brachial plexus traction injury/ burner/stinger	Brachial plexus traction injury/ urner/stinger	SN1
SNAX	Isolated axillary nery palsy (excl ax n palsy due to shoulder dislocation – SDAA)	Isolated axillary nery palsy (excl ax n palsy due to shoulder dislocation – SDAA)	SN2
SNSX	Suprascapular nerve palsy	Suprascapular nerve palsy	SN4
SNVX	Shoulder vascular injury	Shoulder vascular injury	
SNVS	Shoulder vascular injury	Subclavian vein obstruction	
SAXX	Shoulder osteoarthritis	Shoulder osteoarthritis	
SAGX	Glenohumeral osteoarthritis	Glenohumeral osteoarthritis	SA1
SAAX	AC joint arthritis	AC joint arthritis	SAA
SZXX	Shoulder pain/injury not otherwise specified	Shoulder pain/injury not otherwise specified	SZ1
UXXX	Shoulder pain/injury not otherwise specified	Shoulder pain/injury not otherwise specified	
UHXX	Upper arm soft tissue bruising/ haematoma	Upper arm soft tissue bruising/ haematoma	UH1
UHMX	Upper arm muscle bruising/ haematoma	Upper arm muscle bruising/ haematoma	
UHMB	Upper arm muscle bruising/ haematoma	Biceps haematoma	UHB
UHMT	Upper arm muscle bruising/ haematoma	Triceps haematoma	UHT
	Upper arm muscle bruising/ haematoma	Upper arm myositis ossificans	UHM

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
UHZX	Other upper arm soft tissue bruising/haematoma	Other upper arm soft tissue bruising/haematoma	
UKXX	Upper Arm Laceration/Abrasion	Upper Arm Laceration/Abrasion	UK1
UKXQ	Complication of upper arm laceration/abrasion including infection	Complication of upper arm laceration/abrasion including infection	
UKXS	Upper arm laceration requiring suturing	Upper arm laceration requiring suturing	
UKXN	Upper arm laceration/abrasion not requiring suturing	Upper arm laceration/abrasion not requiring suturing	
UMXX	Upper arm muscle strain/spasm/ trigger points	Upper arm muscle strain/spasm/ trigger points	UM1
UMBX	Biceps muscle strain	Biceps muscle strain	UMB
UMTX	Triceps muscle strain	Triceps muscle strain	UMT
UMYX	Upper arm muscle trigger points/pain	Upper arm muscle trigger points/pain	UY1
UMYD	Upper arm muscle trigger points/pain	Upper arm DOMS	
UMYT	Upper arm muscle trigger points/pain	Upper arm trigger points/spasm	
UTXX	Upper arm tendon injury	Upper arm tendon injury	
UFXX	Upper arm fracture	Upper arm fracture	
UFHX	Humerus fracture	Humerus fracture	
UFHM	Humerus fracture	Midshaft humerus fracture	UF1
USXX	Upper arm bony stress/overuse injury	Upper arm bony stress/overuse injury	
USFX	Upper arm stress fracture	Upper arm stress fracture	
USFH	Upper arm stress fracture	Stress fracture humerus	
UYXX	Other upper arm overuse injury	Other upper arm overuse injury	
UYTX	Upper arm soft tissue overuse injury (eg, periostitis)	Upper arm soft tissue overuse injury (eg, periostitis)	
UNXX	Upper arm neurological injury	Upper arm neurological injury	UN1
UNMX	Median nerve injury upper arm	Median nerve injury upper arm	UNM
UNRX	Radial nerve injury upper arm	Radial nerve injury upper arm	UNR
UNUX	Ulnar nerve injury upper arm	Ulnar nerve injury upper arm	
UNSX	Musculocutaneous nerve injury upper arm	Musculocutaneous nerve injury upper arm	
UZXX	Upper arm pain/injury not otherwise specified	Upper arm pain/injury not otherwise specified	
EXXX	Elbow injuries	Elbow injuries	
EHXX	Elbow soft tissue bruising/haematoma	Elbow soft tissue bruising/haematoma	EH1
EKXX	Elbow laceration/abrasion	Elbow laceration/abrasion	EK1
EKXQ	Complication of elbow laceration including infection	Complication of elbow laceration including infection	
EKSX	Elbow laceration/abrasion superficial	Elbow laceration/abrasion superficial	
EKDX	Elbow laceration deep – intraarticular	Elbow laceration deep – intraarticular	
EMXX	Elbow muscle strain/spasm/trigger points	Elbow muscle strain/spasm/trigger points	
ETXX	Elbow tendon injury	Elbow tendon injury	
ETEX	Common extensor origin injury	Common extensor origin injury	
ETET	Common extensor origin injury	Common extensor origin tendinopathy (incl tennis elbow)	ET1
ETES	Common extensor origin injury	Common extensor origin strain/rupture	
ETFX	Common flexor origin injury	Common flexor origin injury	
ETFT	Common flexor origin injury	Common flexor origin tendinopathy	ET2
ETFS	Common flexor origin injury	Common flexor origin strain/rupture	
ETBX	Distal biceps tendon injury	Distal biceps tendon injury	
ETBT	Distal biceps tendon injury	Distal biceps tendinopathy	

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
ETBS	Distal biceps tendon injury	Distal biceps tendon strain	
ETBR	Distal biceps tendon injury	Distal biceps tendon rupture	ER1
ETTX	Distal triceps tendon injury	Distal triceps tendon injury	ET3
ETTT	Distal triceps tendon injury	Distal triceps tendinopathy	
ETTS	Distal triceps tendon injury	Distal triceps tendon strain	
ETTR	Distal triceps tendon injury	Distal triceps tendon rupture	ER2
EJXX	Elbow joint sprain	Elbow joint sprain	EJ1
EJMX	Elbow medial ligament injury	Elbow medial ligament injury	EL1
EJMR	Elbow medial ligament injury	Elbow medial ligament rupture/ grade 3 tear	
EJMC	Elbow medial ligament injury	Elbow medial ligament injury and CFO tear	
EJHX	Elbow hyperextension ± strain anterior elbow structures	Elbow hyperextension ± strain anterior elbow structures	
EJZX	Other elbow strain not otherwise specified	Other elbow strain not otherwise specified	
ECXX	Elbow osteochondral injury	Elbow osteochondral injury	EC1
ECLX	Loose body in elbow	Loose body in elbow	ECL
EDXX	Elbow dislocation	Elbow dislocation	ED1
EDAX	Anterion elbow dislocation	Anterion elbow dislocation	EDA
EDPX	Posterior elbow dislocation	Posterior elbow dislocation	EDP
EDRX	Dislocated radial head	Dislocated radial head	ED2
EUXX	Elbow Instability	Elbow Instability	
EUMX	Elbow valgus instability	Elbow valgus instability	EU1
EUPX	Elbow posterolateral instability	Elbow posterolateral instability	EU2
EGXX	Elbow Impingement/Synovitis	Elbow Impingement/Synovitis	EP1
EGPX	Elbow posterior impingement/ synovitis	Elbow posterior impingement/ synovitis	ET4
EGBX	Elbow olecranon bursitis	Elbow olecranon bursitis	
EFXX	Elbow fractures	Elbow fractures	EF3
EFXA	Avulsion fracture elbow multiple locations or location unspecified	Avulsion fracture elbow multiple locations or location unspecified	EG1
EFHX	Fractured distal humerus	Fractured distal humerus	
EFHS	Fractured distal humerus	Supracondylar humeral fracture	EF1
EFHC	Fractured distal humerus	Fractured humeral condyle(s)	EF2
EFHA	Fractured distal humerus	Avulsion fracture distal humerus	
EFUX	Fractured proximal ulna	Fractured proximal ulna	
EFUO	Fractured proximal ulna	Fractured olecranon	
EFUA	Fractured proximal ulna	Avulsion fracture distal ulna	
EFRX	Fractured distal radius	Fractured distal radius	
EFRH	Fractured distal radius	Fractured radial head	
EFRA	Fractured distal radius	Avulsion fracture distal radius	
ESXX	Elbow stress/overuse injuries incl stress fractures	Elbow stress/overuse injuries incl stress fractures	
ENXX	Elbow neurological injury/ entrapment	Elbow neurological injury/entrapment	EN2
ENUX	Ulnar nerve injury at elbow	Ulnar nerve injury at elbow	EN1
EAXX	Elbow osteoarthritis	Elbow osteoarthritis	EA1
EZXX	Elbow pain/injury not otherwise specified	Elbow pain/injury not otherwise specified	EZ1
RXXX	Elbow pain/injury not otherwise specified	Elbow pain/injury not otherwise specified	
RHXX	Forearm soft tissue bruising/ haematoma	Forearm soft tissue bruising/ haematoma	RH1
RKXX	Forearm laceration/abrasion	Forearm laceration/abrasion	RK1
RKXQ	Complication of forearm laceration/ abrasion including infection	Complication of forearm laceration/ abrasion including infection	

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
RMXX	Forearm muscle injury	Forearm muscle injury	RM1
RMEX	Forearm extensor muscle strain	Forearm extensor muscle strain	
RMFX	Forearm flexor muscle strain	Forearm flexor muscle strain	
RMYX	Forearm muscle soreness/trigger points	Forearm muscle soreness/trigger points	RY1
RTXX	Forearm tendon injury	Forearm tendon injury	
RTEX	Forearm extensor tendon injury	Forearm extensor tendon injury	RT1
RTET	Forearm extensor tendon injury	Forearm extensor tendinopathy	
RTES	Forearm extensor tendon injury	Forearm extensor tenosynovitis	
RTEI	Forearm extensor tendon injury	Intersection syndrome	
RTFX	Forearm flexor tendon injury	Forearm flexor tendon injury	
RFXX	Forearm fracture(s)	Forearm fracture(s)	RF1
RFBX	Fracture radius and ulna midshaft	Fracture radius and ulna midshaft	RFB
RFRX	fracture radius midshaft	fracture radius midshaft	
RFRG	fracture radius midshaft	Galleazzi fracture – midshaft radius fracture, dislocation DRUJ	RMG
RFUX	Fractured ulna midshaft	Fractured ulna midshaft	
RFUM	Fractured ulna midshaft	Monteggia fracture – midshaft ulna fracture and dislocation radial head at elbow	RFM
RSXX	Forearm bony stress/overuse injury including stress fracture	Forearm bony stress/overuse injury including stress fracture	
RSFX	Stress fracture radius and/or ulna	Stress fracture radius and/or ulna	RS1
RYXX	Other stress/overuse injuries to forearm	Other stress/overuse injuries to forearm	
RYPX	Forearm splints/medial ulnar stress syndrome	Forearm splints/medial ulnar stress syndrome	
RYCX	Forearm compartment syndrome	Forearm compartment syndrome	
RNXX	Forearm neurological injury	Forearm neurological injury	
RZXX	Forearm pain/injury not otherwise specified	Forearm pain/injury not otherwise specified	
WXXX	Forearm pain/injury not otherwise specified	Forearm pain/injury not otherwise specified	
WHXX	Wrist and hand soft tissue bruising/ haematoma	Wrist and hand soft tissue bruising/ haematoma	
WHWX	Wrist bruising/haematoma	Wrist bruising/haematoma	WH1
WHHX	Hand bruising/haematoma	Hand bruising/haematoma	PH1
WHPX	Thumb bruising/haematoma	Thumb bruising/haematoma	
WHPU	Thumb bruising/haematoma	Thumbnail haematoma	
WHFX	Finger bruising/haematoma	Finger bruising/haematoma	
WHFU	Finger bruising/haematoma	Fingernail haematoma	PH2
WKXX	Wrist and hand laceration/abrasion	Wrist and hand laceration/abrasion	PK2
WKXQ	Complication of wrist/hand laceration/abrasion including infection	Complication of wrist/hand laceration/abrasion including infection	
WKWX	Wrist laceration/abrasion	Wrist laceration/abrasion	WK1
WKWD	Wrist laceration/abrasion	Dorsal wrist laceration/abrasion	
WWV	Wrist laceration/abrasion	Volar wrist laceration/abrasion	
WKHX	Hand laceration/abrasion	Hand laceration/abrasion	
WKHD	Hand laceration/abrasion	Dorsal hand laceration/abrasion	
WKHV	Hand laceration/abrasion	Palmar hand laceration/abrasion	
WKPX	Thumb laceration/abrasion	Thumb laceration/abrasion	
WKPU	Thumb laceration/abrasion	Laceration of thumb nail/nailbed	
WKFX	Finger laceration/abrasion	Finger laceration/abrasion	
WKFU	Finger laceration/abrasion	Laceration of fingernail/nailbed	
WKBX	Blisters of wrist/hand (incl fingers/thumb)	Blisters of wrist/hand (incl fingers/thumb)	

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
WKCX	Callous of Wrist/hand (incl fingers/thumb)	Callous of Wrist/hand (incl fingers/thumb)	
WMXX	Wrist and hand muscle injury	Wrist and hand muscle injury	
WTXX	Wrist and hand tendon injury	Wrist and hand tendon injury	PR1
WTTX	Thumb tendon injury	Thumb tendon injury	
WTTT	Thumb tendon injury	De Quervain's tenosynovitis	
WTTZ	Thumb tendon injury	Other tenosynovitis/tendinopathy thumb	
WTTE	Thumb tendon injury	Rupture thumb extensor tendon (excl if complication of wrist fracture – see specific fracture)	WRE
WTTF	Thumb tendon injury	Rupture thumb flexor tendon	
WTTG	Thumb tendon injury	Trigger thumb	
WTDX	Wrist extensor tendon injury	Wrist extensor tendon injury	
WTDT	Wrist extensor tendon injury	wrist extensor tenosynovitis/ tendinopathy at wrist (excl intersection syndrome see – RTEI)	
WTDR	Wrist extensor tendon injury	Rupture wrist extensor tendon	
WTEX	Finger extensor tendon injury (incl mallet finger ± avulsion fracture distal phalanx)	Finger extensor tendon injury (incl mallet finger ± avulsion fracture distal phalanx)	
WTET	Finger extensor tendon injury (incl mallet finger ± avulsion fracture distal phalanx)	Finger(s) extensor tenosynovitis/ tendinopathy	
WTEA	Finger extensor tendon injury (incl mallet finger ± avulsion fracture distal phalanx)	Index finger extensor tendon rupture	PRA
WTEB	Finger extensor tendon injury (incl mallet finger ± avulsion fracture distal phalanx)	Middle finger extensor tendon rupture	PRB
WTEC	Finger extensor tendon injury (incl mallet finger ± avulsion fracture distal phalanx)	Ring finger extensor tendon rupture	PRC
WTED	Finger extensor tendon injury (incl mallet finger ± avulsion fracture distal phalanx)	Little finger extensor tendon rupture	PRD
WTVX	Flexor tendon injury at wrist	Flexor tendon injury at wrist	
WTVT	Flexor tendon injury at wrist	Wrist flexor tenosynovitis/ tendinopathy	WT3
WTVR	Flexor tendon injury at wrist	Rupture wrist flexor tendon	
WTFX	Flexor tendon injury finger(s)	Flexor tendon injury finger(s)	
WTFT	Flexor tendon injury finger(s)	Finger flexor tenosynovitis/ tendinopathy	
WTFA	Flexor tendon injury finger(s)	Index finger flexor tendon rupture	
WTFB	Flexor tendon injury finger(s)	Middle finger flexor tendon rupture	PRT
WTFC	Flexor tendon injury finger(s)	Ring finger flexor tendon rupture	PRF
WTFD	Flexor tendon injury finger(s)	Little finger flexor tendon rupture	
WTFP	Flexor tendon injury finger(s)	Dupytron's contracture	
WTFG	Flexor tendon injury finger(s)	Trigger finger	PT1
WTFF	Flexor tendon injury finger(s)	Flexor pully injury fingers	
WJXX	Wrist and hand joint injury	Wrist and hand joint injury	PL2
WJWX	Wrist sprain/jarring (radiocarpal joint)	Wrist sprain/jarring (radiocarpal joint)	WJ1
WJWG	Wrist sprain/jarring (radiocarpal joint)	Wrist ganglion	WT2
WJWQ	Wrist sprain/jarring (radiocarpal joint)	Other complication of wrist sprain	

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
WJSX	Scapholunate ligament sprain/tear	Scapholunate ligament sprain/tear	WLS
WJSS	Scapholunate ligament sprain/tear	Scapholunate ligament sprain	
WJSR	Scapholunate ligament sprain/tear	Scapholunate ligament rupture	
WJCX	Other carpal ligament injury	Other carpal ligament injury	WL1
WJCV	Other carpal ligament injury	Lunate – triquetral sprain	
WJDX	Distal radioulnar joint injury	Distal radioulnar joint injury	WJ2
WJDT	Distal radioulnar joint injury	Triangular fibrocartilage complex tear	WC1
WJPX	Thumb sprain	Thumb sprain	
WJPC	Thumb sprain	Thumb CMC jt sprain	
WJPM	Thumb sprain	Thumb MCP joint sprain (incl radial and ulnar collat ligs)	PL1
WJPU	Thumb sprain	Thumb UCL lig rupture at MCP joint (skier's thumb)	
WJPR	Thumb sprain	Thumb RCL lig rupture at MCP joint	
WJPI	Thumb sprain	Thumb IP joint sprain	
WJPQ	Thumb sprain	Complication of thumb sprain excl chronic instability (see WUTX)	
WJMX	Metacarpaophalangeal joint sprain	Metacarpaophalangeal joint sprain	
WJMQ	Metacarpaophalangeal joint sprain	Complication of MCP jt sprain excl chronic instability (see WUMQ)	
WJFX	Finger joint sprain (PIP and DIP joints)	Finger joint sprain (PIP and DIP joints)	PG1
WJFQ	Finger joint sprain (PIP and DIP joints)	Complication of finger joint sprain excl. chronic instability	
WCXX	Wrist and hand osteochondral/ chondral injury	Wrist and hand osteochondral/ chondral injury	
WDXX	Wrist and hand dislocations	Wrist and hand dislocations	PD1
WDWX	Radiocarpal joint dislocation	Radiocarpal joint dislocation	
WDDX	DRUJ dislocation	DRUJ dislocation	
WDCX	Dislocation through carpus	Dislocation through carpus	WD1
WDTX	Dislocation of CMC joint of fingers	Dislocation of CMC joint of fingers	
WDPX	Dislocation of thumb joint	Dislocation of thumb joint	
WDPC	Dislocation of thumb joint	Dislocation CMC joint thumb	WD2
WDPM	Dislocation of thumb joint	Dislocation of MCP joint thumb	PDA
WDPI	Dislocation of thumb joint	Dislocation of IP joint thumb	PDF
WDPQ	Dislocation of thumb joint	Complication of thumb joint dislocation excl instability – see WUPX	
WDMX	Dislocation of MCP joint finger(s)	Dislocation of MCP joint finger(s)	
WDMA	Dislocation of MCP joint finger(s)	MCP jt dislocation index finger	PDB
WDMB	Dislocation of MCP joint finger(s)	MCP jt dislocation middle finger	PDC
WDMC	Dislocation of MCP joint finger(s)	MCP jt dislocation ring finger	PDD
WDMD	Dislocation of MCP joint finger(s)	MCP jt dislocation little finger	PDE
WDMM	Dislocation of MCP joint finger(s)	MCP jt dislocation of two or more fingers	
WDMQ	Dislocation of MCP joint finger(s)	Complication of finger MCP jt sprain (excl instability see WUMX)	
WDFX	Dislocation of PIP or DIP joint(s)	Dislocation of PIP or DIP joint(s)	
WDFA	Dislocation of PIP or DIP joint(s)	PIP joint dislocation index finger	PDG
WDFB	Dislocation of PIP or DIP joint(s)	PIP joint dislocation middle finger	PDH
WDFC	Dislocation of PIP or DIP joint(s)	PIP joint dislocation ring finger	PDI
WDFD	Dislocation of PIP or DIP joint(s)	PIP joint dislocation little finger	PDJ
WDFE	Dislocation of PIP or DIP joint(s)	DIP joint dislocation index finger	PDK
WDFF	Dislocation of PIP or DIP joint(s)	DIP joint dislocation middle finger	PDL
WDFG	Dislocation of PIP or DIP joint(s)	DIP joint dislocation ring finger	PDM
WDFH	Dislocation of PIP or DIP joint(s)	DIP joint dislocation little finger	PDN
WDFM	Dislocation of PIP or DIP joint(s)	Multiple PIP and/or DIP joint dislocations	

(*Continued*)

Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
WDFV	Dislocation of PIP or DIP joint(s)	Finger joint dislocation with volar plate injury	
WDFW	Dislocation of PIP or DIP joint(s)	PIP joint dislocation finger unknown	
WDFY	Dislocation of PIP or DIP joint(s)	DIP joint dislocation finger unknown	
WDFQ	Dislocation of PIP or DIP joint(s)	Complication of PIP/DIP joint dislocation (excl chr instability see WUFX)	
WUXX	Chronic wrist or hand instability	Chronic wrist or hand instability	PU1
WUWX	Radiocarpal joint instability	Radiocarpal joint instability	
WUCX	Carpal instability	Carpal instability	WU1
WUCV	Carpal instability	VISI wrist instability	WUV
WUCD	Carpal instability	Scapholunate (DISI) instability	WUD
WUDX	Distal radioulnar joint instability	Distal radioulnar joint instability	WU2
WUPX	Thumb instability	Thumb Instability	
WUPC	Thumb instability	1st CMC joint instability	
WUPM	Thumb instability	1st MCP joint instability	
WUPI	Thumb instability	IP joint instability of thumb	
WUMX	Finger MCP joint instability	Finger MCP joint instability	
WUFX	Finger PIP or DIP joint instability	Finger PIP or DIP joint instability	
WGXX	Wrist and hand impingement/synovitis	Wrist and hand impingement/synovitis	
WGWX	Chronic synovitis of wrist	Chronic synovitis of wrist	WP1
WGWU	Chronic synovitis of wrist	Ulnar abutment syndrome	
WGPX	Chronic synovitis of thumb	Chronic synovitis of thumb	
WGPC	Chronic synovitis of thumb	Chronic synovitis of 1st CMC joint	
WGPM	Chronic synovitis of thumb	Chronic synovitis of 1st MCP joint	
WGPI	Chronic synovitis of thumb	Chronic Synovitis of IP joint thumb	
WGFX	Chronic synovitis of fingers	Chronic synovitis of fingers	PP1
WGFM	Chronic synovitis of fingers	Chronic synovitis of MCP joint(s)	
WGFP	Chronic synovitis of fingers	Chronic synovitis of PIP joint(s)	
WGFD	Chronic synovitis of fingers	Chronic synovitis of DIP joint(s)	
WFXX	Wrist and hand fractures	Wrist and hand fractures	WG1
WFRX	Fracture of distal radius ± ulna	Fracture of distal radius ± ulna	WF3
WFRC	Fracture of distal radius ± ulna	Colles fracture distal radius	RFC
WFRS	Fracture of distal radius ± ulna	Smiths fracture distal radius	RFS
WFRT	Fracture of distal radius ± ulna	Fracture radial styloid	WGR
WFRQ	Fracture of distal radius ± ulna	Wrist fracture with complication (eg, EPL rupture)	
WFUX	Fracture of distal ulna	Fracture of distal ulna	RFU
WFUT	Fracture of distal ulna	Fracture of ulna styloid	WGU
WFSX	Scaphoid fracture	Scaphoid fracture	WF1
WFSP	Scaphoid fracture	Fracture proximal pole scaphoid	WFP
WFSW	Scaphoid fracture	fracture waist scaphoid	WFW
WFSD	Scaphoid fracture	Fracture distal pole scaphoid	WFD
WFSN	Scaphoid fracture	Non union fractured scaphoid	WQ1
WFHX	Fractured hamate	Fractured hamate	WFH
WFHH	Fractured hamate	Fractured hook of hamate	WGH
WFTX	Fractured trapezium	Fractured trapezium	WFT
WFCX	Fracture other carpal bone	Fracture other carpal bone	WF2
WFCM	Fracture other carpal bone	Fracture multiple carpal bones	
WFPX	Fractured thumb	Fractured thumb	
WFPM	Fractured thumb	Fracture shaft 1st MC	PFA
WFPB	Fractured thumb	Bennett's fracture thumb – base 1st MC	PF1
WFPR	Fractured thumb	Rolando fracture (comminuted fracture base 1st MC)	PFR
WFPP	Fractured thumb	Fracture proximal phalanx of thumb	PFF
WFPD	Fractured thumb	Fracture distal phalanx thumb	PFK

(*Continued*)

Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
WFMX	Fracture metacarpals 2–5	Fracture metacarpals 2–5	PF2
WFMM	Fracture metacarpals 2–5	Multiple metacarpal fractures	PFX
WFMA	Fracture metacarpals 2–5	Fracture 2nd metacarpal	PFB
WFMB	Fracture metacarpals 2–5	Fracture 3rd metacarpal	PFC
WFMC	Fracture metacarpals 2–5	Fracture 4th metacarpal	PFD
WFMD	Fracture metacarpals 2–5	Fracture 5th metacarpal	PFE
WFFX	Fracture finger(s) – excl avulsion fractures	Fracture finger(s) – excl avulsion fractures	PF3
WFFA	Fracture finger(s) – excl avulsion fractures	Proximal phalanx fracture index finger	PFG
WFFB	Fracture finger(s) – excl avulsion fractures	Proximal phalanx fracture middle finger	PFH
WFFC	Fracture finger(s) – excl avulsion fractures	Proximal phalanx fracture ring finger	PFI
WFFD	Fracture finger(s) – excl avulsion fractures	Proximal phalanx fracture little finger	PFJ
WFFE	Fracture finger(s) – excl avulsion fractures	Middle phalanx fracture index finger	PFL
WFFF	Fracture finger(s) – excl avulsion fractures	Middle phalanx fracture middle finger	PFM
WFFG	Fracture finger(s) – excl avulsion fractures	Middle phalanx fracture ring finger	PFN
WFFH	Fracture finger(s) – excl avulsion fractures	Middle phalanx fracture little finger	PFO
WFFI	Fracture finger(s) – excl avulsion fractures	Distal phalanx fracture index finger	PFP
WFFJ	Fracture finger(s) – excl avulsion fractures	Distal phalanx fracture middle finger	PFQ
WFFK	Fracture finger(s) – excl avulsion fractures	Distal phalanx fracture ring finger	PFS
WFFL	Fracture finger(s) – excl avulsion fractures	Distal phalanx fracture little finger	PFT
WFFM	Fracture finger(s) – excl avulsion fractures	Multiple phalangeal fractures fingers	PFU
WFFQ	Fracture finger(s) – excl avulsion fractures	Complication from finger fracture (incl malunion)	PQ1
WSXX	Wrist and hand stress/overuse injuries	Wrist and hand stress/overuse injuries	WS1
WSCX	Carpal stress fracture	Carpal stress fracture	
WSHX	Hand stress fracture (incl thumb and fingers)	Hand stress fracture (incl thumb and fingers)	
WSHP	Hand stress fracture (incl thumb and fingers)	Sesamoiditis of thumb	PP3
WNXX	Wrist and hand neurological injury	Wrist and hand neurological injury	WN1
WNCX	Carpal tunnel syndrome	Carpal tunnel syndrome	WNC
WVXX	Wrist and hand vascular injury	Wrist and hand vascular injury	
WVAX	Wrist and hand arterial injury (incl aneurysm)	Wrist and hand arterial injury (incl aneurysm)	WV1
WVNX	Avascular necrosis in wrist/hand	Avascular necrosis in wrist/hand	
WVNS	Avascular necrosis in wrist/hand	AVN scaphoid	
WVNL	Avascular necrosis in wrist/hand	AVN lunate	
WAXX	Wrist and hand osteoarthritis	Wrist and hand osteoarthritis	
WAWX	Wrist osteoarthritis	Wrist osteoarthritis	WA1
WAWS	Wrist osteoarthritis	SLAC Wrist (post S-L tear)	WAS
WAPX	Osteoarthritis of thumb	Osteoarthritis of thumb	
WAPC	Osteoarthritis of thumb	CMC jt OA	
WAPM	Osteoarthritis of thumb	MCP jt OA	

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
WAPI	Osteoarthritis of thumb	IP jt OA	
WAFX	Osteoarthritis of fingers	Osteoarthritis of fingers	PA1
WAFM	Osteoarthritis of fingers	MCP jt OA fingers	
WAFP	Osteoarthritis of fingers	PIP jt OA fingers	
WAFD	Osteoarthritis of fingers	DIP jt OA fingers	
WZXX	Other wrist and hand pain/injury not otherwise specified	Other wrist and hand pain/injury not otherwise specified	
WZCX	Chronic regional pain syndrome	Chronic regional pain syndrome	PP2
WZWX	Other wrist pain NOS	Other wrist pain NOS	WZ1
WZHX	Other hand pain NOS	Other hand pain NOS	
WZPX	Other thumb pain NOS	Other thumb pain NOS	
WZFX	Other finger pain NOS	Other finger pain NOS	
WZZX	Wrist or hand pain undiagnosed	Wrist or hand pain undiagnosed	
CXXX	Other wrist and hand pain/injury not otherwise specified	Other wrist and hand pain/injury not otherwise specified	
CHXX	Chest wall soft tissue bruising/ haematoma	Chest wall soft tissue bruising/ haematoma	
CHRX	Bruised rib(s)/chest wall	Bruised rib(s)/chest wall	CH1
CHSX	Bruised sternum	Bruised sternum	CH2
CKXX	Chest wall laceration/abrasion	Chest wall laceration/abrasion	
CKXQ	Complication of chest wall laceration/abrasion incl infection, perforation to chest cavity	Complication of chest wall laceration/abrasion incl infection, perforation to chest cavity	
CMXX	Chest muscle or tendon strain/ spasm/trigger points	Chest muscle or tendon strain/ spasm/trigger points	CM2
CMTX	Intercostal tendinopathy	Intercostal tendinopathy	CT1
CMYX	Chest muscle trigger points	Chest muscle trigger points	CY1
CJXX	Chest joint sprains	Chest joint sprains	
CJSX	Sternoclavicular joint sprains	Sternoclavicular joint sprains	CJ1
CJSA	Sternoclavicular joint sprains	Anterior Sternoclavicular joint sprain	
CJSP	Sternoclavicular joint sprains	Posterior sternoclavicular joint sprain	
CJCX	Sternocostal/costochondral joint sprains	Sternocostal/costochondral joint sprains	CC1
CJVX	Costovertebral joint sprains	Costovertebral joint sprains	
CDXX	Chest dislocations	Chest dislocations	
CDSX	Sternoclavicular joint dislocation	Sternoclavicular joint dislocation	
CDSP	Sternoclavicular joint dislocation	Posterior sternoclavicular joint dislocation	
CDCX	Costochondral joint dislocation	Costochondral joint dislocation	
CUXX	Chest joint instability	Chest joint instability	
CUSX	Sternoclavicular joint instability	Sternoclavicular joint instability	
CUCX	Costochondral joint instability	Costochondral joint instability	
CUVX	Costovertebral joint instability	Costovertebral joint instability	
CGXX	Synovitis of chest joint	Synovitis of chest joint	
CGSX	Synovitis of sternoclavicular joint	Synovitis of sternoclavicular joint	
CGCX	Costochondritis	Costochondritis	
CGVX	Inflammation/stiffness of costovertebral joints	Inflammation/stiffness of costovertebral joints	
CGZX	Inflammation of other chest joint not otherwise specified	Inflammation of other chest joint not otherwise specified	
CFXX	Chest fracture(s)	Chest fracture(s)	
CFRX	Rib fracture(s)	Rib fracture(s)	CF1
CFRA	Rib fracture(s)	Fracture upper rib (1–4)	CFH
CFRB	Rib fracture(s)	Fracture middle rib (5–9)	CFM
CFRC	Rib fracture(s)	Fracture lower rib (10–12)	CFL
CFRM	Rib fracture(s)	Fracture multiple ribs	CFX

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
CFRQ	Rib fracture(s)	Complication of rib fracture – incl pneumothorax	
CFSX	Sternal fracture	Sternal fracture	CF2
CRCX	Fracture of costochondral margin	Fracture of costochondral margin	
CSXX	Rib stress fracture(s)	Rib stress fracture(s)	CS1
COXX	Chest cavity injury	Chest cavity injury	
COPX	Lung injury(excl injury due to laceration (CKXQ) or rib fracture (CFRQ)	Lung injury(excl injury due to laceration (CKXQ) or rib fracture (CFRQ)	CO1
COPP	Lung injury(excl injury due to laceration (CKXQ) or rib fracture (CFRQ)	Pneumothorax	
COPH	Lung injury(excl injury due to laceration (CKXQ) or rib fracture (CFRQ)	Haemothorax	
CZXX	Chest pain/injury not elsewhere specified	Chest pain/injury not elsewhere specified	OG2
CZZX	Chest pain undiagnosed	Chest pain undiagnosed	CZ1
OXXX	Chest pain/injury not elsewhere specified	Chest pain/injury not elsewhere specified	
OHXX	Abdominopelvic soft tissue bruising/ haematoma	Abdominopelvic soft tissue bruising/ haematoma	OH1
OKXX	Truncal laceration/abrasion	Truncal laceration/abrasion	
OKXQ	Complication of laceration/abrasion to trunk – including infection	Complication of laceration/abrasion to trunk – including infection	
OKXS	Truncal laceration requiring suturing	Truncal laceration requiring suturing	
OKXN	Truncal laceration/abrasion not requiring suturing	Truncal laceration/abrasion not requiring suturing	
OMXX	Truncal muscle strain/spasm/trigger points	Truncal muscle strain/spasm/trigger points	OY1
OMMX	Truncal muscle strain	Truncal muscle strain	OM1
OMMO	Obliques muscle strain	Obliques muscle strain	OMO
OMMT	Trasversus abdominis muscle strain	Trasversus abdominis muscle strain	OMT
OMMR	Rectus abdominis muscle strain	Rectus abdominis muscle strain	GMR
OMYX	Truncal muscle trigger points/spasm	Truncal muscle trigger points/spasm	
OMYR	Rectus abdominis trigger points/spasm	Rectus abdominis trigger points/ spasm	GYR
OMWX	Winded	Winded	
OMCX	Abdominal muscle cramps	Abdominal muscle cramps	
OTXX	Abdominal Tendon Injury	Abdominal Tendon Injury	
OTRX	Rectus abdominis tendon injury	Rectus abdominis tendon injury	
OTRT	Rectus abdominis tendon injury	Rectus abdominus tendinopathy	OT1
OTRD	Rectus abdominis tendon injury	Divarication of rectus abdominis	
OTUX	Unbilical hernia	Unbilical hernia	
OGXX	Abdominal biomechanical injury	Abdominal biomechanical injury	
OGCX	Costoiliac impingement	Costoiliac impingement	OT2
OOXX	Abdominal organ injury	Abdominal organ injury	OO1
OOSX	Spleen trauma	Spleen trauma	OOS
OOIX	Intestinal trauma	Intestinal trauma	OOI
OOLX	Liver trauma	Liver trauma	OOL
OOPX	Pancreatic trauma	Pancreatic trauma	OOP
OOKX	Kidney trauma	Kidney trauma	OOK
OOMX	Multiple organ trauma	Multiple organ trauma	
OOZX	Other organ trauma not otherwise specified	Other organ trauma not otherwise specified	
OPXX	Pelvic organ injury	Pelvic organ injury	GO1
OPBX	Bladder trauma	Bladder trauma	OOB
OZXX	Abdominal pain not otherwise specified	Abdominal pain not otherwise specified	

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
OZZX	Abdominal pain undiagnosed	Abdominal pain undiagnosed	OZ1
DXXX	Abdominal pain not otherwise specified	Abdominal pain not otherwise specified	
DHXX	Thoracic soft tissue bruising/ haematoma	Thoracic soft tissue bruising/ haematoma	DH1
DKXX	Thoracic laceration/abrasion	Thoracic laceration/abrasion	
DKXQ	Complication of thoracic laceration/abrasion including infection	Complication of thoracic laceration/abrasion including infection	
DMXX	Thoracic muscle and tendon strain/spasm/trigger points	Thoracic muscle and tendon strain/ spasm/trigger points	
DMEX	Thoracic extensor muscle strain	Thoracic extensor muscle strain	DM1
DMYX	Thoracic muscle trigger points	Thoracic muscle trigger points	DY1
DJXX	Thoracic spine joint injury	Thoracic spine joint injury	
DJFX	Thoracic facet joint sprain	Thoracic facet joint sprain	DJ1
DJPX	Thoracic facet joint pain/chronic inflammation/stiffness	Thoracic facet joint pain/chronic inflammation/stiffness	DP1
DCXX	Thoracic disc injury	Thoracic disc injury	DC1
DFXX	Thoracic spine fracture	Thoracic spine fracture	DF1
DFVX	Fracture thoracic vertebral body	Fracture thoracic vertebral body	
DFPX	Fracture transverse or posterior process thoracic spine	Fracture transverse or posterior process thoracic spine	DG1
DGXX	Thoracic postural syndrome	Thoracic postural syndrome	
DAXX	Thoracic spine osteoarthritis	Thoracic spine osteoarthritis	
DAFX	Facet joint OA thoracic spine	Facet joint OA thoracic spine	DA1
DZXX	Thoracic pain/injury not otherwise specified	Thoracic pain/injury not otherwise specified	
DZZX	Thoracic pain undiagnosed	Thoracic pain undiagnosed	DZ1
LXXX	Thoracic pain/injury not otherwise specified	Thoracic pain/injury not otherwise specified	
LHXX	Lumbar soft tissue bruising/ haematoma	Lumbar soft tissue bruising/ haematoma	LH1
LKXX	Lumbar laceration/abrasion	Lumbar laceration/abrasion	LK1
LKXQ	Complication of lumbar laceration/ abrasion incl infection	Complication of lumbar laceration/ abrasion incl infection	
LMXX	Lumbar spine muscle and tendon strain/spasm/trigger points	Lumbar spine muscle and tendon strain/spasm/trigger points	LM1
LMYX	Lumbar muscle trigger points	Lumbar muscle trigger points	LY1
LJXX	Lumbar spine joint injury	Lumbar spine joint injury	
LJFX	Lumbar facet joint sprain	Lumbar facet joint sprain	LJ1
LJLX	Lumbar ligament sprain	Lumbar ligament sprain	LL1
LJLI	Lumbar ligament sprain	Iliolumbar ligament pain	
LCXX	Lumbar disc injury	Lumbar disc injury	LC1
LCAX	Lumbar disc annular tear	Lumbar disc annular tear	LC3
LCPX	Lumbar disc prolapse	Lumbar disc prolapse	
LCPA	Lumbar disc prolapse	L1/2 disc prolapse	
LCPB	Lumbar disc prolapse	L2/3 disc prolapse	
LCPC	Lumbar disc prolapse	L3/4 disc prolapse	LCT
LCPD	Lumbar disc prolapse	L4/5 disc prolapse	LCF
LCPE	Lumbar disc prolapse	L5/S1 disc prolapse	LCS
LUXX	lumbar instability	lumbar instability	
LUSX	Spondylolisthesis any level	Spondylolisthesis any level	LB1
LUSA	Spondylolisthesis any level	Grade 1 spondylolisthesis lumbar spine	LBF
LUSB	Spondylolisthesis any level	Grade 2 spondylolisthesis lumbar spine	LBS
LUSC	Spondylolisthesis any level	Grade 3 spondylolisthesis lumbar spine	LBT

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
LUSD	Spondylolisthesis any level	Grade 4 spondylolisthesis lumbar spine	
LURX	Retrolisthesis lumbar spine	Retrolisthesis lumbar spine	
LUPX	Lumbosacral instability	Lumbosacral instability	
LGXX	Lumbar spine facet joint pain/stiffness	Lumbar spine facet joint pain/stiffness	LP1
LFXX	Lumbar spine fracture	Lumbar spine fracture	LG1
LFVX	Lumbar spine vertebral body fracture	Lumbar spine vertebral body fracture	
LFTX	Lumbar spine transverse process fracture	Lumbar spine tranvserse process fracture	
LFTA	Lumbar spine transverse process fracture	Fracture transverse process L1	LGA
LFTB	Lumbar spine transverse process fracture	Fracture transverse process L2	
LFTC	Lumbar spine transverse process fracture	Fracture transverse process L3	LGC
LFTD	Lumbar spine transverse process fracture	Fracture transverse process L4	LGB
LFTE	Lumbar spine transverse process fracture	Fracture transverse process L5	
LFTM	Lumbar spine transverse process fracture	Fracture multiple transverse processes	LGM
LFSX	Lumbar spinous process fracture	Lumbar spinous process fracture	
LFPX	Lumbar pars interarticularis acute fracture	Lumbar pars interarticularis acute fracture	
LFDX	Lumbar pedical fracture	Lumbar pedical fracture	
LFMX	Multiple lumbar spine fractures	Multiple lumbar spine fractures	
LFZX	Other lumbar spine fracture	Other lumbar spine fracture	
LFQX	Complication of lumbar fracture (incl non union – excl spinal injury – see LNFXX)	Complication of lumbar fracture (incl non union – excl spinal injury – see LNFXX)	LQ1
LSXX	Lumbar stress fracture	Lumbar stress fracture	LS1
LSRX	Lumbar spine stress reaction	Lumbar spine stress reaction	LS2
LSPX	Pars interarticularis stress fracture	Pars interarticularis stress fracture	
LSPA	Pars interarticularis stress fracture	Pars stress fracture L1–L3	LSU
LSPD	Pars interarticularis stress fracture	Pars stress fracture L4	LSE
LSPE	Pars interarticularis stress fracture	Pars stress fracture L5	LSF
LSPM	Pars interarticularis stress fracture	Multiple (incl bilateral) pars stress fractures	LBB
LSDX	Lumbar pedicle stress fracture	Lumbar pedicle stress fracture	LS3
LSLX	Other lumbar spine stress fracture	Other lumbar spine stress fracture	
LNXX	Lumbar spine neurological injury	Lumbar spine neurological injury	LN1
LNFX	Lumbar spinal fracture with associated neurological injury	Lumbar spinal fracture with associated neurological injury	
LNFC	Lumbar spinal fracture with associated neurological injury	Lumbar spinal fracture with spinal cord/cauda equina injury	
LNDX	Lumbar disc injury with associated neurological injury	Lumbar disc injury with associated neurological injury	
LNDS	Lumbar disc injury with associated neurological injury	Lumbar disc injury with associated spinal cord/cauda equina injury	
LNDR	Lumbar disc injury with associated neurological injury	Lumbar disc injury with associated unspecified nerve root injury	
LNDA	Lumbar disc injury with associated neurological injury	Lumbar disc injury with associated L1–L3 nerve root injury	
LNDD	Lumbar disc injury with associated neurological injury	Lumbar disc injury with associated L4 nerve root injury	
LNDE	Lumbar disc injury with associated neurological injury	Lumbar disc injury with associated L5 nerve root injury	

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
LNDF	Lumbar disc injury with associated neurological injury	Lumbar disc injury with associated S1 nerve root injury	
LNDM	Lumbar disc injury with associated neurological injury	Lumbar disc injury with associated multiple nerve root injuries	
LNAX	Lumbosacral nerve root impingement due to foraminal stenosis bony and disc	Lumbosacral nerve root impingement due to foraminal stenosis bony and disc	LN2
LNAA	Lumbosacral nerve root impingement due to foraminal stenosis bony and disc	L1–3 nerve root impingement due to foraminal stenosis bony and disc	
LNAD	Lumbosacral nerve root impingement due to foraminal stenosis bony and disc	L4 nerve root impingement due to foraminal stenosis bony and disc	LNF
LNAE	Lumbosacral nerve root impingement due to foraminal stenosis bony and disc	L5 nerve root impingement due to foraminal stenosis bony and disc	LNL
LNAF	Lumbosacral nerve root impingement due to foraminal stenosis bony and disc	S1 nerve root impingement due to foraminal stenosis bony and disc	LNS
LNSX	Lumbar spinal canal stenosis	Lumbar spinal canal stenosis	LN3
LNTX	Lumbosacral nerve stretch/traction injury	Lumbosacral nerve stretch/traction injury	LN4
LNZX	Other lumbosacral nerve injury	Other lumbosacral nerve injury	
LAXX	Osteoarthritis lumbosacral spine	Osteoarthritis lumbosacral spine	
LAFX	Facet joint OA lumbosacral spine	Facet joint OA lumbosacral spine	LA1
LACX	Degenerative lumbar disc disease	Degenerative lumbar disc disease	LC2
LACD	Degenerative lumbar disc disease	Degenerative L4/L5 disc disease	
LACE	Degenerative lumbar disc disease	Degenerative L5/S1 disc disease	
LACM	Degenerative lumbar disc disease	Degenerative disc disease multiple levels lumbar spine	
LZXX	Lumbar pain/Injury nor otherwise specified	Lumbar pain/Injury nor otherwise specified	
LZHX	Lumbar pain with hamstring referral	Lumbar pain with hamstring referral	
LZZX	Lumbar pain undiagnosed	Lumbar pain undiagnosed	LZ1
BXXX	Lumbar pain/injury nor otherwise specified	Lumbar pain/injury nor otherwise specified	
BHXX	Pelvis/buttock soft tissue bruising/haematoma	Pelvis/buttock soft tissue bruising/haematoma	BH1
BHSX	SIJ bruising/haematoma	SIJ bruising/haematoma	
BHBX	Buttock bruising/haematoma	Buttock bruising/haematoma	
BHIX	Bruising/haematoma iliac crest/glut medius	Bruising/haematoma iliac crest/glut medius	
BHZX	Bruising buttock/pelvis not otherwise specified	Bruising buttock/pelvis not otherwise specified	
BKXX	Pelvic/buttock laceration/abrasion	Pelvic/buttock laceration/abrasion	BK1
BKXQ	Complication of pelvis/buttock laceration/abrasion incl infection	Complication of pelvis/buttock laceration/abrasion incl infection	
BMXX	Pelvic/buttock muscle strain/spasm/trigger points	Pelvic/buttock muscle strain/spasm/trigger points	
BMGX	Buttock muscle strain	Buttock muscle strain	BMG
BMGA	Buttock muscle strain	Gluteus maximus strain	
BMGB	Buttock muscle strain	Gluteus medius/minimus strain	
BMGP	Buttock muscle strain	Piriformis muscle strain	
BMYX	Buttock trigger points	Buttock trigger points	BY1
BMYA	Buttock trigger points	Glut max trigger points	
BMYB	Buttock trigger points	Glut med/min trigger points	
BMYP	Buttock trigger points	Piriformis trigger points	BYP
BMYM	Buttock trigger points	Multiple buttock muscle trigger points	
BMYZ	Buttock trigger points	Other gluteal muscle trigger points	
BTXX	Buttock/pelvis tendon injury	Buttock/pelvis tendon injury	
BTGX	Gluteus med/min tendon injury	Gluteus med/min tendon injury	
BTGT	Gluteus med/min tendon injury	Gluteus med/min tendinopathy	BT2

(*Continued*)

Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
BTGB	Gluteus med/min tendon injury	Gluteus med/min tendinopathy with trochanteric bursitis	
BTGR	Gluteus med/min tendon injury	Gluteus med/min tendon rupture	
BTAX	Gluteus maximus tendon Injury	Gluteus maximus tendon Injury	
BTAT	Gluteus maximus tendon Injury	Gluteus maximus tendinopathy	
BTPX	Piriformis tendon injury	Piriformis tendon injury	
BTPT	Piriformis tendon injury	Piriformis tendinopathy	
BTHX	Hamstring tendon injury	Hamstring tendon injury	
BTHT	Hamstring tendon injury	Hamstring origin tendinopathy	
BTHB	Hamstring tendon injury	Hamstring tendinopathy with ischial bursitis	BT1
BTHR	Hamstring tendon injury	Hamstring origin tendon rupture (excl growth plate fracture – see JBFI)	TR1
BJXX	Sacroiliac joint injury	Sacroiliac joint injury	
BJSX	Sacroiliac joint sprain	Sacroiliac joint sprain	
BJCX	Sacrococcygeal joint injury/pain	Sacrococcygeal joint injury/pain	BP2
BUXX	Sacroiliac Joint Instability	Sacroiliac Joint Instability	
BGXX	Buttock and pelvis synovitis/bursitis	Buttock and pelvis synovitis/bursitis	
BGSX	Sacroiliac joint inflammation (excl inflammatory arthritis SIJ – see MRXX)	Sacroiliac joint inflammation (excl inflammatory arthritis SIJ – see MRXX)	
BGTX	Trochanteric bursitis (excl that a/w glut tendinopathy – see BTGB)	Trochanteric bursitis (excl that a/w glut tendinopathy – see BTGB)	GT4
BFXX	Pelvic fracture(s)	Pelvic fracture(s)	GF2
BFLX	Fractured Ilium	Fractured Ilium	GF3
BFSX	Fractured sacrum	Fractured sacrum	
BFCX	Fractured coccyx	Fractured coccyx	
BFIX	Fractured ischium	Fractured ischium	
BFMX	Multiple fractures pelvis and sacrum	Multiple fractures pelvis and sacrum	
BSXX	Pelvic stress fracture(s)	Pelvic stress fracture(s)	
BSLX	Stress fracture ilium	Stress fracture ilium	
BSSX	Stress fracture sacrum	Stress fracture sacrum	
BSCX	Stress fracture coccyx	Stress fracture coccyx	
BSIX	Stress fracture ischium	Stress fracture ischium	
SFMX	Multiple stress fractures pelvis	Multiple stress fractures pelvis	
BFZX	Other stress fracture pelvis	Other stress fracture pelvis	
BNXX	Buttock/pelvic nerve injury	Buttock/pelvic nerve injury	
BNPX	Piriformis syndrome/sciatic nerve entrapment	Piriformis syndrome/sciatic nerve entrapment	BN1
BZXX	Pelvic/buttock pain not otherwise specified	Pelvic/buttock pain not otherwise specified	
BZZX	Buttock pain undiagnosed	Buttock pain undiagnosed	BZ1
GXXX	Pelvic/buttock pain not otherwise specified	Pelvic/buttock pain not otherwise specified	
GHXX	Hip and groin soft tissue bruising/haematoma	Hip and groin soft tissue bruising/haematoma	GH1
GHSX	Scrotal/testicular bruising/haematoma	Scrotal/testicular bruising/haematoma	GH2
GHLX	Labial bruising/haematoma	Labial bruising/haematoma	
GHZX	Other hip/groin bruising/haematoma	Other hip/groin bruising/haematoma	
GKXX	Hip and groin laceration/abrasion	Hip and groin laceration/abrasion	GK1
GKXQ	Complication of laceration/abrasion including infection	Complication of laceration/abrasion including infection	
GMXX	Hip and groin muscle strain/tear	Hip and groin muscle strain/tear	GM8
GMFX	Hip flexor muscle strain/tear	Hip flexor muscle strain/tear	GM1
GMFP	Hip flexor muscle strain/tear	Psoas muscle strain/tear	
GMFI	Hip flexor muscle strain/tear	Iliopsoas muscle strain/tear	GMP
GMYX	Hip and groin muscle spasm/trigger points	Hip and groin muscle spasm/trigger points	GY1

(*Continued*)

Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
GMYP	Hip and groin muscle spasm/trigger points	Trigger points illiopsoas	GYP
GMYS	Hip and groin muscle spasm/trigger points	Snapping psoas tendon	
GTXX	Hip and groin tendon injuries	Hip and groin tendon injuries	
GTFX	Iliopsoas tendon injury	Iliopsoas tendon injury	
GTFT	Iliopsoas tendon injury	Iliopsoas tendinopathy	
GTFB	Iliopsoas tendon injury	Iliopsoas tendinopathy with bursitis	GT3
GTFS	Iliopsoas tendon injury	Iliopsoas tendon strain	
GTFR	Iliopsoas tendon injury	Iliopsoas tendon rupture	
GTRX	Rectus femoris tendon injury	Rectus femoris tendon injury	
GTRT	Rectus femoris tendon injury	Rectus femoris origin tendinopathy	
GTRS	Rectus femoris tendon injury	Rectus femoris tendon strain	
GTRR	Rectus femoris tendon injury	Rectus femoris origin tendon rupture	
GTSX	Sartorius tendon injury	Sartorius tendon injury	
GTST	Sartorius tendon injury	Sartorius tendinopathy	
GTSS	Sartorius tendon injury	Sartorius tendon strain	
GTSR	Sartorius tendon injury	Sartorius tendon rupture	
GTDX	Unspecified or multiple adductor tendon injury	Unspecified or multiple adductor tendon injury	GT1
GTDT	Unspecified or multiple adductor tendon injury	Unspecified or multiple adductor tendinopathy	
GTDS	Unspecified or multiple adductor tendon injury	Unspecified or multiple adductor tendon strain	
GTDR	Unspecified or multiple adductor tendon injury	Unspecified or multiple adductor tendon rupture	
GTLX	Adductor longus tendon injury	Adductor longus tendon injury	
GTLT	Adductor longus tendon injury	Adductor longus tendinopathy	
GTLS	Adductor longus tendon injury	Adductor longus tendon strain	
GTLR	Adductor longus tendon injury	Adductor longus tendon rupture	GR1
GTMX	Adductor magnus tendon injury	Adductor magnus tendon injury	
GTMT	Adductor magnus tendon injury	Adductor magnus tendinopathy	
GTMS	Adductor magnus tendon injury	Adductor magnus tendon strain	
GTMR	Adductor magnus tendon injury	Adductor magnus tendon rupture	
GTAX	Abdominal tendon insertion injury	Abdominal tendon insertion injury	
GTAT	Abdominal tendon insertion injury	Abdominal tendon insertion tendinopathy	
GTAS	Abdominal tendon insertion injury	Abdominal tendon insertion strain	
GTAR	Abdominal tendon insertion injury	Abdominal tendon insertion rupture	
GTHX	Groin hernias	Groin hernias	GT2
GTHS	Groin hernias	Sportsman's hernia	GUH
GTHD	Groin hernias	Direct inguinal hernia	
GTHI	Groin hernias	Indirect inguinal hernia	
GTHF	Groin hernias	Femoral hernia	
GJXX	Hip joint sprain	Hip joint sprain	GJ1
GJLX	Hip joint labral tear	Hip joint labral tear	GCL
GCXX	Hip joint chondral/osteochondral injury	Hip joint chondral/osteochondral injury	
GCCX	Hip joint chondral lesion	Hip joint chondral lesion	GC1
GDXX	Hip joint dislocation	Hip joint dislocation	GD1
GUXX	Instability of hip jt/groin	Instability of hip jt/groin	
GUPX	Pubic symphysis instability	Pubic symphysis instability	GSI
GGXX	Hip joint inflammation/synovitis/other biomechanical lesion	Hip joint inflammation/synovitis/other biomechanical lesion	
GGSX	Synovitis of hip joint	Synovitis of hip joint	GP1
GGCX	Clicking hip (excl click d/t labral tear – GJLX, or psoas tendon – GMYS)	Clicking hip (excl click d/t labral tear – GJLX, or psoas tendon – GMYS)	
GFXX	Hip/groin fractures	Hip/groin fractures	

(*Continued*)

Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
GFFX	Femoral fracture	Femoral fracture	
GFFN	Femoral fracture	Fractured neck of femur	GF1
GFAX	Acetabular fracture	Acetabular fracture	
GFPX	Fracture pubic ramus	Fracture pubic ramus	
GFPS	Fracture pubic ramus	Fracture superior pubic ramus	
GFPI	Fracture pubic ramus	Fracture inferior pubic ramus	
GSXX	Hip/groin stress fracture	Hip/groin stress fracture	
GSFX	Femoral neck stress fracture	Femoral neck stress fracture	GS2
GSFS	Femoral neck stress fracture	Stress fracture superior cortex femoral neck	
GSFI	Femoral neck stress fracture	Stress fracture inferior cortex femoral neck	
GSFB	Femoral neck stress fracture	Stress fracture through femoral neck (both cortices)	
GSPX	Pelvic stress fracture	Pelvic stress fracture	GS3
GSPS	Pelvic stress fracture	Stress fracture superior pubic ramus	
GSPI	Pelvic stress fracture	Stress fracture inferior pubic ramus	
GYXX	Other stress/overuse injury hip and groin	Other stress/overuse injury hip and groin	
GYOX	Osteitis pubis	Osteitis pubis	GS1
GYMX	Chronic non specific or multifactorial groin pain	Chronic non specific or multifactorial groin pain	
GNXX	Groin neurovascular injuries	Groin neurovascular injuries	
GNEX	Nerve entrapment groin	Nerve entrapment groin	GN1
GNEG	Nerve entrapment groin	Genitofemoral nerve entrapment	GNG
GNEI	Nerve entrapment groin	Ilioinguinal nerve entrapment	GNI
GNEO	Nerve entrapment groin	Obturator nerve entrapment	GNO
GNVX	Vascular injury hip joint	Vascular injury hip joint	
GNVA	Vascular injury hip joint	Avascular necrosis femoral head	
GOXX	Groin organ damage	Groin organ damage	
GOSX	Scrotal ± testicular injury	Scrotal ± testicular injury	
GOSR	Scrotal ± testicular injury	Testicular rupture	GOT
GOPX	Penile injury	Penile injury	
GOPR	Penile injury	ruptured penis/urethra	GOU
GAXX	Hip/groin arthritis	Hip/groin arthritis	
GAHX	Osteoarthritis hip joint	Osteoarthritis hip joint	GA1
GZXX	Hip/groin pain not otherwise specified	Hip/groin pain not otherwise specified	
GZZX	Hip/groin pain undiagnosed	Hip/groin pain undiagnosed	GZ1
TXXX	Hip/groin pain not otherwise specified	Hip/groin pain not otherwise specified	
THXX	Thigh soft tissue bruising/haematoma	Thigh soft tissue bruising/haematoma	TH1
THMX	Thigh muscle haematoma	Thigh muscle haematoma	
THMA	Thigh muscle haematoma	Adductor muscle haematoma	
THMH	Thigh muscle haematoma	Hamstring muscle haematoma	THH
THMQ	Thigh muscle haematoma	Quadriceps muscle haematoma	THV
THMI	Thigh muscle haematoma	ITB haematoma	
THMB	Thigh muscle haematoma	Acute artherial bleed thigh	THA
THOX	Myositis ossificans thigh	Myositis ossificans thigh	THM
THZX	Other soft tissue bruising/haematoma not otherwise specified	Other soft tissue bruising/haematoma not otherwise specified	
TKXX	Thigh laceration/abrasion	Thigh laceration/abrasion	TK1
TKXQ	Complication of laceration/abrasion incl. Infection	Complication of laceration/abrasion incl. Infection	
TMXX	Thigh muscle strain/spasm/trigger points	Thigh muscle strain/spasm/trigger points	TY2
TMHX	Hamstring strain	Hamstring strain	TM1

(*Continued*)

Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
TMHB	Hamstring strain	Biceps femoris strain grade 1–2	TMB
TMHS	Hamstring strain	Semimembranosis/tendinosis strain (grade 1–2)	TMS
TMHR	Hamstring strain	Grade 3 hamstring strain	
TMQX	Quadriceps strain	Quadriceps strain	TM2
TMQS	Quadriceps strain	Rectus femoris strain	TMR
TMQR	Quadriceps strain	Rectus femoris rupture	
TMQV	Quadriceps strain	Other quadricep strain	TMV
TMQW	Quadriceps strain	Other quadricep rupture	
TMAX	Adductor strain	Adductor strain	TMA
TMAL	Adductor strain	Adductor longus strain	
TMAM	Adductor strain	Adductor magnus strain	BMM
TMAR	Adductor strain	Adductor muscle rupture/grade 3 strain	
TMLX	Back referred muscle tightness	Back referred muscle tightness	
TMLH	Back referred muscle tightness	Back referred hamstring tightness	
TMCX	Thigh muscle cramping during exercise	Thigh muscle cramping during exercise	
TMCH	Thigh muscle cramping during exercise	Hamstring cramping during exercise	
TMCQ	Thigh muscle cramping during exercise	Quadricep cramping during exercise	
TMCA	Thigh muscle cramping during exercise	Adductor muscle cramping during exercise	
TMYX	Thigh muscle trigger points	Thigh muscle trigger points	
TMYH	Thigh muscle trigger points	Hamstring trigger points	TYL
TMYQ	Thigh muscle trigger points	Quadricep trigger points	TYR
TMYA	Thigh muscle trigger points	Adductor trigger points	GYA
TMGX	Thigh muscle wasting	Thigh muscle wasting	
TMGQ	Thigh muscle wasting	Quadriceps wasting (excl. that were patello femoral pain is clinical diagnosis)	
TTXX	Thigh tendon injuries (see hip/groin or knee depending on tendon location)	Thigh tendon injuries (see hip/groin or knee depending on tendon location)	
TFXX	Thigh fractures	Thigh fractures	
TFFX	Fractured femoral shaft	Fractured femoral shaft	TF1
TSXX	Thigh stress fractures	Thigh stress fractures	
TSFX	Femoral shaft stress fracture	Femoral shaft stress fracture	TS1
TYXX	Other stress/overuse injuries to thigh	Other stress/overuse injuries to thigh	
TYCX	Compartment syndrome of thigh	Compartment syndrome of thigh	
TYPX	Tenoperiostitis of thigh	Tenoperiostitis of thigh	
TNXX	Thigh neurological injury	Thigh neurological injury	
TNEX	Nerve entrapment in thigh	Nerve entrapment in thigh	
TNEL	Nerve entrapment in thigh	Lateral cutaneous nerve of thigh entrapment	GNM
TZXX	Thigh pain/injury not otherwise specified	Thigh pain/injury not otherwise specified	
TZZX	Thigh pain undiagnosed	Thigh pain undiagnosed	TZ1
KXXX	Thigh pain/injury not otherwise specified	Thigh pain/injury not otherwise specified	
KHXX	Knee soft tissue bruising/haematoma	Knee soft tissue bruising/haematoma	KH1
KHQX	Distal quadricep haematoma	Distal quadricep haematoma	
KHMX	Knee MCL contusion	Knee MCL contusion	
KHBX	Traumatic knee bursitis	Traumatic knee bursitis	
KHBP	Traumatic knee bursitis	Prepatellar bursitis	KT6
KHBI	Traumatic knee bursitis	Infrapatellar fat pad haematoma/ bursitis	KH2

(*Continued*)

Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
KHZX	Other soft tissue bruising/ haematoma knee	Other soft tissue bruising/ haematoma knee	
KKXX	Knee laceration/abrasion	Knee laceration/abrasion	KK1
KKXQ	Complication of knee laceration/ abrasion incl infection	Complication of knee laceration/ abrasion incl infection	
KKSX	Superficial knee laceration/abrasion	Superficial knee laceration/abrasion	
KKDX	Deep knee laceration – intraarticular	Deep knee laceration – intraarticular	
KMXX	Knee muscle strain/spasm/trigger points	Knee muscle strain/spasm/trigger points	
KMPX	Popliteus muscle strain	Popliteus muscle strain	
KTXX	Knee tendon injury	Knee tendon injury	KT3
KTQX	Quadriceps tendon injury	Quadriceps tendon injury	
KTQT	Quadriceps tendon injury	Quadriceps tendinopathy	KT7
KTQS	Quadriceps tendon injury	Quadriceps tendon strain	
KTQR	Quadriceps tendon injury	Quadriceps tendon rupture	
KTPX	Patellar tendon injury	Patellar Tendon Injury	
KTPT	Patellar tendon injury	Patellar tendinopathy (excl. Sinding Larsen Johannson syndrome see JTKP)	KT2
KTPS	Patellar tendon injury	Patellar tendon strain	
KTPR	Patellar tendon injury	Patellar tendon rupture	KR1
KTPI	Patellar tendon injury	Insertional patellar tendon pathology, incl intratend ossicle (excl Osgoode Schlatters – see JTKT)	KTT
KTHX	Hamstring tendon injury	Hamstring tendon injury	KR2
KTHM	Hamstring tendon injury	Medial hamstring tendinopathy, incl pes anserine bursitis	KTS
KTHL	Hamstring tendon injury	Lateral hamstring tendinopathy	KTB
KTHS	Hamstring tendon injury	Medial hamstring tendon strain	
KTHR	Hamstring tendon injury	Medial hamstring tendon rupture	
KTHB	Hamstring tendon injury	Lateral hamstring tendon strain	
KTHC	Hamstring tendon injury	Lateral hamstring tendon rupture	
KTGX	Gastrocnemius tendon injury	Gastrocnemius tendon injury	
KTGM	Gastrocnemius tendon injury	Medial gastroc tendinopathy knee	KTM
KTGL	Gastrocnemius tendon injury	Lateral gastroc tendinopathy knee	KTL
KTTX	Popliteus tendon injury	Popliteus tendon injury	KT5
KJXX	Knee sprains/ligament injuries	Knee sprains/ligament injuries	KJ1
KJAX	Acute ACL injury	Acute ACL injury	KL1
KJAP	Acute ACL injury	Partial ACL tear	KLI
KJAR	Acute ACL injury	ACL rupture	
KJAC	Acute ACL injury	ACL strain/rupture with chondral/ meniscal injury	
KJAG	Acute ACL injury	ACL graft rupture	
KJCX	Acute PCL injury	Acute PCL injury	KL2
KJCP	Acute PCL injury	Partial PCL tear	
KJCR	Acute PCL injury	PCL rupture	
KJCC	Acute PCL injury	PCL strain/rupture with associated chondral/meniscal injury	
KJMX	MCL injury knee	MCL injury knee	KL3
KJMA	MCL injury knee	Grade 1 MCL tear knee	
KJMB	MCL injury knee	Grade 2 MCL tear knee	
KJMR	MCL injury knee	MCL rupture knee	KLM
KJMC	MCL injury knee	MCL strain/rupture with chondral/ meniscal damage knee	
KJMQ	MCL injury knee	Complication post MCL strain/ rupture incl Pellegrini Steida lesion	KLP
KJLX	Posterolateral corner and LCL ligament injuries knee	Posterolateral corner and LCL ligament injuries knee	KL4

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
KJLL	Posterolateral corner and LCL ligament injuries knee	LCL strain/rupture	
KJLP	Posterolateral corner and LCL ligament injuries knee	Posterolateral corner strain/rupture	KL5
KJLC	Posterolateral corner and LCL ligament injuries knee	PLC injury with chondral/meniscal injury	
KJPX	Patellar subluxation	Patellar subluxation	
KJBX	Combined ligament injuries knee	Combined ligament injuries knee	
KJBC	Combined ligament injuries knee	Combined ligament injury with chondral/meniscal injury	
KJSX	Superior tib fib joint sprain	Superior tib fib joint sprain	QJ1
KCXX	Knee cartilage injury	Knee cartilage injury	KC8
KCCX	Knee osteochondral injury	Knee osteochondral injury	KC1
KCCM	Knee osteochondral injury	Medial femoral condyle osteochondral injury	KCM
KCCL	Knee osteochondral injury	Lateral femoral condyle osteochondral injury	KCK
KCCT	Knee osteochondral injury	Tibial osteochondral injury	
KCCP	Knee osteochondral injury	Patellofemoral osteochondral injury	KCU
KCCB	Knee osteochondral injury	Two or more osteochondral injury sites	
KCLX	Knee cartilage injury with loose bodies	Knee cartilage injury with loose bodies	
KCMX	Knee meniscal cartilage injury	Knee meniscal cartilage injury	
KCMM	Knee meniscal cartilage injury	Medial meniscal tear	KCP
KCML	Knee meniscal cartilage injury	Lateral meniscal tear	KCR
KCMC	Knee meniscal cartilage injury	Lateral meniscal cyst	
KCMB	Knee meniscal cartilage injury	Medial and lateral meniscal tears	
KCMD	Knee meniscal cartilage injury	Degenerative meniscal tear	
KCBX	Mixed osteochondral and meniscal injury	Mixed osteochondral and meniscal injury	
KDXX	Knee dislocation	Knee dislocation	
KDPX	Patellar dislocation	Patellar dislocation	KD1
KDPF	Patellar dislocation	Patellar dislocation with avulsion fracture patella	
KDKX	Knee dislocation	Knee dislocation	KD2
KDKQ	Knee dislocation	Knee dislocation with neural or vascular complication	
KDSX	Superior tib fib joint dislocation	Superior tib fib joint dislocation	QD1
KUXX	Knee instability (chronic or recurrent subluxations)	Knee instability (chronic or recurrent subluxations)	KU1
KUPX	Patellar instability	Patellar instability	KU2
KUAX	Chronic ACL insufficiency	Chronic ACL insufficiency	KUA
KUCX	Chronic PCL insufficiency	Chronic PCL insufficiency	KUP
KUMX	Chronic MCL insufficiency	Chronic MCL insufficiency	KUM
KUZX	Other instability	Other instability	
KGXX	Knee impingement/synovitis/ iomechanical lesion not associated with other conditions	Knee impingement/synovitis/ biomechanical lesion not associated with other conditions	
KGPX	Patellofemoral pain	Patellofemoral pain	KP1
KGPT	Patellofemoral pain with patellar tendinopathy	Patellofemoral pain with patellar tendinopathy	
KGPL	Excess lateral pressure syndrome	Excess lateral pressure syndrome	
KGPH	Hoffa's fat pad impingement	Hoffa's fat pad impingement	KTH
KGPB	PFS related to bipartite patella	PFS related to bipartite patella	
KGIX	ITB friction syndrome	ITB friction syndrome	KT1
KGSX	Knee joint synovitis	Knee joint synovitis	KP4
KGSP	Synovial plica of knee	Synovial plica of knee	KP3

(*Continued*)

Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
KGBX	Bakers cyst	Bakers cyst	QP1
KGBR	Ruptured bakers cyst	Ruptured bakers cyst	
KFXX	Knee fractures	Knee fractures	KF2
KFPX	Patellar fracture	Patellar fracture	KF1
KFFX	Distal femoral fracture	Distal femoral fracture	
KFFI	Distal femoral fracture	Intraarticular femoral fracture	
KFTX	Proximal tibial fracture	Proximal tibial fracture	
KFTI	Proximal tibial fracture	Intraarticular tibial fracture	
KSXX	Knee stress fracture	Knee stress fracture	
KSPX	Patellar stress fracture	Patellar stress fracture	KS1
KSFX	Distal femoral stress fracture	Distal femoral stress fracture	
KSTX	Proximal tibial stress fracture	Proximal tibial stress fracture	
KAXX	Knee osteoarthritis	Knee osteoarthritis	KA1
KAPX	Patellofemoral osteoarthritis	Patellofemoral osteoarthritis	
KAMX	Medial compartment osteoarthritis knee	Medial compartment osteoarthritis knee	
KALX	Lateral compartment osteoarthritis knee	Lateral compartment osteoarthritis knee	
KABX	Bi or tri-compartmental osteoarthritis	Bi or tri-compartmental osteoarthritis	KAG
KZXX	Knee pain/injury not otherwise specified	Knee pain/injury not otherwise specified	
KZZX	Knee pain undiagnosed	Knee pain undiagnosed	KZ1
KZHX	Knee haemarthrosis cause undiagnosed	Knee haemarthrosis cause undiagnosed	KZ2
QXXX	Knee pain/injury not otherwise specified	Knee pain/injury not otherwise specified	
QHXX	Leg soft tissue bruising/haematoma	Leg soft tissue bruising/haematoma	
QHTX	Pretibial periosteal bruising/ haematoma	Pretibial periosteal bruising/ haematoma	QH1
QHMX	Lower leg muscle haematoma	Lower leg muscle haematoma	
QHMA	Lower leg muscle haematoma	Tib anterior haematoma	
QHMP	Lower leg muscle haematoma	Calf/gastroc haematoma	QH2
QHML	Lower leg muscle haematoma	Peroneal Haematoma	
QHZX	Other soft tissue bruising/ haematoma not otherwise specified	Other soft tissue bruising/haematoma not otherwise specified	
QKXX	Lower leg laceration/abrasion	Lower leg laceration/abrasion	
QKXI	Infection as complication of lower leg laceration/abrasion	Infection as complication of lower leg laceration/abrasion	
QKXQ	Other complication of lower leg laceration/abrasion	Other complication of lower leg laceration/abrasion	
QKAX	Shin laceration/abrasion	Shin laceration/abrasion	QK1
QKPX	Calf laceration/abrasion	Calf laceration/abrasion	QK2
QMXX	Lower leg muscle Injury	Lower leg muscle Injury	QM1
QMAX	Anterior compartment muscle injury	Anterior compartment muscle injury	
QMLX	Lateral compartment muscle injury	Lateral compartment muscle injury	
QMGX	Gastrocnemius muscle injury/strain	Gastrocnemius muscle injury/strain	
QMGM	Gastrocnemius muscle injury/strain	Medial gastroc strain	QMM
QMGL	Gastrocnemius muscle injury/strain	Lateral gastroc strain	QML
QMSX	Soleus injury/strain	Soleus injury/strain	QMS
QMSA	Soleus injury/strain	Soleus strain a/w accessory soleus	
QMYX	Calf muscle trigger points/spasm	Calf muscle trigger points/spasm	QY1
QMYD	Calf muscle trigger points/spasm	Delayed onset muscle soreness	QY3
QMYG	Calf muscle trigger points/spasm	Gastroc muscle trigger points/spasm	
QMYM	Calf muscle trigger points/spasm	Medial gastroc trigger points/spasm	QYM
QMYL	Calf muscle trigger points/spasm	Lateral gastroc trigger points/spasm	QYL
QMYS	Calf muscle trigger points/spasm	Soleus Trigger points/Spasm	QYS
QMYP	Calf muscle trigger points/spasm	Peroneal trigger points/spasm	
QMCX	Calf cramping during exercise	Calf cramping during exercise	

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
QTXX	Lower leg tendon injuries (see knee or ankle depending on tendon location)	Lower leg tendon injuries (see knee or ankle depending on tendon location)	
QFXX	Lower leg fractures	Lower leg fractures	
QFTX	Fractured midshaft tibia ± fibula	Fractured midshaft tibia ± fibula	QFT
QFTT	Fractured midshaft tibia ± fibula	Fractured midshaft tibia	
QFTF	Fractured midshaft tibia ± fibula	Fractured midshaft tibia and fibula	
QFTC	Fractured midshaft tibia ± fibula	Compound midshaft fractured tibia ± fibula	QFC
QFTQ	Fractured midshaft tibia ± fibula	Fractured tibia ± fibula with other complication (eg, Compartment syndrome)	
QFFX	Fractured fibula	Fractured fibula	QF2
QFFP	Fractured fibula	Fractured proximal fibula	QFH
QFFM	Fractured fibula	Fractured midshaft fibula	QFM
QFFD	Fractured fibula	Fractured distal shaft fibula	QFD
QFFS	Fractured fibula	Fractured fibula with associated syndesmosis injury ankle	
QFFN	Fractured fibula	Fractured fibula with associated peroneal nerve injury	
QSXX	Fractured fibula	Fractured fibula	
QSTX	Stress fracture tibia	Stress fracture tibia	QS1
QSTA	Stress fracture tibia	Anterior stress fracture tibia	QSA
QSTP	Stress fracture tibia	Posteromedial stress fracture tibia	QSP
QSFX	Stress fracture fibula	Stress fracture fibula	QS2
QYXX	Other leg overuse injury	Other leg overuse injury	
QYMX	Chronic compartment syndrome lower leg	Chronic compartment syndrome lower leg	QYP
QYMA	Chronic compartment syndrome lower leg	Anterior compartment syndrome	QYA
QYMP	Chronic compartment syndrome lower leg	Posterior compartment syndrome	
QYMD	Chronic compartment syndrome lower leg	Deep posterior compartment syndrome	
QYML	Chronic compartment syndrome lower leg	Lateral (peroneal) compartment syndrome	
QYMM	Chronic compartment syndrome lower leg	Compartment syndrome multiple sites lower leg	
QYBX	Tenoperiostitis of lower leg	Tenoperiostitis of lower leg	
QYBA	Tenoperiostitis of lower leg	Anterior shin periostitis/stress syndrome/shin splints	QTA
QYBP	Tenoperiostitis of lower leg	Posteromedial shin periostitis/ stress syndrome/shin splints	QT1
QNXX	Neurological injury of lower leg	Neurological injury of lower leg	
QNPX	Peroneal nerve palsy (with foot drop)	Peroneal nerve palsy (with foot drop)	QN1
QVXX	Vascular injury lower leg	Vascular injury lower leg	
QVAX	Acute anterior compartment syndrome (excl that from fractured tibia – see QFTQ)	Acute anterior compartment syndrome (excl that from fractured tibia – see QFTQ)	QYB
QVZX	Other acute compartment syndrome to lower leg	Other acute compartment syndrome to lower leg	
QVVX	Other vascular injury to lower leg	Other vascular injury to lower leg	
QVVP	Other vascular injury to lower leg	Popliteal artery entrapment	QV4
QZXX	Other lower leg pain/injury not otherwise specified	Other lower leg pain/injury not otherwise specified	
QZZX	Lower leg pain undiagnosed	Lower leg pain undiagnosed	QZ1

(*Continued*)

Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
AXXX	Other lower leg pain/injury not otherwise specified	Other lower leg pain/injury not otherwise specified	
AHXX	Ankle soft tissue bruising/haematoma	Ankle soft tissue bruising/ haematoma	AH1
AHHX	Heel bruising/haematoma incl fat pad contusion	Heel bruising/haematoma incl fat pad contusion	
AKXX	Ankle laceration/abrasion	Ankle laceration/abrasion	AK1
AKXQ	Complication of ankle laceration/ abrasion incl infection	Complication of ankle laceration/ abrasion incl infection	
AKBX	Blisters heel	Blisters heel	
AKSX	Superficial ankle laceration/abrasion	Superficial ankle laceration/abrasion	
AKDX	Deep (intraarticular) laceration ankle	Deep (intraarticular) laceration ankle	
ATXX	Ankle tendon injury	Ankle tendon injury	AT7
ATAX	Achilles tendon injury	Achilles tendon injury	AT1
ATAT	Achilles tendon injury	Achilles tendinopathy	
ATAP	Achilles tendon injury	Achilles paratenonopathy	
ATAE	Achilles tendon injury	Achilles enthesopathy	
ATAB	Achilles tendon injury	Achilles enthesopathy with retrocalcaneal bursitis	
ATAS	Achilles tendon injury	Achilles tendon strain	
ATAR	Achilles tendon injury	Achilles tendon rupture	AR1
ATAM	Achilles tendon injury	Midsubstance Achilles tendon rupture	ARM
ATAI	Achilles tendon injury	Insertional Achilles tendon rupture	ARI
ATEX	Extensor tendon injuries at ankle	Extensor tendon injuries at ankle	AT5
ATEA	Extensor tendon injuries at ankle	Tibialis anterior tenosynovitis	
ATTX	Tibialis posterior injuries	Tibialis posterior injuries	
ATTT	Tibialis posterior injuries	Tibialis posterior tendinopathy	
ATTS	Tibialis posterior injuries	Tibialis posterior strain	
ATTR	Tibialis posterior injuries	Tibialias posterior tendon rupture	FR1
ATHX	Flexor hallucis tendon injury	Flexor hallucis tendon injury	
ATHT	Flexor hallucis tendon injury	FHL tendinopathy	
ATHI	Flexor hallucis tendon injury	FHL tenosynovitis	
ATHS	Flexor hallucis tendon injury	FHL strain	
ATHR	Flexor hallucis tendon injury	FHL rupture	
ATPX	Peroneal tendon injury	Peroneal tendon injury	AT6
ATPT	Peroneal tendon injury	Peroneal tendinopathy	
ATPS	Peroneal tendon injury	Peroneal tendon strain	
ATPR	Peroneal tendon injury	Peroneal tendon rupture	FRP
ATPU	Peroneal tendon injury	Peroneal tendon subluxation/ dislocation	
AJXX	Ankle sprains	Ankle sprains	AJ1
AJSX	Ankle syndesmosis sprain	Ankle syndesmosis sprain	AJ2
AJLX	Ankle lateral ligament sprain	Ankle lateral ligament sprain	AL1
AJLR	Ankle lateral ligament sprain	Lateral ligaments rupture (grade 3 injury)	ALT
AJLC	Ankle lateral ligament sprain	Calcaneofibular ligament sprain	
AJLA	Ankle lateral ligament sprain	Anterior talofibular ligament sprain	
AJDX	Ankle deltoid ligament sprain	Ankle deltoid ligament sprain	AL2
AJMX	Ankle multiple ligaments sprain	Ankle multiple ligaments sprain	
ACXX	Ankle osteochondral injuries	Ankle osteochondral injuries	AC1
ACTX	Talar dome osteochondral injury	Talar dome osteochondral injury	ACD
ACPX	Tibial plafond osteochondral lesion	Tibial plafond osteochondral lesion	ACP
ACLX	Loose body ankle joint	Loose body ankle joint	ACL
ADXX	Ankle dislocation	Ankle dislocation	AD1
AUXX	Chronic ankle instability	Chronic ankle instability	AU1

(*Continued*)

Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
AUMX	Chronic medial instability	Chronic medial instability	AUM
AULX	Chronic lateral instability	Chronic lateral instability	AUL
AGXX	Ankle synovitis/impingement/bursitis	Ankle synovitis/impingement/bursitis	
AGSX	Synovitis of ankle and subtalar joint	Synovitis of ankle and subtalar joint	
AGSA	Synovitis of ankle and subtalar joint	Ankle joint synovitis	AP1
AGSS	Synovitis of ankle and subtalar joint	Subtalar joint synovitis/sinus tarsi syndrome	AP3
AGTX	Tarsal tunnel syndrome	Tarsal tunnel syndrome	AN1
AGAX	Anterior impingement ankle	Anterior impingement ankle	AT4
AGAB	Anterior impingement ankle	Anterior inpingement ankle d/t osteophytes	
AGPX	Posterior impingement ankle	Posterior impingement ankle	
AGPO	Posterior impingement ankle	Ankle posterior impingement with os trigonum	AT3
AGPS	Posterior impingement ankle	Ankle posterior impingement post ankle sprain	
AGPZ	Posterior impingement ankle	Other posterior ankle impingement	
AGBX	Bursitis not otherwise specified	Bursitis not otherwise specified	
AGBC	Bursitis not otherwise specified	Calcaneal bursitis (pump bump)	
AFXX	Ankle fracture	Ankle fracture	AF2
AFAX	Fracture tibia and fibula at ankle joint	Fracture tibia and fibula at ankle joint	AF1
AFAM	Fracture tibia and fibula at ankle joint	Fracture medial malleolus	AFM
AFAL	Fracture tibia and fibula at ankle joint	Fracture lateral malleolus	AFL
AFAP	Fracture tibia and fibula at ankle joint	Fracture posterior malleolus	
AFAB	Fracture tibia and fibula at ankle joint	Bimalleolar fracture	AFB
AFAT	Fracture tibia and fibula at ankle joint	Trimalleolar fracture	AFX
AFAS	Fracture tibia and fibula at ankle joint	Ankle fracture with diastasis of syndesmosis	
AFTX	Fractured talus	Fractured talus	AGO
AFTN	Fractured talus	Fractured talar neck	
AFTL	Fractured talus	Fractured lateral process talus	AGL
AFTD	Fractured talus	Fractured talar dome	
AFTO	Fractured talus	Fractured os trigonum	
AFTP	Fractured talus	Fractured posterior process talus	
AFTZ	Fractured talus	Fractured talus not otherwise specified	AFT
AFCX	Fractured calcaneus	Fractured calcaneus	AFC
AFCA	Fractured calcaneus	Fractured anterior process calcaneus	
ASXX	Ankle stress injuries/stress fractures	Ankle stress injuries/stress fractures	AS1
ASTX	Stress fracture tibia at ankle	Stress fracture tibia at ankle	AST
ASTM	Stress fracture tibia at ankle	Medial malleolar stress fracture	QSM
ASFX	Stress fracture fibula at ankle	Stress fracture fibula at ankle	
ASFM	Stress fracture fibula at ankle	Lateral malleolar stress fracture	QSL
ASCX	Stress injury calcaneus	Stress injury calcaneus	
ASCF	Stress injury calcaneus	Stress fracture calcaneus	ASC
ASCC	Stress injury calcaneus	Fat pad contusion heel	FH3
ASLX	Stress fracture talus	Stress fracture talus	
ANXX	Nerve injury at ankle	Nerve injury at ankle	
ANCX	Calcaneal nerve entrapment	Calcaneal nerve entrapment	
ANCM	Calcaneal nerve entrapment	Medial calcaneal nerve entrapment	AN2
AVXX	Vascular injury ankle	Vascular injury ankle	
AAXX	Osteoarthritis of ankle/subtalar joint	Osteoarthritis of ankle/subtalar joint	
AAAX	Ankle joint osteoarthritis	Ankle joint osteoarthritis	AA1
AASX	Subtalar joint arthritis	Subtalar joint arthritis	
AZXX	Ankle pain/injury not otherwise specified	Ankle pain/injury not otherwise specified	
AZCX	Chronic regional pain syndrome ankle	Chronic regional pain syndrome ankle	AP2
AZZX	Ankle pain undiagnosed	Ankle pain undiagnosed	AZ1

(*Continued*)

Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
AZZP	Ankle pain undiagnosed	Posterior ankle pain undiagnosed	
FXXX	Ankle pain/injury not otherwise specified	Ankle pain/injury not otherwise specified	
FHXX	Foot soft tissue bruising/haematoma	Foot soft tissue bruising/haematoma	FH1
FHHX	Haematoma great toe	Haematoma great toe	
FHHU	Haematoma great toe	Nail bed haematoma great toe	FH2
FHPX	Haematoma lesser toes	Haematoma lesser toes	
FHPU	Haematoma lesser toes	Nail bed haematoma lesser toes	
FHZX	Other foot soft tissue bruising/ haematoma not elsewhere specified	Other foot soft tissue bruising/ haematoma not elsewhere specified	
FKXX	Foot laceration/abrasion	Foot laceration/abrasion	FK2
FKXQ	Complication of foot laceration/ abrasion incl infection	Complication of foot laceration/ abrasion incl infection	
FKBX	Blisters foot	Blisters foot	
FKCX	Callous on foot	Callous on foot	
FKUX	Ulceration foot	Ulceration foot	
FMXX	Foot muscle strain/spasm/trigger points	Foot muscle strain/spasm/trigger points	FM1
FMYX	Foot muscle trigger points, cramping, spasm	Foot muscle trigger points, cramping, spasm	FY1
FTXX	Foot tendon injuries	Foot tendon injuries	
FTTX	Tibialis posterior tendon injury in foot	Tibialis posterior tendon injury in foot	
FTTI	Tibialis posterior tendon injury in foot	Tibialis posterior insertional tendinopathy	FT7
FTEX	Extensor tendon injury in foot	Extensor tendon injury in foot	
FTET	Extensor tendon injury in foot	Extensor tendinopathy in foot	FT2
FJXX	Foot joint sprain	Foot joint sprain	FL1
FJPX	Plantar fasciitis strain	Plantar fasciitis strain	FT1
FJPR	Plantar fasciitis strain	Plantar fascia rupture	
FJPD	Plantar fasciitis strain	Mid/distal plantar fasciitis	
FJSX	Spring ligament sprain in foot	Spring ligament sprain in foot	
FJMX	Midfoot joint/ligament sprain	Midfoot joint/ligament sprain	
FJFX	Forefoot joint sprain (ie, MTP and IP joints lesser toes)	Forefoot joint sprain (ie, MTP and IP joints lesser toes)	FLL
FJHX	Sprain of great toe	Sprain of great toe	
FJHM	Sprain of great toe	Sprain of 1st MTP joint/turf toe	FJ2
FJHR	Sprain of great toe	Sprain 1st MTP jt with volar plate rupture	FPL
FJHP	Sprain of great toe	Sprain IP ligament(s) great toe	
FCXX	Foot chondral/osteochondral lesion	Foot chondral/osteochondral lesion	
FDXX	Foot dislocation	Foot dislocation	FD2
FDTX	Dislocation of midfoot through TMT joints	Dislocation of midfoot through TMT joints	FDL
FDHX	Dislocation of great toe MTP jt	Dislocation of great toe MTP jt	
FDMX	Dislocation of lesser toe MTP joint	Dislocation of lesser toe MTP joint	
FDPX	Dislocation of IP joint of lesser toe	Dislocation of IP joint of lesser toe	
FGXX	Synovitis/impingement/biomechanical lesion of foot	Synovitis/impingement/biomechanical lesion of foot	
FGCX	Cuboid syndrome	Cuboid syndrome	FT6
FGSX	Synovitis of midfoot joints	Synovitis of midfoot joints	FP2
FGMX	Synovitis of MTP joint(s)	Synovitis of MTP joint(s)	
FFXX	Foot fractures	Foot fractures	FG1
FFTX	Fracture tarsal bone	Fracture tarsal bone	FF1
FFTB	Fracture tarsal bone	Fracture cuboid	FFB
FFTN	Fracture tarsal bone	Fracture navicular	FFN
FFTC	Fracture tarsal bone	Fracture cuneiform	FFC
FFMX	Fracture metatarsal(s)	Fracture metatarsal(s)	FF2

(*Continued*)

Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
FFMA	Fracture metatarsal(s)	Fracture 1st metatarsal	FFO
FFMB	Fracture metatarsal(s)	Fracture 2nd metatarsal	FFS
FFMC	Fracture metatarsal(s)	Fracture 3rd metatarsal	FFT
FFMD	Fracture metatarsal(s)	Fracture 4th metatarsal	FFD
FFME	Fracture metatarsal(s)	Fracture 5th metatarsal shaft	FFF
FFMV	Fracture metatarsal(s)	Avulsion fracture 5th metatarsal base	FGF
FFMM	Fracture metatarsal(s)	Fracture two or more metatarsals	FFX
FFHX	Fracture great toe	Fracture great toe	
FFHP	Fracture great toe	Fracture great toe proximal phalanx	
FFHD	Fracture great toe	Fracture great toe distal phalanx	
FFPX	Fracture lesser toes (2–5)	Fracture lesser toes (2–5)	FF3
FFQX	Complication of fractured foot including non union	Complication of fractured foot including non union	FQ1
FSXX	Stress Reactions/Fractures in Foot	Stress Reactions/Fractures in Foot	FS1
FSNX	Navicular stress fracture	Navicular stress fracture	FSN
FSNN	Navicular stress fracture	Non union navicular stress fracture	
FSBX	Cuboid stress fracture	Cuboid stress fracture	FSB
FSCX	Cuneiform stress fracture	Cuneiform stress fracture	FSC
FSMX	Metatarsal stress fracture	Metatarsal stress fracture	FS2
FSMA	Metatarsal stress fracture	First metatarsal stress fracture	FSO
FSMB	Metatarsal stress fracture	Second metatarsal stress fracture	FSS
FSMC	Metatarsal stress fracture	Third metatarsal stress fracture	FST
FSMD	Metatarsal stress fracture	Fourth metatarsal stress fracture	FSD
FSME	Metatarsal stress fracture	Fifth metatarsal stress fracture	FSF
FSMP	Metatarsal stress fracture	Base second metatarsal stress fracture	
FSMZ	Metatarsal stress fracture	Other metatarsal stress fracture	
FSMR	Metatarsal stress fracture	Stress rxn metatarsal/metatarsalgia	FP3
FSSX	Sesamoid stress injury	Sesamoid stress injury	FP1
FSSF	Sesamoid stress injury	Sesamoid stress fracture	FS3
FSSA	Sesamoid stress injury	AVN Sesamoid	
FSSS	Sesamoid stress injury	Sesamoiditis/stress fracture	
FAXX	Foot osteoarthritis	Foot osteoarthritis	FA2
FAMX	Arthritis of midfoot	Arthritis of midfoot	
FAHX	Arthritis MTP joint great toe	Arthritis MTP joint great toe	FA1
FAHR	Arthritis MTP joint great toe	Hallux rigidis	
FAHB	Arthritis MTP joint great toe	Bunion of great toe MTP joint	
FAPX	Arthritis of lesser toes	Arthritis of lesser toes	FB3
FAPC	Arthritis of lesser toes	Claw toes	
FAPH	Arthritis of lesser toes	Hammer toes	
FAPB	Arthritis of lesser toes	Bunion 5th MTP joint	
FNXX	Foot neurological injury	Foot neurological injury	
FNMX	Morton's neuroma	Morton's neuroma	FN1
FVXX	Foot vascular injuries	Foot vascular injuries	
FZXX	Foot pain/injury not otherwise specified	Foot pain/injury not otherwise specified	
FZZX	Foot pain undiagnosed	Foot pain undiagnosed	FZ1
FZCX	Chronic regional pain syndrome foot	Chronic regional pain syndrome foot	FP5
XXXX	Injuries location unspecified/crossing	Injuries location unspecified/crossing	
XHXX	Soft tissue bruising/haematoma location unspecified or crossing anatomical boundaries	Soft tissue bruising/haematoma location unspecified or crossing anatomical boundaries	
XHUX	Soft tissue bruising upper limb	Soft tissue bruising upper limb	
XHLX	Soft tissue bruising lower limb	Soft tissue bruising lower limb	
XKXX	Laceration/abrasion location unspecified or crossing anatomical boundaries	Laceration/abrasion location unspecified or crossing anatomical boundaries	
XKUX	Laceration/abrasion upper limb	Laceration/abrasion upper limb	

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
XKLX	Laceration/abrasion lower limb	Laceration/abrasion lower limb	
XMXX	Muscle strain/spasm/trigger points location unspecified or crossing anatomical boundaries	Muscle strain/spasm/trigger points location unspecified or crossing anatomical boundaries	
XMUX	Muscle strain upper limb	Muscle strain upper limb	
XMLX	Muscle strain lower limb	Muscle strain lower limb	
XMSX	Muscle strain spine	Muscle strain spine	
XMYX	Trigger points/spasm multiple locations	Trigger points/spasm multiple locations	
XTXX	Tendon injury location unspecified or crossing anatomical boundaries	Tendon injury location unspecified or crossing anatomical boundaries	
XTTX	Tendinopathy location unspecified	Tendinopathy location unspecified	
XTRX	Tendon strain/rupture location unspecified	Tendon strain/rupture location unspecified	
XTUX	Tendon strain/rupture upper limb	Tendon strain/rupture upper limb	
XTLX	Tendon strain/rupture lower limb	Tendon strain/rupture lower limb	
XJXX	Sprain location unspecified	Sprain location unspecified	
XJUX	Upper limb joint sprain	Upper limb joint sprain	
XJLX	Lower limb joint sprain	Lower limb joint sprain	
XJSX	Spinal joint sprain	Spinal joint sprain	
XCXX	Chondral/osteochondral injury location unspecified	Chondral/osteochondral injury location unspecified	
XDXX	Dislocation location unspecified	Dislocation location unspecified	
XDUX	Upper limb joint dislocation	Upper limb joint dislocation	
XDLX	Lower limb joint dislocation	Lower limb joint dislocation	
XUXX	Instability of joint location unspecified	Instability of joint location unspecified	
XUUX	Upper limb joint instability	Upper limb joint instability	
XULX	Lower limb joint instability	Lower limb joint instability	
XFXX	Fracture location unspecified or crossing anatomical boundaries	Fracture location unspecified or crossing anatomical boundaries	
XFUX	Fracture upper limb	Fracture upper limb	
XFLX	Fracture lower limb	Fracture lower limb	
XSXX	Stress fracture location unspecified or crossing anatomical boundaries	Stress fracture location unspecified or crossing anatomical boundaries	
XSUX	Upper limb stress fracture	Upper limb stress fracture	
XSLX	Lower limb stress fracture	Lower limb stress fracture	
XGXX	Stress fracture location unspecified or crossing anatomical boundaries	Stress fracture location unspecified or crossing anatomical boundaries	
XGPX	Postural syndrome	Postural syndrome	
XGUX	Upper limb synovitis/impingement lesion	Upper limb synovitis/impingement lesion	
XGLX	Lower limb synovitis/impingement lesion	Lower limb synovitis/impingement lesion	
XNXX	Neurological lesion location unspecified or crossing anatomical boundaries	Neurological lesion location unspecified or crossing anatomical boundaries	
XNSX	Spinal injury location unspecified or crossing anatomical boundaries	Spinal injury location unspecified or crossing anatomical boundaries	
XNUX	Upper limb neurological injury	Upper limb neurological injury	
XNLX	Lower limb neurological injury	Lower limb neurological injury	
XVXX	Vascular injury location unspecified or crossing anatomical boundaries	Vascular injury location unspecified or crossing anatomical boundaries	
XVUX	Upper limb vascular injury	Upper limb vascular injury	
XVLX	Lower limb vascular injury	Lower limb vascular injury	
XAXX	Osteoarthritis location unspecified or crossing anatomical boundaries (excl generalised oa see mrox)	Osteoarthritis location unspecified or crossing anatomical boundaries (excl generalised oa see mrox)	
XAUX	Upper limb osteoarthritis	Upper limb osteoarthritis	

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
XALX	Lower limb osteoarthritis	Lower limb osteoarthritis	
IMXX	Generalised abnormality of the musculoskeletal system	Generalised abnormality of the musculoskeletal system	
IMLX	Leg length abnormality	Leg length abnormality	
IMLT	Femoral leg length discrepancy	Femoral leg length discrepancy	
IMLQ	Tibial leg length discrepancy	Tibial leg length discrepancy	
IMLA	Apparent leg length discrepancy	Apparent leg length discrepancy	
IMHX	Hypo or hyper – mobility of joints	Hypo or hyper – mobility of joints	
IMHO	Hypo or hyper – mobility of joints	Generalised hypomobility of joints	
IMHE	Hypo or hyper – mobility of joints	Generalised hypermobility of joints	
INXX	Structural abnormality cervical spine	Structural abnormality cervical spine	NB1
IDXX	Thoracic spine structural abnormality	Thoracic spine structural abnormality	
IDSX	Thoracic scoliosis	Thoracic scoliosis	DB1
IDKX	Thoracic kyphosis	Thoracic kyphosis	
ILXX	Lumbosacral spine structural abnormality	Lumbosacral spine structural abnormality	LB3
ILSX	Lumbar scoliosis	Lumbar scoliosis	LB2
ILCX	Congenital abnormality lumbar spine	Congenital abnormality lumbar spine	
ILCB	Congenital abnormality lumbar spine	Spina bifida	
ILCL	Congenital abnormality lumbar spine	Lumbarisation of s1	
ILCS	Congenital abnormality lumbar spine	Sacralisation of l5	
ICXX	Chest structural abnormality	Chest structural abnormality	
ICRX	Cervical rib	Cervical rib	SB1
IOXX	Abdominopelvic structural abnormality	Abdominopelvic structural abnormality	
ISXX	Shoulder structural abnormality	Shoulder structural abnormality	
IEXX	Elbow structural abnormality	Elbow structural abnormality	
IWXX	Wrist and hand structural abnormality	Wrist and hand structural abnormality	
IWUX	Radioulnar variance	Radioulnar variance	RB1
IWUP	Radioulnar variance	Positive ulnar variance	
IWUN	Radioulnar variance	Negative ulnar variance	
IWCX	Carpal bone structural abnormality	Carpal bone structural abnormality	
IWCB	Carpal bone structural abnormality	Carpal boss	WT4
IGXX	Structural abnormality of hip/groin	Structural abnormality of hip/groin	
IGHX	Congenital abnormality of hip joint	Congenital abnormality of hip joint	
IGHD	Congenital abnormality of hip joint	Congenital dislocation of hip	GB1
IKXX	Structural abnormality of knee	Structural abnormality of knee	
IKPX	Bi or multipartite patella	Bi or multipartite patella	KB1
IKCX	Congenital cartilage abnormality of knee	Congenital cartilage abnormality of knee	
IKCD	Congenital cartilage abnormality of knee	Discoid lateral meniscus	KB2
IQXX	Structural abnormality of lower leg	Structural abnormality of lower leg	
IQMX	Muscle abnormality of lower leg	Muscle abnormality of lower leg	
IQMS	Muscle abnormality of lower leg	Accessory soleus muscle (excl inj to that muscle)	QB1
IAXX	Structural abnormality of ankle	Structural abnormality of ankle	
IACX	Tarsal coalition of foot	Tarsal coalition of foot	FB1
IACT	Tarsal coalition of foot	Talonavicular coalition	FBT
IACC	Tarsal coalition of foot	Calcaneocuboid coalition	
IACN	Tarsal coalition of foot	Calcaneonavicular coalition	FBC
IFXX	Structural abnormality of foot	Structural abnormality of foot	
IFAX	Accessory bone foot	Accessory bone foot	FB2
JXXX	Paediatric diagnoses	Paediatric diagnoses	
JTXX	Traction apophysitis/avusion fracture apophysitis	Traction apophysitis/avusion fracture apophysitis	

(*Continued*)

Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
JTSX	Traction injury to apophysis at shoulder	Traction injury to apophysis at shoulder	
JTEX	Traction injury to apophysis at elbow	Traction injury to apophysis at elbow	
JTEM	Traction injury to apophysis at elbow	Apophysitis/avulsion fracture medial epicondyle elbow	
JTWX	Traction injury to apophysis at wrist/hand	Traction injury to apophysis at wrist/hand	
JTBX	Traction injury to apophysis at buttock and pelvis	Traction injury to apophysis at buttock and pelvis	GG1
JTBI	Traction injury to apophysis at buttock and pelvis	Apophysitis/avulsion fracture iliac crest	GGO
JTBH	Traction injury to apophysis at buttock and pelvis	Apophysitis/avulsion fracture ischial tuberosity	GGH
JTGX	Traction injury to apophysis at groin/hip joint	Traction injury to apophysis at groin/hip joint	
JTGS	Traction injury to apophysis at groin/hip joint	Apophysitis/avulsion fracture ASIS	GGS
JTGR	Traction injury to apophysis at groin/hip joint	Apophysitis/avulsion fracture AIIS	GGR
JTGZ	Traction injury to apophysis at groin/hip joint	Other apophysitis/avulsion fracture groin/hip	GGA
JTKX	Traction injury to apophysis at knee	Traction injury to apophysis at knee	
JTKP	Traction injury to apophysis at knee	Apophysitis/avulsion fracture distal pole patella (SLJ)	KTJ
JTKT	Traction injury to apophysis at knee	Apophysitis/avulsion fracture tibial tubercle (OGS)	KT4
JTAX	Traction injury to apophysis ankle	Traction injury to apophysis ankle	
JTAC	Traction injury to apophysis ankle	Apophysitis/avulsion fracture to calcaneus (Severs Dx)	AT2
JTFX	Traction injury to foot	Traction injury to foot	
JTFM	Traction injury to foot	Apophysitis/avulsion fracture base 5th metetarsal	
JTZX	Other traction injury to apophysis not otherwise specified	Other traction injury to apophysis not otherwise specified	
JCXX	Other osteochondroses	Other osteochondroses	
JCLX	Osteochondrosis spine	Osteochondrosis spine	
JCLS	Osteochondrosis spine	Scheuermanns disease	DT1
JCSX	Osteochondrosis shoulder	Osteochondrosis shoulder	
JCEX	Osteochondrosis elbow	Osteochondrosis elbow	ECO
JCEC	Osteochondrosis elbow	Capitellar osteochondrosis	
JCWX	Osteochondrosis of wrist and hand	Osteochondrosis of wrist and hand	
JCWR	Osteochondrosis of wrist and hand	Epiphysitis of distal radius	
JCGX	Osteochondroses of hip joint	Osteochondroses of hip joint	
JCGP	Osteochondroses of hip joint	Perthes disease	GA3
JCGS	Osteochondroses of hip joint	Slipped capital femoral epiphysis	GA2
JCKS	Osteochondrosis of knee	Osteochondrosis of knee	KC4
JCKF	Osteochondrosis of knee	OCD medial or lateral femoral condyle	
JCKP	Osteochondrosis of knee	OCD patella	
JCKT	Osteochondrosis of knee	Epiphysitis of medial tibial plateau (Blount's Disease)	
JCAX	Osteochondrosis of ankle	Osteochondrosis of ankle	
JCFX	Osteochondrosis of foot	Osteochondrosis of foot	FC1
JCFK	Osteochondrosis of foot	Kholer's disease – navicular osteochondrosis	
JCFF	Osteochondrosis of foot	Freiberg's disease – osteochondrosis of MT head	
JCZX	Other osteochondrosis not elsewhere specified.	Other osteochondrosis not elsewhere specified.	

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
VXXX	Disabled athlete conditions	Disabled athlete conditions	
VAXX	Injury/illness in an amputee athlete	Injury/illness in an amputee athlete	
VASX	Stump problem	Stump problem	
VASI	Stump problem	Infection of stump	
VASS	Stump problem	Stump skin pressure sores	
VASZ	Stump problem	Other stump injury	
VWXX	Injury/illness specific to a spinal cord injured athlete	Injury/illness specific to a spinal cord injured athlete	
VWAX	Autonomic dysreflexia	Autonomic dysreflexia	
VWSX	Skin pressure sores	Skin pressure sores	
VWUX	Urinary problem	Urinary problem	
VWUR	Urinary problem	Urinary retention/blocked catheter	
VWUI	Urinary problem	Urinary infection	
VZXX	Injury/illness specific to disabled athletes not elsewhere specified	Injury/illness specific to disabled athletes not elsewhere specified	
YXXX	Post surgical patient	Post surgical patient	
YNXX	Post neck surgery	Post neck surgery	
YSXX	Post shoulder surgery	Post shoulder surgery	
YSSX	Post shoulder stabilisation	Post shoulder stabilisation	
YSSA	Post shoulder stabilisation	Post arthroscopic shoulder stabilisation	
YSSO	Post shoulder stabilisation	Post open shoulder stabilisation	
YSAX	Post AC joint surgery	Post AC joint surgery	
YSRX	Post rotator cuff surgery	Post rotator cuff surgery	
YEXX	Post elbow surgery	Post elbow surgery	
YWXX	Post wrist/hand surgery	Post wrist/hand surgery	
YWCX	Post carpal tunnel release	Post carpal tunnel release	
YWWX	Post surgery on wrist joint	Post surgery on wrist joint	
YWWS	Post surgery on wrist joint	Post scapholunate stabilisation	
YWHX	Post hand/finger/thumb surgery	Post hand/finger/thumb surgery	
YGXX	Post hip/groin surgery	Post hip/groin surgery	
YGGX	Post surgery for overuse groin injury	Post surgery for overuse groin injury	
YGGA	Post surgery for overuse groin injury	Post adductor tenotomy	
YGGH	Post surgery for overuse groin injury	Post hernia repair	
YGGM	Post surgery for overuse groin injury	Post mixed groin surgery	
YGSX	Post hip arthroscopy	Post hip arthroscopy	
YGAX	Post hip arthroplasty	Post hip arthroplasty	
YKXX	Post knee surgery	Post knee surgery	
YKLX	Post knee reconstructive surgery	Post knee reconstructive surgery	
YKLA	Post knee reconstructive surgery	Post ACL reconstruction	
YKLC	Post knee reconstructive surgery	Post PCL reconstruction	
YKCX	Post cartilage surgery knee	Post cartilage surgery knee	
YKCM	Post cartilage surgery knee	Post menisectomy	
YKCR	Post cartilage surgery knee	Post meniscal repair	
YKCC	Post cartilage surgery knee	Post chondral debridement	
YKCT	Post cartilage surgery knee	Post cartilage transplant	
YKPX	Post surgery for patellofemoral pain (incl debridement/lat release/ realignment surgery/patellectomy)	Post surgery for patellofemoral pain (incl debridement/lat release/ realignment surgery/patellectomy)	
YKAX	Post knee replacement surgery	Post knee replacement surgery	
YKAH	Post knee replacement surgery	Post hemiarthroplasty knee	
YKAT	Post knee replacement surgery	Post total arthroplasty knee	
YKZX	Post other knee surgery	Post other knee surgery	
YKQX	Complication post knee surgery – eg, infection	Complication post knee surgery – eg, infection	KO1
YQXX	Post lower leg surgery	Post lower leg surgery	
YQAX	Post Achilles tendon surgery	Post Achilles tendon surgery	
YQFX	Post compartment release surgery	Post compartment release surgery	

(*Continued*)

Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
YAXX	Post ankle surgery	Post ankle surgery	
YARX	Post ankle reconstruction ± other procedure	Post ankle reconstruction ± other procedure	
YAAX	Post ankle arthroscopy and debridement	Post ankle arthroscopy and debridement	
YFXX	Post foot surgery	Post foot surgery	
YFHX	Post great toe surgery	Post great toe surgery	
YZXX	Post surgery on other site not specifically mentioned	Post surgery on other site not specifically mentioned	
MXXX	Medical Illness	Medical Illness	MX7
MIXX	Infection	Infection	
MISX	Skin infection	Skin infection	
MISH	Skin infection	Skin infection head/face/neck	HI2
MISE	Skin infection	Skin infection elbow	EI1
MISW	Skin infection	Skin infection wrist/hand	PI1
MISB	Skin infection	Skin infection pelvis/buttock – incl ischial abscess	BI1
MISQ	Skin infection	Skin infection lower leg	QI1
MISF	Skin infection	Skin infection foot	FI2
MISN	Skin infection	Skin infection toenail – incl infected ingrown toenail	
MISL	Skin infection	Lymphadenopathy secondary to skin infection	
MISZ	Skin infection	Other skin infection not specifically mentioned	
MIWX	Skin infection – viral (incl warts)	Skin infection – viral (incl warts)	
MIWH	Skin infection – viral (incl warts)	Herpes simplex (incl scrum pox)	
MIWW	Skin infection – viral (incl warts)	Wrist and hand warts	PK3
MIWF	Skin infection – viral (incl warts)	Feet warts – incl plantar warts	FK3
MIWZ	Skin infection – viral (incl warts)	Other warts	
MIFX	Skin Infection – fungal	Skin Infection – fungal	
MIFG	Skin Infection – fungal	Fungal infection groin	GI1
MIFF	Skin Infection – fungal	Tinea pedis/athlete's foot	FI1
MIFZ	Skin Infection – fungal	Other fungal infection	
MIRX	Respiratory tract infection (bacterial or viral)	Respiratory tract infection (bacterial or viral)	MI1
MIRS	Respiratory tract infection (bacterial or viral)	Sinusitis	
MIRP	Respiratory tract infection (bacterial or viral)	Pharyngitis	
MIRT	Respiratory tract infection (bacterial or viral)	Tonsillitis	
MIRU	Respiratory tract infection (bacterial or viral)	Other upper resp tract infection	
MIRB	Respiratory tract infection (bacterial or viral)	Bronchitis	
MIRN	Respiratory tract infection (bacterial or viral)	Pneumonia	
MIRL	Respiratory tract infection (bacterial or viral)	Other lower respiratory tract infection	
MIEX	Ear infection	Ear infection	
MIEE	Ear infection	Otitis externa	HI1
MIEM	Ear infection	Middle ear infection	
MIGX	Gastrointestinal infection	Gastrointestinal infection	MI2
MIGB	Gastrointestinal infection	Bacterial gastroenteritis (incl food poisoning)	
MIGV	Gastrointestinal infection	Viral gastroenteritis	
MIGG	Gastrointestinal infection	Amoebic dysentery	

(*Continued*)

Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
MIGH	Gastrointestinal infection	Viral hepatitis (A, B, or C)	
MIGZ	Gastrointestinal infection	Other gastrointestinal infection	
MIUX	Genitourinary infection	Genitourinary infection	MI6
MIUS	Genitourinary infection	Sexually transmitted disease	
MIUP	Genitourinary infection	Pyelonephritis	
MIUC	Genitourinary infection	Cystitis	
MIUZ	Genitourinary infection	Other genitourinary infection	
MIAX	Joint infection – septic arthritis (excl. complications of surgery or perforating lacerations)	Joint infection – septic arthritis (excl. complications of surgery or perforating lacerations)	
MIAS	Joint infection – septic arthritis (excl. complications of surgery or perforating lacerations)	Infected shoulder joint	
MIAE	Joint infection – septic arthritis (excl. complications of surgery or perforating lacerations)	Infected elbow joint	
MIAW	Joint infection – septic arthritis (excl. complications of surgery or perforating lacerations)	Infected wrist, hand, finger, thumb joint	
MIAG	Joint infection – septic arthritis (excl. complications of surgery or perforating lacerations)	Infected hip joint	GI2
MIAO	Joint infection – septic arthritis (excl. complications of surgery or perforating lacerations)	Infected pubic symphysis	
MIAK	Joint infection – septic arthritis (excl. complications of surgery or perforating lacerations)	Infected knee joint	KI1
MIAA	Joint infection – septic arthritis (excl. complications of surgery or perforating lacerations)	Infected ankle joint	AI1
MIAF	Joint infection – septic arthritis (excl. complications of surgery or perforating lacerations)	Infected foot joint	
MIBX	Infection of bone – osteomyelitis	Infection of bone – osteomyelitis	
MIBD	Infection of bone – osteomyelitis	Septic discitis – osteomyelitis of the spine	
MIVX	Systemic viral infection (excl viruses localised to one area)	Systemic viral infection (excl viruses localised to one area)	MI5
MIVG	Systemic viral infection (excl viruses localised to one area)	Glandular fever	
MIVC	Systemic viral infection (excl viruses localised to one area)	Chicken pox	
MIZX	Other infection not otherwise specified	Other infection not otherwise specified	MI8
MVXX	Environmental Illness	Environmental Illness	MX1
MVBX	Barotrauma	Barotrauma	
MVBD	Barotrauma	Decompression sickness	
MVHX	Heat Illness	Heat Illness	
MVHO	Heat Illness	Hypothermia	
MVHS	Heat Illness	Sunburn	
MVHE	Heat Illness	Hyperthermia/heat stroke	
MVHR	Heat Illness	Rhabdomyolysis	
MCXX	Cardiovascular Illness	Cardiovascular Illness	MV1
MCAX	Athletes heart	Athletes heart	
MCIX	Ischaemic heart disease	Ischaemic heart disease	
MCCX	Conduction abnormality incl arrhythmias	Conduction abnormality incl arrhythmias	

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
MCHX	HOCM	HOCM	
MCMX	Murmours/Valvular disease	Murmours/Valvular disease	
MCVX	Venous disease	Venous disease	
MCVV	Venous disease	Varicose veins	QV3
MCVQ	Venous disease	DVT calf	QV1
MCVS	Venous disease	Subclavian vein/axillary vein thrombosis	SV1
MCVZ	Venous disease	Other venous disease incl calf/ankle oedema, cause unknown	QV2
MCPX	Peripheral vascular disease	Peripheral vascular disease	
MCZX	Other cardiovascular disease	Other cardiovascular disease	
MPXX	Respiratory disease	Respiratory disease	
MPAX	Asthma and/or allergy	Asthma and/or allergy	MX3
MPAL	Asthma and/or allergy	Allergy – rhinitis/sinusitis/hayfever (for urticaria see MDUX)	
MPAA	Asthma and/or allergy	Asthma – allergic	
MPAE	Asthma and/or allergy	Asthma – exericse induced only	
MPCX	Chronic airflow limitation	Chronic airflow limitation	
MPFX	Cystic fibrosis	Cystic fibrosis	
MPZX	Other respiratory illness not otherwise specified	Other respiratory illness not otherwise specified	
MNXX	Neurological illness	Neurological illness	MN1
MNBX	Brachial neuritis	Brachial neuritis	
MNEX	Epilepsy	Epilepsy	
MNHX	Headaches (excl. those exercise related or Msk in origin – see HZXX)	Headaches (excl. those exercise related or Msk in origin – see HZXX)	
MNHM	Headaches (excl. those exercise related or Msk in origin – see HZXX)	Migraine	
MNHC	Headaches (excl. those exercise related or Msk in origin – see HZXX)	Cluster headaches	
MNHS	Headaches (excl. those exercise related or Msk in origin – see HZXX)	Sinus headache	
MNHZ	Headaches (excl. those exercise related or Msk in origin – see HZXX)	Headache not otherwise specified	
MNCX	Cerebral palsy	Cerebral palsy	
MNZX	Other neurological problem	Other neurological problem	
MNZM	Other neurological problem	Generalised tight muscles/spasticity	
MRXX	Rheumatological Illness	Rheumatological Illness	XP1
MROX	Osteoarthritis – generalised (for OA isolated to one jt see ?AXX)	Osteoarthritis – generalised (for OA isolated to one jt see ?AXX)	
MRGX	Gout	Gout	
MRGE	Gout	Gout in elbow	
MRGP	Gout	Gout in hands/fingers	
MRGK	Gout	Gout in knee	
MRGA	Gout	Gout in ankle/foot (incl big toe)	FP4
MRGZ	Gout	Gout in other location not otherwise specified	
MRPX	Pseudogout	Pseudogout	
MRPK	Pseudogout	Pseudogout in knee	
MRPZ	Pseudogout	Pseudogout in other joint/location	
MRSX	Seronegative arthritis	Seronegative arthritis	
MRSA	Seronegative arthritis	Anklylosing spondylitis	
MRSP	Seronegative arthritis	Psoriatic arthritis	
MRSR	Seronegative arthritis	Reiter's syndrome	
MRSS	Seronegative arthritis	Non specific seronegative arthritis affecting SIJ	BP1
MRSO	Seronegative arthritis	Non specific seronegative arthritis affecting	

(*Continued*)

Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
MRSM	Seronegative arthritis	Non specific seronegative arthritis affecting many joints	
MRRX	Rheumatoid arthritis	Rheumatoid arthritis	
MRRO	Rheumatoid arthritis	Rheumatoid arthritis affecting	
MRRM	Rheumatoid arthritis	Rheumatoid arthritis affecting many joints	
MRFX	Fibromyalgia/multiple sore muscle areas	Fibromyalgia/multiple sore muscle areas	XY1
MRZX	Rheumatological disease other/ undiagnosed	Rheumatological disease other/ undiagnosed	
MRZK	Rheumatological disease other/ undiagnosed	Inflammatory arthritis of knee	KP2
MGXX	gastrointestinal illness	gastrointestinal illness	
MGPX	Gastritis	Gastritis	
MGPE	Gastritis	Exercise associated gastritis/reflus	
MGPN	Gastritis	NSAID associated gastritis/peptic ulceration	
MGPU	Gastritis	Gastritis/peptic ulceration – non exercise/NSAID related	
MGDX	Diarrhoea	Diarrhoea	
MGDR	Diarrhoea	Runner's diarrhoea	
MGMX	Haematemesis/malaena/GI bleeding	Haematemesis/malaena/GI bleeding	
MGSX	Surgical bowel problem	Surgical bowel problem	MO8
MGSA	Surgical bowel problem	Appendicitis	MO1
MGSC	Surgical bowel problem	Cholecystitis	
MUXX	Genitourinary illness (excl infection see MIGX)	Genitourinary illness (excl infection see MIGX)	MO2
MUUX	Urinary illness	Urinary illness	
MUUH	Urinary illness	Haematuria	
MUVX	Varicocoele	Varicocoele	
MUGX	Gynaecological illness	Gynaecological illness	MX5
MUGE	Gynaecological illness	Diet and exercise associated amennorhoea	
MUGA	Gynaecological illness	Other amenorrhoea	
MUGD	Gynaecological illness	Dysmennorrhoea	
MUGO	Gynaecological illness	OCP Advice	
MUGZ	Gynaecological illness	Other gynaecological illness	
MUPX	Pregnancy	Pregnancy	
MUPE	Pregnancy	Exercise advice	
MUPS	Pregnancy	Pregnancy associated musculosketal injury	
MUPT	Pregnancy	Request for pregnancy test	
MHXX	Haematological illness and nutritional deficiencies	Haematological illness and nutritional deficiencies	
MHAX	Anaemia	Anaemia	
MHAI	Iron deficiency	Iron deficiency	
MYXX	Endocrine illness	Endocrine illness	
MYTX	Thyroid disorder	Thyroid disorder	
MYZX	Other endocrine disorder	Other endocrine disorder	
MDXX	Dermatological illness (excl infections MIXX, skin lesions/ tumours MECX and sunburn MVHX)	Dermatological illness (excl infections MIXX, skin lesions/ tumours MECX and sunburn MVHX)	XK1
MDUX	Urticaria	Urticaria	
MDPX	Psoriasis	Psoriasis	
MDDX	Dermatitis	Dermatitis	
MDZX	Other rash not otherwise mentioned or undiagnosed	Other rash not otherwise mentioned or undiagnosed	

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
MDZW	Dermatological illness (excl infections MIXX, skin lesions/ tumours MECX and sunburn MVHX)	Dermatological illness (excl infections MIXX, skin lesions/ tumours MECX and sunburn MVHX)	
MDZG	Dermatological illness (excl infections MIXX, skin lesions/ tumours MECX and sunburn MVHX)	Dermatological illness (excl infections MIXX, skin lesions/ tumours MECX and sunburn MVHX)	
MOXX	Opthalmological illness (excl trauma)	Opthalmological illness (excl trauma)	
MTXX	ENT illness including dental (excl sinusitis – see MPAL)	ENT illness including dental (excl sinusitis – see MPAL)	
MSXX	Psychological/psychiatric Illness	Psychological/psychiatric Illness	MX6
MSFX	Eating/overexercising disorder in females	Eating/overexercising disorder in females	
MSFA	Eating/overexercising disorder in females	Anorexia nervosa	
MSFB	Eating/overexercising disorder in females	Bulimia nervosa	
MSFE	Eating/overexercising disorder in females	Exercise addiction	
MSFF	Eating/overexercising disorder in females	Female athlete triad	
MSMX	Eating/overexercising disorder in males	Eating/overexercising disorder in males	
MSDX	Depression	Depression	
MSAX	Anxiety/panic disorder	Anxiety/panic disorder	
MSZX	Other psychological/psychiatric disorder not otherwise specified	Other psychological/psychiatric disorder not otherwise specified	
MEXX	Tumours/malignancies	Tumours/malignancies	
MESX	Tumour shoulder	Tumour shoulder	SE1
MEUX	Tumour upper arm	Tumour upper arm	
MEEX	Tumour elbow	Tumour elbow	
MERX	tumour forearm	tumour forearm	
MEWX	Tumour wrist/hand	Tumour wrist/hand	
MEHX	Tumour head	Tumour head	
MENX	Tumour neck	Tumour neck	
MEDX	Tumour thoracic spine/chest wall	Tumour thoracic spine/chest wall	DE1
MELX	Tumour lumbar spine	Tumour lumbar spine	LE1
MEBX	Tumour pelvis and buttock	Tumour pelvis and buttock	
MEGX	Tumour groin and hip	Tumour groin and hip	
METX	Tumour thigh	Tumour thigh	TE1
MEKX	Tumour knee	Tumour knee	KE1
MEQX	Tumour lower leg	Tumour lower leg	QE1
MEAX	Tumour ankle	Tumour ankle	
MEFX	Tumour foot	Tumour foot	
MEMX	Haematological malignancy	Haematological malignancy	
MECX	Skin lesion/tumour	Skin lesion/tumour	DK2
MECA	Skin lesion/tumour	Benign skin lesion	
MECB	Skin lesion/tumour	Bcc	
MECS	Skin lesion/tumour	Scc	
MECM	Skin lesion/tumour	Melanoma	
MECP	Skin lesion/tumour	Multiple skin cancers	
MECZ	Skin lesion/tumour	Other skin tumour	
MEZX	Other tumour not otherwise mentioned	Other tumour not otherwise mentioned	ME1
MBXX	Drug use/overdose/poisoning	Drug use/overdose/poisoning	MX2
MZXX	Medical illness undiagnosed/other	Medical illness undiagnosed/other	
MZFX	Tired athlete undiagnosed	Tired athlete undiagnosed	MZ1
MZZX	Other medical illness	Other medical illness	MZ2

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Appendix 2 (*Continued*)

OSICS10 code	Specific	Detail	OSICS9
MZZF	Other medical illness	Chronic Fatigue Syndrome	MZC
MZZO	Other medical illness	Obesity	
ZXXX	Consultations	Consultations	
ZEXX	Exercise prescription	Exercise prescription	ZZ4
ZEAX	Exercise prescription for patient with arthritis	Exercise prescription for patient with arthritis	
ZEOX	Exercise prescription for patient with obesity	Exercise prescription for patient with obesity	
ZEOJ	Exercise prescription for patient with obesity	Exercise prescription for patient with juvenile obesity	
ZECX	Exercise prescription for patient with cardiac disease	Exercise prescription for patient with cardiac disease	
ZERX	Exercise prescription for patient with respiratory disease	Exercise prescription for patient with respiratory disease	
ZEVX	Exercise prescription for patient with overtraining/chronic fatigue	Exercise prescription for patient with overtraining/chronic fatigue	
ZEMX	Exercise prescription for patient with other medical disease	Exercise prescription for patient with other medical disease	
ZPXX	Paperwork	Paperwork	
ZPMX	Medical certificate	Medical certificate	
ZPRX	Referral	Referral	
ZPPX	Prescription repeat	Prescription repeat	
ZSXX	Screening examination	Screening examination	
ZSPX	Preparticipation screen	Preparticipation screen	ZZ2
ZSMX	General medical screen	General medical screen	
ZSDX	Dive medical	Dive medical	
ZOXX	Preparation for overseas travel – advice immunisations	Preparation for overseas travel – advice immunisations	ZZ3
ZTXX	Advice on equipment/other aids eg, appropriate footwear.	Advice on equipment/other aids eg, appropriate footwear.	