PHD

Epidemiology of Injury in Elite Level Female Rugby Union Players in England

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Epidemiology of Injury in
Elite Level Female Rugby Union
Players in England

Nicola Gabb

A thesis submitted for the degree of Doctor of Philosophy
University of Bath
Department of Health
October 2017

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Publications:

Abstracts:

Conference Poster Presentations:

Abstract

Women’s Rugby Union has been through a period of transition, from the introduction of professional contracts, to the expansion of international 15-a-side and sevens competitions. Despite increased popularity and growth, little published literature has investigated the specific epidemiology and risk factors for injuries in women’s rugby union. This research was undertaken to investigate the injury risk to elite female players in both the 15-a-side and sevens games. Chapter 4 presents an epidemiological study of match injuries in elite club level women’s rugby union. The overall match injury incidence rate was 43 per 1000 player hours with a mean injury severity of 36 days. This incident rate is low compared to that of the male game. This suggests that sex specific research is preferable to accurately guide future practices and interventions. Chapter 5 investigates the epidemiology if injuries across 2 seasons, in an International women’s squad. With an injury incidence rate of 128 per 1000 player-hours the results illustrate a similar incidence rate of injuries to those observed in men’s International competitions but a significantly higher incidence rate when compared to women’s club level. The impact of injury and illness on a squad’s player availability is an important consideration both for the players’ own performance and for the squad’s performance. Chapter 6 investigates how environmental factors (e.g. short preparation period, weekly training load and the magnitude of the change in training load) contributed to the number of injuries sustained by an International squad in an intense period of training, prior to a World Cup tournament. Similarly, in Chapter 7, injuries sustained by a World Cup sevens training squad were monitored, across an intense period of training and competition. The high injury incidence rate of 187 per 1000 player-hours highlights the difference in injury risk between women and men, with environmental factors likely to have been a contributory factor. A sport still in transition, continued sex specific research is crucial to ensure the introduction of appropriate injury prevention strategies in women’s rugby Union.
Chapter 1: Introduction

1.1 Research context and background literature

Rugby is a full contact sport characterised by intermittent activity, with periods of low intensity movements such as walking and jogging punctuated by frequent bouts of high-intensity activities such as running and sprinting, along with collision events such as tackling, scrummaging, rucking and mauling (Roberts et al., 2008). These physical demands, and in particular the regular exposure to collisions and physical contact, ensure that the inherent risk of injury to the rugby playing population is substantial (Williams et al., 2013).

Rugby Union is one of the few sports in which women compete under the same rules, using the same protective-equipment as their male counterparts. The incidence, type and cause of injuries in the men’s game has and continues to be widely researched. In contrast the women’s game is under-researched, despite evidence from other contexts (e.g. military populations) to suggest that there might be a greater risk of injury for women compared to their male counterparts; consequently, sex specific investigations are required. Evidence from other sports such as soccer (Ristolainen et al., 2009), hockey (MacCormick et al., 2014) and handball (Langevoort et al., 2007) suggest that differences in injury incidence rates exist between the respective men’s and women’s games, with proposed explanations including physiological/anatomical differences and quantity of training (Langevoort et al., 2007).

Injury surveillance aims to describe the occurrence of, the circumstances around, and factors associated with injury (Caine et al., 1996). From the collected information, meaningful comparisons of injury patterns between studies of the same sport and from other sports/activities can be made. This in turn enables the relative risk of injury to participants to be gauged, both from the sport as a whole and from individual events (i.e. the tackle or scrum); if the risk is judged to be sufficiently high this provides an indication of those areas where preventative action may be required (van Mechelen et al., 1992). Indeed, Brooks and Fuller (2006) consider the data collected from these epidemiological
studies to be essential for the continued development of injury prevention, treatment and rehabilitation strategies.

The current literature reporting upon the incidence of injuries in women’s rugby spans 20 years (1998 – 2018) yet consisted of just 7 papers (Carson et al., 1999a, Taylor et al., 2011a, Doyle and George, 2004, Kerr et al., 2008, Bird et al., 1998, Schick et al., 2008, Peck et al. 2013). Generalisation between the papers is difficult, if not impossible, because of the varying methodologies/injury definitions used, the diverse playing levels observed (community, college and elite), and type of competition or time-period across which players were competing (i.e. 2-3 week tournament versus season long league competition). In 2007, World Rugby published a consensus statement for reporting time-loss and medical attention injuries in rugby union (Fuller et al., 2007c). The document provided researchers with a framework within which to conduct their research, with recommended definitions and methods. The aim of the consensus statement was to help researchers improve consistency of reporting, which would enhance the opportunities for making comparisons and generalisations between the papers.

1.2 Purpose of research

The overall aim of this research is to understand the aetiology of injuries in elite women’s rugby union with a long-term aspiration of identifying appropriate routes for injury reduction.

The specific research questions developed are:

1. What is the injury profile of women’s elite level club rugby union players?
2. What is the injury profile of women’s International level rugby union players?
3. How does the incidence of injury and illness impact on player availability during an intense period of training and competition prior to and during the Women’s Rugby World Cup?
4. What is the injury profile of elite female rugby sevens players, during preparation for and during the rugby sevens world cup?
1.3 Structure of thesis

The main body of this thesis opens with a review of literature, which provides the context for the foundation of this thesis. (Chapter 2). Focusing on six specific areas (Figure 1.1), the literature review will start by exploring the value of injury surveillance and its contribution to injury prevention in sport. The second section will discuss the factors associated with selecting a specific research design and the importance of the research design in the context of injury surveillance. A consideration of data collection and reporting methodologies is contained within section three, with an emphasis on the importance of consistency in order to give the results of injury surveillance studies proper context. The fourth section provides a review of the current body of research reporting upon match injuries in four distinct rugby union playing populations (elite men, community, youth and women). The incidence and severity of injuries sustained by women competing in alternative sports or physical occupations is reviewed in the penultimate section. Finally, section six explores the available literature reporting upon the incidence of illness within rugby union squads.

A general methodology section is presented in Chapter 3 followed by four research chapters, which present the findings of four injury surveillance studies. The first study (chapter 4) is a longitudinal prospective cohort study, aiming to explore the nature of injuries sustained by elite level (English Premiership) adult female rugby union players during match play. Providing the first longitudinal study of elite women’s club rugby this paper aims to outline the patterns of injury sustained by this player group, using comparable methodologies to those used in the men’s game and other sports. Similarly, the second study (chapter 5) is a longitudinal prospective injury surveillance study, observing International (England Elite Playing Squad (EPS)) rather than club players across the study period. The difference in the standard at which the club and international players compete and the higher level of medical/technical support, are explored in these studies. The third study (chapter 6), builds upon the observations of the second study, in that it reports upon the impact of injury and illness on EPS player availability during an intense period of training and competition prior to and during the Women’s Rugby World
Cup. The aim is to monitor the difference in injury risk, for players experiencing a rapid increase in training load and intensity, whilst also receiving greater medical/technical support. The final study (chapter 7) presents a longitudinal description of the incidence, nature and severity of injuries sustained by elite international women’s rugby sevens players during a 6-month period of intensive training and competition. With evidence suggesting a difference between the pattern of injuries in rugby sevens and the 15-a-side game, this study aims to build upon the current body of literature for rugby sevens whilst exposing the specific risk encountered by this player group.
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2.2 Injury surveillance – Research design.
2.3 Reporting injury data.
2.4 Match-related injuries in rugby union.
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2.8 Research rationale

Chapter 3: Methodology

Research

Chapter 4: Epidemiology of match injuries in elite female rugby union players.
Chapter 5: Match injuries in international female rugby union players.
Chapter 6: Impact of injury and illness on the preparation of a rugby world Cup winning squad.
Chapter 7: Epidemiology of injuries in a women’s International rugby sevens squad.

Chapter 8: Discussion

Figure 1:1  Thesis structure
Chapter 2: Literature Review

2.1 Injury Surveillance in Sport

Rugby is a physically demanding game and is characterised by intermittent activity, with periods of low intensity movements such as walking and jogging punctuated by frequent bouts of high-intensity activities such as running and sprinting, along with collision events such as tackling, scrummaging, rucking and mauling (Roberts et al., 2008, Gabbett et al., 2008). These physical demands, and in particular the regular exposure to collisions and physical contact, ensure that the inherent risk of injury to the rugby playing population is substantial (Williams et al., 2013, Gabbett, 2004). Indeed, compared with many professional team sports, rugby union and rugby league have some of the highest incidences of match injuries, albeit with rates similar to those of other full contact sports such as Ice Hockey (Lorentzon et al., 1988), American Football (Meyers and Barnhill, 2004) and Australian Rules Football (Orchard and Seward, 2002). Given the relatively high incidence of injuries in rugby and the potential long-term consequences (e.g., osteoarthritis (Drawer and Fuller, 2001)), injury prevention/reduction is an important endeavour and is the joint responsibility of individual athletes, coaches and sport regulatory bodies. As society grows ever more litigious, the use of risk management strategies in addressing injury prevention/reduction becomes even more important with injury surveillance playing an integral part in this process (Caine et al., 1996). Injury surveillance seeks to describe the occurrence of, the circumstances around and factors associated with injury (Caine et al., 1996). By seeking to understand the risk factors for (or causes of) injury, sport injury surveillance studies come under the umbrella of the ‘epidemiological research’ paradigm. Data collected from these epidemiological studies are considered essential for the continued development of injury prevention, treatment and rehabilitation strategies (Brooks and Fuller, 2006) as described in injury prevention frameworks such as that developed by Van Mechelen and colleagues (1992) (Figure 2.1).
Note: Injury surveillance required in Steps 1, 2 and 4.

Figure 2.1  Sports Injuries - Van Mechelen’s Sequence of Prevention (adapted from Van Mechelen (1992)).

2.2  Injury Surveillance - Research Design

If injury surveillance is to play a pivotal role in an evidence-based approach to injury prevention then employing valid and reliable methods is critical (Finch, 2006). Surveillance, as defined by the World Health Organization (WHO) is the “on-going, systematic collection, analysis and interpretation of health data essential to the planning, implementation, and evaluation of health practice …” (Holder et al., 2002). With valid, standardised and reliable methodologies, injury surveillance can be used to monitor trends across sports and from country to country (Finch, 2006). In order to address some of the methodological and definition based challenges of injury surveillance, a number of sports e.g. Cricket (Orchard et al., 2005, Fuller et al., 2006, Fuller et al., 2007c) have produced
consensus statements. The aim of these statements is to improve uniformity across different injury surveillance studies to both increase the scientific value of these studies and to increase the ability to generalise and compare results across sports, countries and playing levels (Hodgson et al., 2007, Meeuwisse and Love, 1997, Waldén et al., 2005).

2.2.1 Case Control

Case-Control studies are observational studies in which, individuals (Case Group) who are identified as having contracted, developed or sustained an illness or injury are compared with a control group who have not encountered the same illness/injury. Ideally both the case and control groups will come from the same population and therefore have encountered similar exposure to potential risk factors. For example, Beynnon et al (2006) compared serum estrogen and progesterone concentrations in female alpine skiers who had sustained an ACL tear with uninjured control skiers; the aim of the study was to determine whether the likelihood of sustaining an ACL injury was affected by the phase of the menstrual cycle.

The nature of case-control studies means that the researcher starts by looking for the outcome (e.g. ACL Injury) then moves onto the associated exposure (hormone levels). Having the advantage of being relatively simple and economical in terms of collecting the information, the retrospective nature of this approach does mean that researchers must take care to prevent the introduction of bias (either recall or interviewer); methods of achieving this include standardizing the questioning, ensuring questions are easily understandable and masking the interviewer as to whether subjects are from the case or control group. (Verhagen and Van Mechelen, 2010)

2.2.2 Clinical Trials

Clinical trials are prospective studies, in which researchers monitor the effect of a defined intervention on a specific outcome and compare the results with those of a control group who have received either a placebo or a common intervention (Verhagen and Van Mechelen, 2010).
Randomised Control trials (RCT) are considered the gold standard for clinical trials because valid methodologies allow the differences observed between outcomes to be attributed to each groups respective intervention. Methodological validity is assessed against a number of factors including: clearly defined research question; randomisation of participants; stratification, where appropriate; blinding of participants and research staff; appropriate sample size; and, completeness in terms of reporting the outcome from every trial participant who commenced the study (Akobeng, 2005).

Paradoxically the precise elements that give clinical trials their validity also provide the greatest challenges in terms of cost, inefficiencies, participant recruitment/compliance, and the ability to replicate ‘real life’ situations (Verhagen and Van Mechelen, 2010).

2.2.3 Cohort Studies

Prospective and retrospective cohort studies are observational studies, which follow participants over time to observe what is naturally occurring. In the sporting context, they monitor the occurrence of injuries amongst athletes whose exposure may vary across time.

Retrospective studies consider historical exposures, identifying a group of individuals and then looking back in time to record injury data. However, this reliance on existing data, which was typically not designed to answer any specific research question, means that retrospective studies are susceptible to bias (e.g. selection and/or misclassification bias) and thus considered less reliable than prospective studies (Hägglund et al., 2005). In addition, Junge and Dvorak (2000) found almost two-thirds of injuries were not recalled by players when comparing data collected weekly from the team medic versus a retrospective questionnaire completed by players at the end of season.

In contrast, prospective studies follow a group of individuals over a period of time exposed to a specific ‘condition’ (e.g., rugby training and match play) and record in real time how the condition affects an outcome (e.g., injuries). The prospective nature of these studies generally provides investigators with greater control over the data collection process and, as a consequence, there is potential to collect more detailed information on
exposure, confounders and outcomes from the participants and data collectors (Aschengrau and Seage, 2008). The disadvantage of prospective cohort studies is the time required, and therefore potentially the associated cost, for their completion.

2.2.4 Data Collection Methods

There are numerous different methods of collecting both injury and exposure data. For example, they can emanate from the participant themselves, from their medical records or from the medics who regularly work with the team. The data can be collected through self-reporting via Short Message Service (SMS) or online systems, through interviews, video analysis, or simply through the completion of agreed or validated injury collection questionnaires. Each method has specific strengths and weaknesses, some of which may also depend on the participants being studied (i.e. whether a medic is available, funding for online or SMS systems, access to participants historical medical records).

The participant (or player) may be considered to be the best source of information regarding whether or not they have sustained an injury (Junge et al., 2004b) with technological advances such as SMS text messaging, smartphone applications and web based surveys enabling researchers to more easily capture injury data from large samples. Although these more modern methods are continually evolving there are some potential issues, including the privacy of electronic records and the potential costs associated with the software, its development or its operation (i.e. costs associated with sending text messages). Indeed, an injury surveillance study utilising text messaging in elite female soccer, required a minimum of three text messages to be sent to each of the 228 participants, every week during the 7 month study, with each participant bearing the cost associated with each reply; furthermore, for each injury that was declared researchers were subsequently required to spend time contacting the respective players by telephone to ascertain the details of the injury (Nilstad et al., 2012). Whether technological or more traditional methods (e.g. simple questionnaires) are adopted there is evidence that suggests there is a risk to the reliability and detail gleamed from self-reporting (Øyen et al., 2009, Baker et al., 2010, Twellaar et al., 1996).
An alternative method of recording injuries is to identify them using video analysis, but this method has its own limitations (Junge and Dvorak, 2000) with Andersen et al (2004) able to identify only 50% of acute injuries from video compared with those reported in the same match by medical staff. In addition, video analysis will not capture those injuries that are reported after the match and those of a gradual onset.

Meeuwisse & Love (1997) suggested that an ideal system employs data collected by the team medics who work with a team on a regular basis. The advantage of this method is that the medic is able to provide a specific diagnosis, details of treatment and, if pitch-side, is able to provide an objective view on how the injury was sustained (Junge et al., 2004b). Adopted within a broad range of sports, the use of medical personnel has been found to be more reliable, firstly, in terms of the proportion of injuries reported (Bjørneboe et al., 2011) and perhaps also in terms of the accuracy of diagnosis. Indeed in a recent review of, worldwide on-going sports injury surveillance systems only 20% used non-medical personnel in the collection of their injury data (Ekegren et al., 2016). The system isn’t without its flaw’s, not least because it relies both on sports/clubs/individuals having access to medics and is dependant on players reporting all injuries to medical staff regardless of the consequences (i.e. missing significant matches) (Roderick et al., 2000).

The crucial factor when selecting which data method to employ is tailoring it to the environment and personnel in which it will be used (Bjørneboe et al., 2011). Given that the elite teams incorporated within this study are required to employ medical staff as part of their contract with the RFU and that full time medical staff work with the England Women’s teams, this study was able to adopt the data methods employed by some of the more recent large-scale sports injury surveillance studies (Junge et al., 2004b, Langevoort et al., 2007, Palmer-Green et al., 2013) in utilising these medical personnel.
2.2.5 Sample Size

The statistical power of a surveillance study is its ability to identify true associations between a risk factor and injury. Factors affecting the power of a study include: the strength of the relationship between the risk factor and the injury; the acceptable level of statistical significance; and, the frequency of the injuries (Bahr and Holme, 2003). It is generally accepted that an increase in the sample size will lead to increased power in the study (Whitley and Ball, 2002). For example, a methodological analysis by Brooks and Fuller (2006) reviewed the effect of increasing the number of rugby union clubs on the 95% CI of the incidence of match injuries; it highlighted that the likelihood of identifying significant differences between subgroups improved, as the size of the population increased and the CI decreased.

In the context of rugby, there are generally two methods by which increasing the sample size could be achieved: the first is to increase the number of participating clubs/squads; and the second is to extend the time period across which the data are collected. The first solution may be logistically difficult if not impossible to attempt where, for example, all the teams at a given playing level are already taking part in the study. The second solution, whilst achievable where the entire population is being studied, does have the disadvantage of being time consuming and potentially costly; it can, however, help combat the season-to-season variations in injury patterns that have been noted by some researchers (Gabbett, 2000, Gabbett, 2008, Phillips et al., 1998, Holder et al., 2002).

The disadvantage of extending the time-period, rather than increasing the number of participants, lies in the occurrence of repeated observations and thereby the amount of independence associated with recurrent injuries sustained by player. Although the proportion of injuries which are reported to be recurrent in nature appears to be fairly small (~12%), the severity of these injuries appears to be noticeably greater when compared with all new index injuries (Williams et al., 2013). A taxonomy for the identification and classification of recurrent injuries is still evolving, the intention is to enable researchers to fully explore the extent to which repeated observations or subsequent injuries are related to previous or index injuries (Finch and Cook, 2013).

2.2.6 Injury Definition
There is continued debate regarding both the most appropriate definition of an injury and how severe those injuries must be before the injury is reported as part of injury surveillance. In rugby union, the World Rugby (previously International Rugby Board) consensus statement’s definition is: “Any physical complaint, which was caused by a transfer of energy that exceeded the body’s ability to maintain its structural and/or functional integrity, that was sustained by a player during a rugby match or rugby training, irrespective of the need for medical attention or time-loss from rugby activities” (Fuller et al., 2007b).

The decision as to whether to collect information about injuries that result in time missed from training or playing (i.e., time-loss injuries) versus any injury that requires medical attention, but does not lead to any time away from training or playing (i.e., no-time-loss injuries) remains a topic of debate. The World Rugby consensus statement currently defines both medical attention and time-loss; however, it states the expectation that most studies will focus on time-loss injuries only due to the high number of minor contusions routinely encountered (Fuller et al., 2007b). Recording all injuries (both no-time-loss and time-loss) may more accurately reflect the true workload expected of medical practitioners (Gissane et al., 2012), but there is an additional burden placed on those collating the data when no-time-loss injuries are included (i.e., many more injuries to report). As a consequence, those without a vested interest and with limited resources may under-report this type of injury and therefore it is unsurprising that some researchers have noted that recording only time-loss injuries is likely to provide more accurate and reliable data (Orchard and Seward, 2002, Engebretsen and Bahr, 2009). The additional choice required when opting for a time-loss definition, is the period of time/activity, from which the player/participant must be absent, in order for the injury to be categorized ‘time-loss’ within the confines of the specific study e.g. missing >1 day (24 hours) of training/competition; missing ≥1 match; missing ≥7 days. Although a previous rugby union study reported only small differences between the incidence of injuries when a missed match definition was compared with a ≥7 days definition, it was acknowledged that this was unlikely to be the case where match schedules were irregular (i.e. not weekly) (Brooks and Fuller, 2006). Using missed match definitions also makes comparisons within and between sports more challenging where match schedules are not
comparable (Orchard and Hoskins, 2007).

In summary, there is a responsibility on those designing injury surveillance studies to maximise their scientific value by ensuring that the data collected are as robust and fit for purpose as possible. Where time and costs allow injury surveillance should be prospective and appropriately sized. The introduction and use of consensus statements, providing guidance on injury definition and study methodology, is intended to allow comparisons between difference cohorts by reducing or eliminating the problems and inconsistencies associated with injury surveillance (Orchard et al., 2005, Fuller et al., 2006, Fuller et al., 2007c).

2.3 Reporting Injury Data

2.3.1 Injury Incidence

Table 2.1 Variations in conclusions following different injury incidence reporting modes (adapted from Brooks & Fuller (2006))

<table>
<thead>
<tr>
<th>Reporting Format</th>
<th>Backs</th>
<th>Forwards</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injuries/1000 player hours</td>
<td>91 (84-97)</td>
<td>92 (86-98)</td>
<td>Probability of injury is the same for backs and forwards</td>
</tr>
<tr>
<td>Injuries/ 1000 Athletic Exposure</td>
<td>106 (98-114)</td>
<td>89 (83-95)</td>
<td>Results indicate that backs are significantly more likely to get injured than forwards.</td>
</tr>
</tbody>
</table>

The World Rugby Consensus statement favours the reporting of injuries based on 1000 player hours (Fuller et al., 2007b), as table 2.1 illustrates, even quite small variations in reporting formats (i.e. hours rather than athletic exposures) can quite substantially change the results yielded. Whilst this enables comparison of sports of varying duration, it could be considered less intuitive for those competing in or governing the sport. Consequently, an argument exists for reporting injury incidence rates in more than one way in order to take account for the idiosyncrasies of the sport concerned, for example rugby matches
routinely last 80 minutes so it may be useful to report injuries in terms of both 1000 match-hours and per match played.

Furthermore, when designing studies it is important to consider that injury definition and injury severity are frequently intertwined, and consequently to ensure that cross-study comparisons can be confidently made then consideration must be given to both. For example, Brooks & Fuller (2006) noted that a difference in injury definition according to the minimum severity could result in a very different overall severity picture being portrayed.

Table 2.2 Injury definitions and their effect on calculated mean severity values from the same rugby union injury dataset (adapted from Brooks & Fuller (2006))

<table>
<thead>
<tr>
<th>Definition of Injury</th>
<th>Mean Severity (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;1 days’ absence</td>
<td>18 (16, 20)</td>
</tr>
<tr>
<td>&gt; 2 days’ absence</td>
<td>20 (18, 21)</td>
</tr>
<tr>
<td>&gt;3 days’ absence</td>
<td>23 (20, 25)</td>
</tr>
<tr>
<td>≥ 7 days’ absence</td>
<td>33 (30, 35)</td>
</tr>
<tr>
<td>Missing ≥ 1 Match</td>
<td>35 (32, 39)</td>
</tr>
</tbody>
</table>

2.3.2 Injury Severity

Injury severity is important to consider when trying to identify the true magnitude of the injury problem within sports epidemiology studies (Brooks and Fuller, 2006), and where injury prevention is the priority, severity may assist with prioritising resources (Neville and Folland, 2009). It is generally accepted that the most appropriate measure of injury severity in sport is the length of time lost from competition or practice, measured in days (Nilstad et al., 2012), as it allows direct comparison of injuries within a study as well as more globally across all studies in which comparable methodologies have been adopted. Furthermore, measuring severity by length of time lost from competition or practice is less subjective than simply judging severity based on an injury diagnosis alone.
Alternative methods do exist and they include reporting injury severity by the financial cost (Van Mechelen, 1992) and proportion of the season missed (Quarrie et al., 2001).

Finally, when reporting injury severity, it must be remembered that mean severity values alone may not portray the entire story, as Fuller and colleagues (2012) found when comparing average severity figures for the 2007 and 2011 RWCs (15 days and 24 days respectively). They noted that a small number of high severity injuries skewed the 2011 RWC data, and for this reason the median is often considered a more appropriate summary statistic, which for the 2007 and 2011 RWCs was 7 and 8 days, respectively (Fuller et al., 2012). Consequently, it could be argued that both median and mean severity values should be reported, particularly when the overall number of injuries in a dataset is small.

2.3.3 Training and Match Data

When comparing match with training data in rugby union, the number of injuries and the amount of exposure time is vastly different (Holtzhausen et al., 2007, Brooks et al., 2005b, Brooks et al., 2005a, Kemp et al., 2012, Bird et al., 1998). For example, Brooks et al (2005a), investigating injury rates in the English Premiership, reported 1534 match injuries following 16,782 hours of match exposure compared with 395 training injuries which occurred during 196,409 hours of training exposure (Brooks et al., 2005a, Brooks et al., 2005b). Consequently, in this example if the injury data for both matches and training are combined (9 injuries per 1000 player hours) the incidence of match injuries (91/1000 player hours) is hidden, as is the relatively low incidence of training injuries (2/1000 player hours). Therefore, separate reporting of match and training injuries is recommended to aid generalisation and fairer evaluation. The substantially higher match injury incidence may lead to the conclusion that only match injury patterns need to be studied; however it is important to note that over 10 seasons of the English Professional Rugby Injury Surveillance Project, 20% of all injuries were sustained in training (Kemp et al., 2013). Given that the training environment is more controllable than the match environment, efforts to reduce injury burden from training activities may be one of the more straightforward routes to injury reduction.
In summary, the key message in terms of injury definition and injury reporting is consistency, as this provides a context in which to review the results, whether in terms of comparison with previous results or with results from other sports or activities. The advent of injury surveillance consensus statements has gone some way to ensure that there is a framework from which researchers should work, thus improving the likelihood that intra-sport comparisons can be made. Furthermore, with collaborations between sports, such as that seen with football and rugby (Fuller et al., 2007c), where consensus statements approve similar methodologies, opportunities to make inter-sport comparisons will also be enhanced into the future.

2.4 Match-related Injuries in Rugby Union

The physically demanding nature of rugby union is widely reported. If efforts to maintain and improve the safety of players is to be evidence based, systematic and consistent injury surveillance is required to inform decision makers. Whether it is to guide law changes, to clarify the interpretations of current laws, for injury prevention/ treatment or rehabilitation strategies, an understanding of the risk factors associated with the injuries sustained is essential. The value of injury surveillance is reliant upon consistent and systematic monitoring and reporting of injuries; consequently the emergence of the World Rugby approved consensus statement, for studies of injuries in rugby union (Fuller et al., 2007b), was an important step forward. The consistency gained by researchers adopting definitions and methodologies laid down in such consensus statements aids cross-study comparisons and wider generalisation.

2.4.1 Men’s Elite Rugby Union

There is a relative wealth of data pertaining to injuries in elite men’s rugby with papers published as far back as the 1950s (O’Connell, 1954). The game itself has changed greatly since these initial studies with the most notable change being the adoption of professionalism in 1995. Providing the early published data from the long-running RFU Premiership Injury Surveillance Project, Brooks and Fuller (2005a) reported that match
injury incidence was 91 injuries per 1000 player hours (95% CI: 87 to 96). Comparable data (i.e. injury resulting in more than 24 hrs time-loss/one day lost) from Southern Hemisphere competitions, provide similar incidence rates from the 2008 Super 14 Competition (96 injuries per 1000 player hours) and the Vodacom cup (71 injuries per 1000 player hours) (Fuller et al., 2009). Indeed, a meta-analysis of injuries in men’s elite professional rugby union reports a match injury incidence of 81 per 1000 player hours (95% CI 63-105) (Williams et al., 2013). In terms of International Rugby Union, the incidence figures from the Rugby World Cup (RWC) tournaments indicate a similar injury profile with 84 injuries per 1000 player hours noted at the 2007 RWC (Fuller et al., 2008), 89 injuries per 1000 player hours at the 2011 competition (Fuller et al., 2012) and 90 injuries per 1000 player hours at the 2015 competition (Fuller et al., 2017). However, injury rates for the Welsh Men’s International squad (199 Injuries per 1000 player hours; 95% CI 171-231) were found to be significantly greater, across a 3-year period, than has been reported in the multi-team RWC tournaments (Moore et al., 2015).

Mean injury severity figures for the English Premiership data range from 16 days to 27 days lost (2002/03 to 2011/12 seasons) (Kemp et al., 2013). Similarly, the average severity of injuries sustained by players competing in the Vodacom Cup was 21 days, however players competing in the 2008 Super 14 competition experienced, on average, 13 days absence from training/playing with each injury (Fuller et al., 2009). The meta-analysis described above reported a mean severity for match injuries of 20 days (95% CI 14-27) (Williams et al., 2013). The mean severity of injuries reported from the 2007 and 2011 RWC tournaments were, 15 days (median = 6 days) 24 days (median = 7 days) and 30 days (median = 8 days) respectively, with a small number of high severity injuries reported to be responsible for upward trend in means between 2007 and 2015 (Fuller et al., 2008, Fuller et al., 2012, Fuller et al., 2017)). In contrast to the higher incidence noted in the Welsh Men’s International squad, both the mean (18 days) and median severity (8 days) of injuries, sustained by this cohort across the 3-year period, was similar to that reported at the 2007 and 2011 RWCs (Moore et al., 2015).

The product of injury incidence and mean injury severity, referred to variously as “injury burden”, “injury risk” or “absolute risk” (Fuller et al., 2007a), gives an estimate of the overall cost of injuries to a club in terms of days absence resulting from a given period of
exposure. For example, Brooks and Kemp (2011) observed time-loss injuries occurring to professional rugby players in the English premiership and reported that injury burden for forwards was 1569 days absence per 1000 player-hours with similar figures for backs of 1507 days absence per 1000 player-hours. In simplistic terms, these figures equate to each premiership team losing a forward for 17 days following every match and losing a back for 14 days every match.

The contact nature of rugby is highlighted by the finding that 456 contact events occur per game in elite level rugby (Fuller et al., 2007a). These events include tackling, being tackled, mauls, rucks, collisions, lineouts and scrums (Fuller et al., 2007a), and when grouped together these events are responsible for approximately 80% of injuries sustained during a rugby match (Williams et al., 2013). Individually, being tackled was found by Williams and colleagues to be associated with more injuries than any other event with an incidence figure of 29 per 1000 player hours, this was closely followed by tackling and the ruck/maul (17 and 19 per 1000 player hours, respectively) before a drop in incidence rates was noted for collisions, scrums, other contact events and lineouts (11, 7, 6 & 1 per 1000 player hours, respectively) (Williams et al., 2013).

The tackle event is consistently reported to be responsible for the highest number of injuries in rugby union. There are, however, reported to be 221 tackle events per game and thus it could be argued that the high number of injuries are purely symptomatic of the number of events occurring (Fuller et al., 2007a). Reporting propensity for injury, therefore, provides some perspective as it enables the comparison of incidence rates and severity relative to the number of events. For example, Fuller et al. (2007a) reported that the tackle produced an injury propensity (risk of injury per event) of 6.1 injuries per 1000 events, however the scrum (not collapsed) had a higher propensity to cause injury with a reported rate of 9.0 injuries per 1000 events. Reporting injury propensity is useful when considering where to target injury prevention strategies since it identifies the risk per individual event.

The body region sustaining the greatest number of injuries is consistently found to be the lower limbs (Fuller et al., 2009, Brooks et al., 2005a), and figure 2.2 shows the injury incidence for this region of the body to range from 42 to 55 injuries per 1000 player hours (Fuller et al., 2017, Williams et al., 2013, Fuller et al., 2009, Brooks et al., 2005a).
Williams et al. (Williams et al., 2013) collating epidemiological data across the senior men’s professional game found that the lower limb (47 injuries per 1000 player hours; 95% CI: 26-84) was significantly more likely to sustain an injury than the upper limb (14; CI: 8-25), head (13; CI: 7-23), and trunk (9; CI: 5-16).

**Upper Limb**
- RWC 2015 = 23
- RWC 2011 = 17
- RWC 2007 = 17
- Super 14s = 21
- Vodacom Cup = 24
- RFU Premiership (2002-04)= 9

**Lower Limb**
- RWC 2015 = 55
- RWC 2011 = 42
- RWC 2007 = 46
- Super 14s = 49
- Vodacom Cup = 52

**Head/Neck**
- RWC 2015 = 12
- RWC 2011 = 16
- Vodacom Cup = 18
- RWC 2007 = 9
- Super 14s = 21
- RFU Premiership (2002-04)=

**Trunk**
- RWC 2015 = 10
- RWC 2011 = 10
- RWC 2007 = 11
- Super 14s = 10
- Vodacom Cup = 7
- RFU Premiership = 9

**Note:** RWC - Rugby World Cup; RFU – Rugby Football Union

Figure 2-2 Injury incidence by body region for men’s elite rugby (Fuller et al., 2017, Fuller et al., 2009, Fuller et al., 2008, Fuller et al., 2012, Brooks et al., 2005a).

2.4.2 Men’s Community Rugby Union

‘Community’ rugby refers to the non-elite level of the game, usually at least one level below a country’s top tier of club rugby and played in the most part by an amateur player population. Surprisingly, despite the vast majority of the world’s playing population competing at community level, there is currently limited injury epidemiology information from this large subset of the rugby population. Community rugby is more difficult to
study than the elite game, due mainly to the amateur nature of the players and typically less interaction between players and coaching/medical staff. Nevertheless, it is important to establish whether differences exist between the elite and community game in order to determine whether it is appropriate to transfer injury surveillance findings and injury prevention messages from the elite to the community game.

The range of published incidence rates for time-loss injuries recorded in the community rugby population is 14 to 45 per 1000 player hours, but as can be seen in Table 2.3 the injury definitions vary greatly (Roberts et al., 2013, Schneiders et al., 2009, Garraway and Macleod, 1995, Hughes and Fricker, 1994). Despite this, the values reported using equivalent definitions are lower than those reported for the professional game, which is not unexpected as the intensity of play is likely to be very different between the populations. Importantly, this is not solely seen when comparing amateur with professional levels as it is also evident between levels of community rugby, with a greater incidence of time-loss injuries noted at higher than lower levels of community rugby (figure 2.3) (Bird et al., 1998, Roberts et al., 2013).

![English RFU Rugby Levels](image)

**English RFU Rugby Levels**

- Group A: Semi-Professional
- Group B: Amateur
- Group C: Recreational / Social

*Note: Injury Definition was ≥8days lost from match play or training.*

**Figure 2.3** Recorded Injury incidence recorded for players competing at 3 different levels of English community rugby across three seasons (2009-2012), adapted from Roberts (Roberts et al., 2013).
Although the financial cost to the team of losing players may be negligible at community level, there remains a health and potentially economic cost to the individual which should not be overlooked. Unfortunately, inconsistent reporting methods for severity within the community rugby literature prevents easy comparisons between studies. The most recent literature by Roberts and colleagues (Roberts et al., 2013), measuring injuries resulting in ≥8 days time-loss from participation, reports that community players miss on average 8 weeks of rugby match-play per injury. In a small proportion of these injuries the absence may also correspond with absence from employment which potentially has a cost for the individual, the employer and health providers.

In terms of the body region injured, the lower limb has been reported to account for between 35 and 48% of all injuries at this playing level (Chalmers et al., 2012, Hughes and Fricker, 1994, Bird et al., 1998, Schneiders et al., 2009). Whilst the head is often reported to sustain a relatively high number of injuries (Hughes and Fricker, 1994, Bird et al., 1998, Schneiders et al., 2009), Schneiders and co-workers (2009) noted that injuries to this site mainly comprised medical attention injuries (e.g. cuts and lacerations) for which the player was minimally absent. However, there is evidence that more serious injuries to the head, in the form of concussion, have previously been under-reported (Fraas et al., 2014); this might be in part due to a mandatory three week removal from play if a concussion was suspected or diagnosed prior to May 2011 that required players to be removed from play for three weeks (Marshall and Spencer, 2001). Changes to concussion management now allows adult players to return to play after as little as 19 days. The players must be managed by an appropriate medical practitioner and complete a graduated return to play protocol. Where players are managed in an enhanced care setting e.g. professional clubs, the minimum return to play period is just 6 days, but only where the players’ return is closely supervised by a doctor competent in the management of concussion/traumatic brain injury. (RFU, 2016)

Consistent with the elite game is that contact between players results in the greatest number of injuries in community rugby with the tackle cited as the most common injury-causing event, accounting for between 40 and 59% of all injuries followed by injuries associated with rucks & mauls (29-30%) (Bird et al., 1998, Hughes and Fricker, 1994, Schneiders et al., 2009). Interestingly, Schneiders et al (2009) reported that tackling (29%) resulted in a greater number of injuries than being tackled (19%) whereas Roberts
et al. reported results more consistent with the elite game and found the reverse, with the ball carrier sustaining significantly more injuries than the tackler, 28% versus 22%, respectively (Roberts et al., 2013).

**Figure 2.4** Injury Proportion by body region for community level men’s rugby
Table 2.3  Incidence and severity in community rugby literature

<table>
<thead>
<tr>
<th>Author</th>
<th>Injury Definition</th>
<th>Injury Incidence (using published data)</th>
<th>Time-Loss Injury Incidence (&gt;24 hours) Injuries per 1000 player hours (*recalculated where required)</th>
<th>Injury Severity Outcome</th>
<th>Injury Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hughes and Fricker (1994)</td>
<td>Medical Attention Only and Time-Loss Injuries</td>
<td>1 injury per 16.7 player-games (time loss only)</td>
<td>unable to recalculate for &gt; 24 hr time-loss only</td>
<td>No. of days lost: Minor ≤ 1 week Intermediate = 1 to 3 weeks Serious &gt; 3 weeks</td>
<td>% of Injuries classified as: Minor = 59% Intermediate = 29% Serious = 13%</td>
</tr>
<tr>
<td>Garraway and Macleod (1995)</td>
<td>Included injuries &lt;24 hours in duration</td>
<td>14 injuries per 1000 player hours</td>
<td>unable to recalculate for &gt; 24 hr time-loss only</td>
<td>Transient - &lt;7 days Mild - &lt;28 days Moderate – 29-84 days Severe - &gt;84 days</td>
<td>Transient = 22% Mild = 38% Moderate = 24% Severe = 16%</td>
</tr>
<tr>
<td>Bird et al. (1998)</td>
<td>Medical Attention Only and Time-Loss Injuries</td>
<td>9.9 injuries per 100 player games (time loss only)</td>
<td>unable to recalculate for &gt; 24 hr time-loss only</td>
<td>Not reported</td>
<td>Not reported</td>
</tr>
<tr>
<td>Schneiders et al. (2009)</td>
<td>Medical Attention Only and Time-Loss Injuries</td>
<td>52 injuries per 1000 player hours</td>
<td>34*</td>
<td>No. of days lost: Slight - 0-1 days Minimal - 2-3 days Mild - 4-7 days Moderate - 8-28 days Severe - &gt;28 days</td>
<td>% of Injuries classified as: Slight = 35% Mild = 17% Moderate = 30% Severe = 7% Season Ending = 8% Career Ending = 4%</td>
</tr>
</tbody>
</table>
Incidence rates for RFU levels 9-3 ranged from 14.2 to 21.7 injuries per 1000 player hours based on ≥ 8 days time-loss.

<table>
<thead>
<tr>
<th>Roberts et al. (2013)</th>
<th>Time-Loss Injuries &gt;7 days</th>
<th>16.9 per 1000 player hours$</th>
<th>unable to recalculate for &gt;24 hr time-loss only</th>
<th>Mean no. of matches missed</th>
<th>6.6 per injury</th>
</tr>
</thead>
</table>

$Incidence rates for RFU levels 9-3 ranged from 14.2 to 21.7 injuries per 1000 player hours based on ≥ 8 days time-loss.
2.4.3 Youth Rugby Union

Participation in rugby at youth level is increasingly popular both within developed nations, such as the UK (RFU, 2012), and developing rugby nations such as the USA (Chadwick et al., 2011). Played at grass-roots level through to international tournaments, introducing young people to a contact sport such as rugby requires careful management. Individual national governing bodies have developed and oversee various youth development programmes and have responsibility for safeguarding the welfare of their participants. Indeed, in the majority of major rugby playing nations there are age-specific conditions or variations in laws under which young players compete.

Importantly, the risk of injury is reported to be higher for young people who have advanced to a higher level within their sport compared with their less experienced peers; moreover, those injuries may have a detrimental effect on the bone health of these young athletes, who may experience problems such as bone length discrepancies or altered joint mechanics (Caine et al., 2006). If this is considered in respect of the risk of injury associated with rugby itself, then particular interest in this playing group must be taken. There is currently a broad array of injury surveillance literature concentrating on youth rugby, unfortunately there is very little consistency in terms of the injury definitions and data collection methods used and consequently it is difficult to make meaningful comparisons (Bleakley et al., 2011).

Concentrating on those studies that have reported injury incidence rates for time-loss injuries sustained throughout the season (i.e. not during an International tournament), the incidence values range from 16 to 49 injuries per 1000 player hours (Table 4) (Palmer-Green et al., 2013, Kerr et al., 2008, Haseler et al., 2010). Although injury definitions used are similar, there are a number of contextual differences between the youth rugby studies that might in part explain the variation in injury incidence figures. Although it is difficult to quantify the effects of some factors on outcome measures e.g environmental conditions, there are factors that can and have been analysed e.g. standard of play and the use of non-medically qualified personnel (Schiff et al., 2010). Indeed, injury data from the Junior Rugby World (JRW) tournaments has shown that the higher standard of play associated with the tier one JRW Championship has resulted in a significantly higher injury incidence than that reported from the tier two JRW Trophy tournament (Fuller and
Taylor, 2012b). Another consideration, must also be the age of the players, as it has been found that the risk of injury increases with age through youth rugby, with Haseler et al. (2010) reporting an injury incidence of 6/1000 player hours for under 10s and 49/1000 player hours for the under 17s age group.

Injury severity is not routinely reported in all of the available youth rugby literature (Bird et al., 1998, Junge et al., 2004a, Brown et al., 2012) but where it is reported, the range for mean severity for each injury varies from 26 days through to 54 days absence from matches and/or training (Palmer-Green et al., 2013, Haseler et al., 2010, Fuller and Taylor, 2012b). However, this does include injuries sustained both in tournament and non-tournament play.

As with both elite and community level senior rugby, the tackle is the most common match event associated with injury in the youth game (Garraway et al., 1999, Kerr et al., 2008, Collins et al., 2008, Palmer-Green et al., 2013), with between 50% and 58% of all injuries occurring in the tackle (Fuller and Taylor, 2012b, Palmer-Green et al., 2013, Haseler et al., 2010). There does not, however, appear to be a consensus when reviewing which body region has the highest incidence of injury; Palmer-Green et al (2013) reported that the lower limb was the region sustaining the greatest number of injuries at both school and academy levels, whereas Haseler et al (2010) observed that the upper limb sustained marginally more injuries than the lower limb region. This is an area that needs further investigation to inform comprehensive injury reduction strategies.
<table>
<thead>
<tr>
<th>Author</th>
<th>Injury Definition</th>
<th>Age Range</th>
<th>Collection Method</th>
<th>Injury Incidence Time-loss Injuries (per 1000 player hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerr et al (2008)</td>
<td>Requiring medical attention. Resulting in any restriction of the player’s participation for ≥ 1 day beyond the injury event.</td>
<td>USA collegiate ~17-21 Yrs</td>
<td>medics/ team coaches/ identified player</td>
<td>16*</td>
</tr>
<tr>
<td>Brown et al (2012)</td>
<td>Time-loss Injuries – absence from more than one match in tournament or one day of normal/planned activity after the tournament.</td>
<td>U16 (South Africa - Tournament)</td>
<td>team reported to tournament medic</td>
<td>20</td>
</tr>
<tr>
<td>Brown et al (2012)</td>
<td></td>
<td>U18 – Academy (South Africa - Tournament)</td>
<td>team reported to tournament medic</td>
<td>25</td>
</tr>
<tr>
<td>Brown et al (2012)</td>
<td></td>
<td>U18 (Craven) (South Africa - Tournament)</td>
<td>team reported to tournament medic</td>
<td>29</td>
</tr>
<tr>
<td>Fuller &amp; Taylor (2012a)</td>
<td>IRB Consensus statement definition – Time-loss injuries (≥ 24 hrs absence)</td>
<td>U20 Tier 1 nations (International Tournament)</td>
<td>Team medic</td>
<td>47 to 87%</td>
</tr>
<tr>
<td>Fuller &amp; Taylor (2012b)</td>
<td>U20 Tier 2 nations (International Tournament)</td>
<td>Team medic</td>
<td>20 to 50(^\text{g})</td>
<td></td>
</tr>
</tbody>
</table>

* Re-calculated to report time-loss incidence rate only.  
\(^{g}\) Range of injury incidence rates observed from 2008-2012.
2.4.4 Women’s Rugby Union

There are reports of women having played rugby as far back as the First World War, although the first women’s Rugby World Cup, hosted by Wales, was not held until 1991. It is estimated that 1.7 million women worldwide play rugby union in one of the formats (World Rugby, 2015), with both international and national competitions held routinely.

Despite the growth in the women’s game, relatively little evidence is available from this population as to the incidence, causes or severity of injuries sustained during match play or practice. Indeed, a search of current literature yields only seven injury surveillance papers examining the incidence of injuries in the women’s game (Carson et al., 1999a, Taylor et al., 2011a, Doyle and George, 2004, Kerr et al., 2008, Bird et al., 1998, Schick et al., 2008 and Peck et al. 2013). Unfortunately, similar to other populations, the ability to generalise and make cross-study comparisons is restricted due to the variability in the methodologies adopted within these papers. Table 2.5 details the variations both in terms of the competitive level, injury definition and methodology for women’s rugby injury surveillance studies.

The incidence rate for injuries sustained in women’s rugby ranges from 16 to 38 injuries per 1000 player-match-hours, in studies adopting the injury definitions and data collection procedures detailed in the 2007 rugby union consensus statement (Fuller et al., 2007c); this is lower than elite men’s rugby but is very similar to the range for both community men’s and youth rugby (Kerr et al., 2008, Taylor et al., 2011a). The only reported mean severity of injuries within the women’s game is 55 days per injury sustained, based on injuries sustained at the 2010 Women’s RWC (Taylor et al., 2011a). Unfortunately, other studies have not reported mean injury severity with many not reporting severity at all (Table 2.5). Women’s rugby remains, for the most part, amateur and consequently the level of medical cover and rehabilitation opportunities may hamper the time it takes a player to return to play. Thus it is perhaps not a surprise that the mean severity of injuries (55 days; 95% CI: 24.1–85.9) reported for the 2010 women’s RWC was significantly higher than that reported for the 2007 men’s RWC (15 days; 95% CI: 11.7-17.7) (Taylor et al., 2011a, Fuller et al., 2008).
Similar to the men’s game, the tackle is responsible for the greatest proportion of injuries with figures ranging from 38% to 66% (Kerr et al., 2008, Taylor et al., 2011a, Schick et al., 2008). For those studies that categorised the tackle event further, being tackled (33%, 33%, 36% respectively) accounted for proportionally more injuries compared with tackling (21%, 5%, 21%, respectively) (Schick et al., 2008, Kerr et al., 2008, Taylor et al., 2011a). Further description of injury causation was limited in the remaining women’s rugby literature.

The lower limbs were again identified as the region of the body sustaining the greatest number of injuries with a range from 41% to 67% (Kerr et al., 2008, Carson et al., 1999a, Bird et al., 1998, Schick et al., 2008, Taylor et al., 2011a, Doyle and George, 2004); however caution must be taken when comparing these figures, due to the variations in: injury definition, environment (season long studies versus tournament conditions) and the level of play (collegiate, school, International).
<table>
<thead>
<tr>
<th>Author</th>
<th>Competitive Level</th>
<th>Injury Definition</th>
<th>Incidence</th>
<th>Time-Loss Injury Incidence (&gt;24 hours) plus only</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bird et al. (1998)</td>
<td>Community/School</td>
<td>Medical Attention or causing the player to miss at least one schedule match or practice.</td>
<td>6.1 per 100 player-game hours</td>
<td>Unable to recalculate for &gt;24 hr time-loss only</td>
<td>% of Injuries per severity AIS* category:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>AIS-1 – minor = 76.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>AIS-2 – moderate = 22.8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>AIS-3 – serious = 0.5%</td>
</tr>
<tr>
<td>Carson et al. (1999a)</td>
<td>National and Regional (Canadian)</td>
<td>Rugby-related event that kept a player out of practice or competition for &gt; 24hrs or required attention of a physician.</td>
<td>21 per 1000 player-game hours</td>
<td></td>
<td>% of Injuries per severity category:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NTO = 4%; 1 day = 7.2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2-3 days = 17.1% 4-7 days = 20.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt;7days = 51%</td>
</tr>
<tr>
<td>Doyle &amp; George (2004)</td>
<td>National (England)</td>
<td>Rugby-related event that kept a player out of practice or competition for &gt; 24hrs or required attention of a physician.</td>
<td>3.6 per 1000 playing hours</td>
<td></td>
<td>% of Injuries per severity category:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;1 week – 43% 1-3 weeks – 20%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt;3 weeks – 37%</td>
</tr>
<tr>
<td>Kerr et al (2008)</td>
<td>Collegiate</td>
<td>Requiring medical attention. Resulting in any restriction of the player’s participation for ≥ 1 day beyond the injury event.</td>
<td>17.1 per 1000 player-game hours</td>
<td></td>
<td>% of Injuries per severity category:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No time loss – 11%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 week absence – 37%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 week absence – 7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt;2 week absence – 44%</td>
</tr>
<tr>
<td>Study</td>
<td>Setting</td>
<td>Definition</td>
<td>Incidence Rate</td>
<td>Severity</td>
<td>Notes</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------</td>
<td>----------------------------------------------------------------------------</td>
<td>----------------</td>
<td>----------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>Schick et al (2008)</td>
<td>World Cup</td>
<td>IRB Consensus statement definition – Time-loss injuries (≥ 24 hrs absence)</td>
<td>37.5 per 1000 player-game hours</td>
<td>37.5</td>
<td>Severity not reported due to incomplete data.</td>
</tr>
<tr>
<td>Taylor et al (2011a)</td>
<td>World Cup</td>
<td>IRB Consensus statement definition – Time-loss injuries (≥ 24 hrs absence)</td>
<td>35.5 per 1000 player-game hours</td>
<td>35.5</td>
<td>No. of days lost from play: Mean = 55 days per injury Median = 9 days per injury</td>
</tr>
<tr>
<td>Peck et al (2013)</td>
<td>Military Collegiate</td>
<td>Any new event occurring during rugby practice or match requiring medical attention.</td>
<td>29.1 per 10,000 Athletic Exposures</td>
<td>unable to recalculate for &gt;24 hr time-loss only</td>
<td>Severity not reported</td>
</tr>
</tbody>
</table>

*AIS – Abbreviated Injury Scale*
Rugby Union is a sport played worldwide by a diverse population of men, women and youth players. Injury definitions, reporting measures, and general methodologies vary greatly across the existing rugby injury surveillance literature making cross-study comparisons difficult to perform. The publication of the consensus statement for the collection of injury data in Rugby Union goes some way to alleviate some of these challenges in terms of comparability in the future, although comparisons with past studies may remain challenging. Importantly, the injury surveillance process is not static, and as the game/population evolves so should the definitions/methodologies used for injury surveillance, and thus regular reviews of the consensus statement would be prudent.

Rugby Union is played at varying levels from amateur through to fully professional. The injury incidence varies greatly between playing levels with the highest reported in elite men’s game and the lowest reported in the women’s game. Figure 6 provides a graphical illustration of the ranges that have been observed in each of the different rugby playing populations. In the youth population, the risk of injury increases with age (Haseler et al., 2010) and with the level of rugby being played (Palmer-Green et al., 2013). Although the incidence of injuries are important, the severity of injuries, or the time a player is unable to play or fully train, also has a large impact on the individual and indeed the club. Whilst the incidence of injuries increases at higher playing levels it appears that severity increases as the playing level decreases, which may be indicative of a number of factors including the amount of medical support, time given to rehabilitation, player & club priorities. Disappointingly, despite the importance of severity in terms of determining the true magnitude of the injury problem for both the sport and the individual, there remains a gap in the literature for consistent cross-study comparisons.
A consistent finding across the entire rugby-playing spectrum is that contact mechanisms, and specifically the tackle, account for the greatest number of injuries, with ‘being tackled’ commonly associated with the greatest number of injuries. Interestingly, when injury risk per event is considered in elite men’s rugby, the scrum has a higher propensity to cause injury than the tackle (Fuller et al., 2007a), highlighting the importance of providing context to all injury surveillance data collected. While strategies can be put in place in an attempt to minimise the number/severity of injuries in rugby union, the game remains a high intensity full contact sport and as such injuries are unlikely to be eradicated. Consequently, it is crucial to develop an accurate picture of those areas where injury prevention, rule changes/reinforcement and/or coaching can have an impact to maximise approaches to injury reduction and enhance the welfare of players.

Note: The data is for injuries sustained across at least one season (i.e. not purely during a tournament) and the injury definition used is that of time-loss with >24 hours lost from training or match play.

Figure 2.5 Comparison of the range of Incidence rates recorded across the rugby playing population.

2.4.6 Conclusion
2.5 Injuries in Women’s Sport and Military Physical Training

There is conflicting evidence as to whether women, are generally, at greater or lesser risk of sustaining an injury than their male counterparts (Deitch et al., 2006, Langevoort et al., 2007, Arendt and Dick, 1995); but the weight of evidence for women being at higher risk of more specific injuries such as Anterior Cruciate Ligament (ACL) injuries is certainly available (Arendt and Dick, 1995, Deitch et al., 2006, Myklebust et al., 1998). More recently there has been a growing body of evidence in respect to sex differences in reported concussion injury rates and the resultant time-loss from participation.

2.5.1 ACL Injuries

In the fast and aggressive game of basketball a retrospective review of injury data collected across six seasons reported that the incidence of injury for women competing in the National Basketball Association league was significantly higher than their male counterparts (19.3 versus 14.6 per 1000 Athletic Exposures, respectively). More specifically, the researchers identified that women included within the study, sustained four-fold more ACL injuries than their male counterparts when normalised for exposure. (Deitch et al., 2006)

In contrast, female participants of handball, observed across three international tournaments, were reported to sustain injuries at a rate of 19 injuries per 1000 player hours, which was calculated to be significantly lower than their male counterparts (34 injuries per 1000 player hours) (Langevoort et al., 2007). Similar to the observations noted above for basketball players, female competitors in handball sustain five-fold more ACL injuries than male competitors (Myklebust et al., 1998).

The reports from soccer are again different, with women found to sustain injuries at a similar rate to their male counterparts (Ristolainen et al., 2010, Junge et al., 2004b, Junge and Dvorak, 2007, Ekstrand et al., 2006) and whilst the dominant affected body region for both sexes is to the lower extremities (Tegnander et al., 2008, Junge et al., 2004b, Hartmut et al., 2010), female football players sustain a significantly greater number of ACL injuries than men (0.31 versus 0.13 per 1000 athletic-exposures, respectively)(Arendt and Dick, 1995).
The proposed reasons for the increased risk of ACL injury in women is likely to be multifactorial with differences including: anatomical make-up, neuromuscular components, hormone levels and fatigue all possible explanations. Anatomically females when compared to males have wider pelvis breadth, smaller ACL (length & X-Section) and increased general joint laxity which affects movement and loading patterns within the lower extremities and thus places additional stress on tendons and ligaments (Krosshaug et al., 2005).

From a neuromuscular perspective, much of the discussion in respect of sex differences surrounds the timing and strength of muscle activation by female athletes (Myer et al., 2005), with researchers suggesting that women have a higher risk of ACL injury due to their inability to adequately balance muscle recruitment during landing activities (Hewett et al., 2005).

Fatigue also alters lower limb biomechanical and neuromuscular factors that are suggested to increase ACL injury. Results following military recruits during a 12 week initial training programme found that women worked at a significantly greater percentage of their heart rate reserve (HRR) than the men within their platoon. Furthermore, it was noted that the men in the mixed platoon worked at a substantially lower percentage of their HRR compared to the men training in the single sex platoon (Blacker et al., 2009). The risk of operating at high rather than low levels of HRR has been found to be an increase in cardio-vascular strain which in turn leads to fatigue (Aåstrand, 1956). Consequently, women may be at greater risk of ACL injury simply through fatiguing more quickly than their male counterparts, when competing at the same standard or level of play (e.g. International, Colligate, premiership). The relationship between ACL injuries and fatigues is not yet proven, further research is required.

Hormones have also been implicated in the reason for the increased risk of ACL injuries. The pre-ovulatory phase (rather than the post-ovulatory phase) and the monthly variations in sex steroid hormones (estrogen, relaxin) continues to be the focus of much injury risk factor research (Shultz et al., 2012). There is evidence that elevated levels of both relaxin (Dragoo et al., 2011) and estrogen (Silvers and Mandelbaum, 2007) are likely to increase
the risk of ACL injury in females but what has not been established is the phase of the menstrual cycle in which women are most susceptible to this increased risk of injury (Vescovi, 2011).

2.5.2 Concussion

There is a growing body of evidence from a variety of sex-comparable sports that women have a greater incidence of reported concussion than their male counterparts. Covassin (2016) reported that female basketball (4.7 /1000 athlete exposures) and soccer players (6.5 /1000 athlete exposures) had a concussion incidence, of 1.5 times greater than that of their male counterparts (3.3 and 4.2 /1000 athlete exposures, respectively). They also noted that the incidence of reported concussion, in female softball players was 1.95 times that of male baseball players (2.3 and 1.2 /1000 athlete exposures, respectively). Whilst, there is evidence that the difference in incidence between sexes may emanate simply from females being more honest in reporting symptoms (Dick, 2009) than their male counterparts who may underreport their symptoms (Covassin et al., 2016). There is also evidence of physiological variances, which may contribute to the aforementioned sex differences including: biomechanical difference in head and neck mechanics and hormone levels.

In terms of head and neck mechanics, there is evidence that females display significantly greater head-neck segment peak angular acceleration compared with males; this is despite initiating muscle activity earlier and using a greater percentage of their maximum head-neck segment muscle activity (Tierney et al. 2005). Tierney et al. (2005) suggests that the reason for this greater head-neck acceleration, in females, may be related to their lower levels of strength, neck-girth and head mass; indeed in their study, they reported that females displayed 29% less head-neck stiffness and 50% lower isometric strength compared with male subjects. Given that Hrysomallis (2016) reported that initial investigations suggested that isometric neck strength was directly related to both neck injuries and concussion risk in sport, the comparatively lesser isometric neck strength in women, may in part explain why they are at greater risk of concussion injuries than their male counterparts.
An additional consideration is the physiological effect of hormones, with evidence suggesting that sex hormones such as progesterone may be a contributory factor in the difference observed in the incidence and severity of concussions in men and women (Covassin et al., 2016). The ‘withdrawal hypothesis’ as described by Wunderle (2014) proposes that the difference in symptoms and outcomes, experienced by women compared to men, is due to falls in hormones specifically progesterone immediately following a concussion. The premise is, that following an injury to the brain or concussion, suppression of the Hypothalamus-pituitary glands-gonadal glands (HPG) occurs leading to a reduction in the concentration of a number of hormones; it is this withdrawal or abrupt reduction in progesterone which is believed to contribute or cause the poorer outcomes noted in pre-menopausal (and post-menarche) women (Bazarian et al., 2010). Further, studies utilising compatible methodologies are needed to investigate the full effect of these differences, as sample sizes are small, presentation is complex and evaluation tools are often subjective (Brook et al., 2016).

2.6 Illness in Rugby Union

The incidence of illness in female rugby players has not yet been reported, but evidence from multi-sport elite events suggests that females may be at higher risk of developing an illness compared with males (Palmer-Green and Elliott, 2015). Data collected on over 10,000 athletes, competing at the 2012 Summer Olympics, indicated that women were 60% more likely to sustain an illness than their male counterparts (Engebretsen et al., 2013); with results from a smaller data collection of Great Britain athletes at the 2014 winter Olympics also finding that women were more likely to incur illness (Palmer-Green and Elliott, 2015). In common with reports from other elite sporting events, respiratory infections were the most common time-loss and medical attention illness (Engebretsen et al., 2013, Palmer-Green and Elliott, 2015), with physical stress and dehydration of the airways cited as possibly contributory factors to this type of illness (Kippelen et al., 2012).

In terms of illness surveillance within men’s rugby, there are a small number of studies from which reference can be taken. One such study followed the Super 14 (now Super 15) Rugby Union contest across the 16-week competition period; recording both time-loss and medical attention illnesses, the incidence of illness for the sample of 259 elite
The unique characteristics of the super rugby tournament challenge the validity of generalising the results into the women’s game, with clubs: travelling nationally, internationally and intercontinentally; experiencing variable rest/preparation periods between matches; changing time zones; and, facing opponents of varying standard/difficulty. Data pertaining to illnesses sustained during European men’s competitions is currently unavailable (Cross, 2016), however given that it has yet to be determined whether comparisons can confidently be made between elite women’s rugby union and their male counterparts, it would seem sensible where practicable to incorporate sex specific illness surveillance into future longitudinal observation studies.

2.7 Physical Demands of Rugby Union

The characteristics of rugby union match-play, specifically the physical demands, may have a significant impact on injury risk (Read et al., 2017). Evidence from other sports, specifically cricket, rugby league and soccer, similarly identifies relationships between the demands of these respective sports and the risk of injury for its participants.

2.7.1 15-a-side Rugby

The physical demands of men’s elite club rugby were described in detail by Roberts et al. (2008). They reported that backs travelled, on average, 6127m (±724m) and forwards 5581m (±692m). Measuring both low intensity activities (walking, walking, jogging and medium-intensity running) and high intensity activities (HIA), which included high intensity running (>5m s⁻¹), sprinting and static exertion (scrummaging, rucking, mauling and tackling). Roberts et al. (2008) reported forwards performed more HIA than backs, which they attributed to more time spent in static exertion, whilst backs spent a greater amount of time performing high intensity running and covered greater distances walking. Demonstrating the highly intermittent nature of rugby union, the study highlighted the difference in physical demands between various playing positions, whilst also
stressing the importance, more generally of all players having the ability to accelerate and decelerate.

There is little literature pertaining to the physical demands of women’s rugby, however a comparison of physical and physiological differences between female and male rugby athletes found that men have greater speed, strength and power (Lakomy et al., 2000). These differences in performance could affect the shape of the women’s game (Virr et al., 2014) and consequently influence injury risk. Statistics from the 2014 European six-nations competition would support this assertion, with differences between the sexes in: the percentage of ball in play (men 10% > women); number of scrums (women 54% > men), rucks/mauls (men 20% > women) and kicks (men 44% > women); and the average number of passes per match (men 22%> women) (World Rugby, 2018).

2.7.2 Rugby Sevens

Rugby sevens is a condensed version of the 15-a-side game. Played on full-size pitches, 7 players compete 5-6 matches in a tournament format (2 or 3-day duration), with each of the matches consisting of two 7 minute halves. Principally, played under the same rules as the 15-a-side game, the intensity of tournament play coupled with fewer players, unsurprisingly ensures that the physical demands for rugby sevens players is very different (Vesconi and Goodale, 2015). In contrast to scientific literature relating to the women’s 15-a-side game, the announcement of the inclusion of rugby sevens as an Olympic Sport, in 2009, has led to an increasing amount of literature pertaining to women’s rugby 7’s (Clarke et al., 2017).

Clarke et al. (2017) compared the game demands of Australian International sevens squads (men and women) whilst competing in International World Series tournaments. The consistency in reporting and methodology, enables direct comparison between the women’s and men’s game, albeit the sample size is limited to just one squad from each sex. The results revealed that men cover greater distances across the course of the match (1249m ±348 v 1078m±197), achieve greater maximum speeds (8.7±0.99 v 8.05±0.55), cover greater sprint
distances \((223.2\pm104.7 \text{ v } 148.6\pm39.1)\) and sustain a significantly greater number of impacts \(>10\text{g} \ ((25\pm11.2 \text{ v } 12.6\pm4.7)).\) (Clarke et al., 2017)

The difference in physical demands are likely to be due to a multitude factors: anthropometric differences; longevity of professionalization within the sevens game; standard of opposition; exclusivity of players to one format of rugby union (women players often competing in 15-a-side and rugby sevens); variations in game tactics (Vescovi and Goodale, 2015; Clarke et al., 2017). These differences, despite the continued development of the women’s rugby sevens game, prevent confident generalisation of research findings between the sexes.

2.7.3 Summary

There is an increasing amount of scientific literature pertaining to the physical demands of men’s rugby union, with differences identified between senior and youth levels (Read et al., 2017), in addition to positional differences (e.g. backs v forwards) (Roberts et al., 2008). What remains unclear is the physical demands on female players competing in the 15-a-side game, compared to their male counterparts and therefore the consequences for injury risk and prevention. This further amplifies the requirement for sex-specific analysis of injury risk in rugby Union.

The women’s rugby sevens game is in a slightly different position in terms of quantity of sex specific research, largely due to its increased popularity following its inclusion in the Olympics (Clarke et al., 2017). The research, is however limited by the small squad sizes, which can realistically only be overcome by longitudinal studies of single squads or data collection from multi-teams within a tournament environment.

Irrespective of the data collection methodology, the current research confirms that there are clear differences between the sexes and between the two formats of the rugby union game (15-a-side and sevens). And consequently, supports the
need for sex and format (15-a-side and rugby sevens) specific research which can provide knowledge about injury risk to both these groups of players.

2.8 Research Rationale

This review of literature has highlighted the importance of undertaking injury prevention efforts for health, performance, financial and legal reasons. Despite the acknowledgement that injury surveillance is a crucial part of sports development and management, the review highlights the scarcity of published literature pertaining to women’s rugby union. Whilst also establishing the scientific basis for conducting sex specific research.

This first section of the review of literature, provides a summary of the principal literature relating to the discipline of sports injury surveillance and explores the value that injury surveillance plays in respect of injury prevention in sport. Furthermore, this chapter considers the myriad of choices available to researchers when designing their studies and the difficulty experienced, for those wishing to make comparisons between studies, when consistent approaches are not adapted. Acknowledging that the practical and financial restrictions on researchers executing viable and comparable injury surveillance is not insignificant; the importance of consistency in definitions and methodologies is however recognized as being essential and consequently the emergence of consensus statements is discussed in this chapter.

Focusing on the World Rugby consensus statement for reporting injury data in rugby union (Fuller et al., 2007c), the literature review discusses the rationale for the reporting of various types of injury data e.g. incidence, injury severity, injury burden, injury propensity. The complexities of deciding-upon definitions and methodologies are also highlighted, with examples of how the various elements such as injury definition and severity are intertwined. The importance of consistency is promoted throughout this chapter, as consistent collection and reporting of injury data enhances the opportunity to make inter-sport and intra-sport comparisons.

The literature review then proceeds to provide greater detail of match-related injuries sustained by rugby union players in: men’s elite, community and youth rugby union; in
addition to those reported from within women’s rugby union. Reviewing some of the key results from previous studies the injury incidence, injury severity, injury burden, common site of injuries and mechanisms by which the respective injuries occur, is discussed for each of the various populations. The key message is the diversity which is evident in both the quantity of research that has been reported and the choice of definitions and methodologies. Furthermore, the results themselves, where comparable, vary greatly between populations and supports the need for population specific injury reporting, particularly in populations such as the women’s game where there is a paucity of injury surveillance data reported to-date. A full and accurate understanding of high risk areas, specifically, for female rugby union players is needed, if injury prevention strategies are to be both justified and then implemented.

The debate regarding whether women are at greater risk of injury than their male counterparts in a more general sporting/physical activity context is also discussed; whilst the discussions in many areas continue, the literature review highlights two specific injury diagnosis where the weight of evidence supporting a sex difference is apparent (ACL Injuries and Concussion). The sex differences noted with ACL injuries and concussion are most likely multifactorial with anatomical make-up, neuromuscular components, hormone levels and fatigue differences purported to explain variances in ACL injury rates whilst hormone, physiological variances and simple compliance of reporting explaining the difference in concussion incidence rates and severity.

The literature review, then discusses the relatively unexplored consequences of illness in rugby union and notes the sex differences that have been noted within multi-sport competitions such as the Summer Olympics. Again, as with injury profiles of men versus women, the evidence as to whether data, pertaining to illnesses, from men’s rugby union can simply be adopted for the female population has yet to be conclusively ascertained.

Finally this chapter reviews the physical demands of rugby union, both the 15-a-side and sevens format. The current research highlights the differences between the two formats of the game, whilst also supporting the requirement for sex specific research in both 15-a-side rugby union and rugby sevens.
The following experimental chapters are included within this thesis:

Chapter 4: Epidemiology of match injuries in elite female rugby union players.

Chapter 5: Match injuries in international female rugby union players.

Chapter 6: Impact of injury and illness on the preparation of a Rugby World Cup winning squad.

Chapter 7: Epidemiology of injuries in a women’s international rugby sevens World Cup Squad.
Chapter 3: General Methods

3.1 Study Design

The overall approach, to the studies of injury and illness within this thesis, was observational and of a prospective nature. Following cohorts of elite women’s rugby players across three seasons, data was gathered for both club and international levels of play.

3.2 Elite Population

The women’s rugby premiership competition represents the highest level of women’s club rugby played in England. Comprising eight clubs, teams played home and away fixtures against each other in a league format (14 fixtures per season) with the team finishing with the highest points becoming Premiership Champions. In contrast, the club finishing with the lowest points played in a play-off competition with a club from the lower championship leagues to compete to remain in the premiership competition the following season.

The England Elite Playing Squad (EPS), consisting of approximate 44 players, is selected each season from the pool of players competing predominantly (but not exclusively) in the English Premiership. Players from within the EPS are subsequently selected to represent England in both 15-a-side and rugby sevens matches and tournaments.

Rugby is a game played by a diverse range of players of different ages, sex and ability. In the women’s game, the elite playing population constitutes a relatively small proportion of the total women’s playing population in the UK. The benefits of using the elite population in this study was the consistency it offered in terms of: regular and recordable training exposure; medically qualified personnel providing prospective injury reporting; and, the population to be observed, with clubs and International squads required to participate by the RFU.
3.3 Sample Size

The entire elite English playing population was invited to participate in the study, in order to maximise the opportunity of identifying robust associations between risk factors and injuries (as discussed in 2.23) (Bahr and Holme, 2003). In addition, in Chapters 4 and 5 the study was performed across three seasons; as evidence suggests (Doyle and George, 2004, Taylor et al., 2011b, Peck et al., 2013) that a single season alone was unlikely to yield a sufficient number of injuries to give the study the statistical power required to make associations. Indeed, researchers estimate that more than 200 cases are needed to identify small to moderate associations between the risk factor and injury risk (Bahr and Holme, 2003) e.g. the association between being tackled and the incidence of Injury.

The studies detailed within Chapters 6 and 7 capture the injury surveillance data from the England 15s and 7s world cup squads, respectively. The duration of the surveillance periods for both studies (< 8 months) is believed to be appropriate for the associated populations and the competitions within which they were preparing and competing. The predominantly amateur nature of women’s rugby often leads to short but intense preparatory phases, leading up to major international tournaments, which inevitably leads to an abrupt increase in training load. Incorporating these studies into longer surveillance studies would dilute the effect that such short but intense preparatory phases have on the injury risk to these individuals.

3.4 Ethical Considerations and Informed Consent

All studies within this programme of work received ethical approval from the University of Bath’s Research Ethics Approval Committee for Health (REACH), initially in June 2011, with subsequent amendments to the protocol approved in June 2013 and January 2014.

Prior to providing written consent, all eligible players were provided with a ‘Player Information Sheet’ containing a full written explanation detailing the purpose of the study, the requirement on participants and any risk to those taking part (Appendix A.1-
A.4). In addition, players were informed that participation in the respective studies was voluntary and that they were free to withdraw at any time without giving a reason.

3.5 Project Development and Management

Funding for the project was provided by the Women’s RFU, with agreement reached that the studies would encompass both the women’s premiership clubs and the England women’s squads. A steering group consisted of: the Head of Performance (Women’s rugby), Nicky Ponsford; RFU Head of Medical Services, Dr Simon Kemp; RFU Women’s Team doctor, Dr Harriet Collins; Lead Investigators, Dr Keith Stokes and Dr Grant Trewartha; and primary researcher, Niki Gabb. Meetings were held on a bi-annual basis with results presented and the aims/priorities of each stage of the research agreed.

3.5.1 Club Recruitment

The injury surveillance study was introduced by the RFU women’s doctor, to representatives of the eight premiership clubs in 2011 at a pre-season club meeting. In an attempt to ensure compliance with the project, the individual elements required of club coaching and medical staff were added to agreements held between the RFU and the clubs. The agreements (or toolkits) detail a number of pre-agreed tasks that clubs must fulfil in order to receive funding from the RFU each year and the requirements of the injury surveillance study were added to this document for the duration of the study. During the course of the three-year study, promotion/relegation ensured that 10 different clubs were included within the study with seven teams included across the entire three-year period and three teams only participating for one year each.

3.5.2 Participant Recruitment – Premiership Clubs

In season one, club representatives (medics/coaches/club captain) were asked to collect and return consent (Appendix A.1) and baseline (Appendix A.5) information from club first team players at the start of the season. Although this method of capturing consent had previously been successful within the men’s Premiership competition, it was necessary throughout the season to monitor match team sheets, establish those eligible
players that had not been invited to participate and subsequently approach club staff
during the season, in order to invite eligible players to participate and thus ensure that
consent had been given prior to any data being included in the studies.

It was apparent by the end of the first season that the amateur nature of the women’s game
required a more proactive approach to recruiting players into the study. Relying upon
club medical staff to recruit players and gain their consent resulted in variable success
with staff at 3 clubs finding the task too onerous, mainly due to the minimal amount of
time spent with uninjured squad members. Consequently, in season’s two and three, with
the agreement of the clubs, visits to each club were made during preseason in order to
allow the primary researcher the opportunity to collect consent and baseline information
from each individual player; players that were not consented during this period were
followed up during the season either during club visits or through liaison with club
medics.

3.5.3 Participant Recruitment – England Elite Playing Squad

England training camps were attended at the start of each season where all EPS players
were invited to participate within the injury surveillance study and complete consent and
baseline forms. Squad medics collected forms from any players who were not captured
during these camps (Sevens and 15-a-side).

Similarly, consent (Appendix A.2-4) and baseline forms were collected at the start of the
15-a-side England World Cup squad campaign in order to add monitoring of illness to the
study.

3.6 Data Collection Forms

The data collection forms utilised within the study were adapted from those developed
for the England Professional Rugby Injury Surveillance Project (Brooks et al., 2005a) and
data recorded in accordance with the guidance detailed within the rugby injury consensus
statement (Fuller et al., 2007c). The documents that were used included:
3.6.1 Baseline form

In season one, baseline forms (Appendix A.5) were used to collect: date of birth, height, body mass, normal playing position, dominant hand, dominant leg, and ethnic origin. In season two and three, an additional element was added in order to collect information on players’ rugby playing experience.

3.6.2 Weekly Injury Form

On a weekly basis, club medics used the ‘Weekly Injury’ form (Appendix C.1) to submit a list of any players who had sustained a reportable injury (see section 3.6).

3.6.3 Main Injury Form

The details of each individual reportable injury was recorded using a ‘Main Injury form’ (Appendix C.2). Using a unique player reference number provided following baseline data collection, details of when the injury occurred, how it occurred, whether it was during training or match play, the cause of the injury, an injury diagnosis and the respective treatment were recorded. There were additional details required in respect of the type of equipment (gum shield, shoulder pads and head guard) that the players were wearing when injured, the type of training activity the injury occurred within (if appropriate), the number of matches missed, details pertaining to menstrual cycle and also details of any diagnostic investigation required. Finally, the return to play date was required to enable calculation of total days’ absence from training/competition due to the injury.

3.7 Data Collection

Data collection for the 4 studies contained within this thesis was completed between June 2011 and August 2014. The specific dates for each study are detailed in table 3.1.
Table 3.1 - Data Collection dates for England and Premiership Squads for all three seasons.

<table>
<thead>
<tr>
<th></th>
<th>Season One</th>
<th>Season Two</th>
<th>Season Three</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Premiership</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chapter 4</strong></td>
<td>27 Jun 11 – 24 Jun 12</td>
<td>25 Jun 12 – 23 Jun 13</td>
<td>24 Jun 13 – 22 Jan 14</td>
</tr>
<tr>
<td><strong>England</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chapters 5</strong></td>
<td>N/A</td>
<td>27 Jun 12 – 21 Aug 13</td>
<td>22 Aug 13 – 20 Aug 14</td>
</tr>
<tr>
<td><strong>England 15-a-side</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>World Cup Squad</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chapter 6</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>1 Jan 14 – 20 Aug 14</td>
</tr>
<tr>
<td><strong>England Sevens</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>World Cup Squad</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chapter 7</strong></td>
<td>N/A</td>
<td>2 Jan 13 - 3 July 13</td>
<td>N/A</td>
</tr>
</tbody>
</table>

3.7.1 Injury Data

Team medical staff provided details of all injuries using an injury definition adapted from the guidance provided in the rugby injury consensus statement on reporting injuries in rugby union, and was ‘any physical complaint, that was sustained by a player during a rugby match or during training (rugby skills or conditioning) that prevented a player from taking a full part in training and/or match play for more than one day following the day of injury’ (Fuller et al., 2007c). At Premiership club level, the RFU require clubs to recruit the services of a registered physiotherapist and as a consequence the majority of data was provided by chartered physiotherapists. A small number of clubs received permission from the RFU to use experienced sports therapists in the absence of a physiotherapist. At England level, the players received treatment from both chartered physiotherapists and a team doctor with the Lead RFU women’s doctor providing details of all injuries sustained by England Senior players.
In using specialist medical staff, rather than relying upon individual players, it is anticipated that both consistency and accuracy will be maximised. The benefit of utilising the club medic will include consistency and accuracy of diagnosis, treatment and/or referral, which potentially could be a challenge where input is being received from multiple sources of varying experience.

3.7.2 Exposure Data – Match

Match exposure for England squads was taken from official team sheets provided by the RFU (women’s) competitions officer. Individual playing time was accumulated and an overall team total calculated. The use of official match team sheets, provided a more accurate calculation of team exposure with player suspension periods omitted from the final team total. Match exposure for club sides was more difficult to capture in this manner due to the inconsistent quality of match reports. Consequently, the common and accepted practice of using 1200 minutes per team (15 players competing for 80 minutes each) per match was used when calculating injury incidence and burden.

3.7.3 Exposure Data – Training

Elite playing squad players are required to maintain an accurate record of their training activity as part of their RFU contracts; although predominantly an amateur game players received regular financial payments to assist with costs associated with playing and training. Consequently, training exposure for the elite playing squad was taken from individual electronic player training diaries, a centrally controlled system which players were required to maintain as part of their RFU player contracts. The primary researcher was provided with access to the RFU electronic data hub (elitehub) in order to download all training data inputted by players; details logged by players included: date, activity, duration, players subjective rate of perceived exertion (RPE) and load (RPE*duration).

Training activity was downloaded into a Microsoft excel document with rest periods, injury periods and travelling time removed before training activity for each study period was collated for all consented players. Despite the financial penalties likely to be incurred and a continual pressure to complete the training diaries by all staff, there were varying
levels of compliance during the study periods and consequently to minimise the skewing of data likely to be seen with a mean average a median average was calculated. Rehabilitation activity for injured players was not included in the total training exposure and thus excluded from the median used for calculation of incidence and burden.

Premiership players are not required to maintain training diaries, consequently only match injuries and exposure data was captured.

3.8 Definitions

The Injury definitions used were taken or adapted from the 2007 rugby union consensus statement (Fuller et al., 2007c), and included:

**Time-loss Injury** - any injury that prevents a player from taking a full part in all training and match activities typically planned for that day for a period of greater than 24 hours.

**Medical Attention Injury** - any injury that results in a player receiving medical attention but did not result in any time-loss or restriction in participation.

**Recurrent Injury** - any injury of the same type and at the same site as a previously reported injury (Index) and occurs after a player returned to play from the Index injury. This was achieved both through the use of the initial information provided by the physio and then carefully analysing the data and confirming any apparent discrepancies with the respective physio’s.

**Injury Incidence** - Throughout this work injury incidence was presented and calculated in terms of the number of reported injuries that were sustained for every 1000 hours of exposure. Training and Match Injuries were presented individually (as discussed in 2.32) because the number of injuries and the amount of exposure time is vastly different between training and match data.

**Injury Severity** - was calculated in terms of “the number of days that have elapsed from the date of injury to the date of the player’s return to full participation in team training
and availability for match selection”. Injuries were subsequently grouped and reported in terms of the following categories: slight (0–1 days), minimal (2–3 days), mild (4–7 days), moderate (8–28 days), severe (>28 days) and “career ending” and “non-fatal catastrophic injuries”.

**Injury Burden** – is the total cost of injury to the sport/individual/squad and was presented in terms of the total number of days’ absence per 1000 player-hours and calculated by multiplying the injury incidence by mean severity.

**Incidence Proportion** – represents the number of players who sustained injuries/illness as a proportion of the entire population over the study period (Knowles et al., 2006). (Chapter 6)

**Injury Prevalence** – was calculated using the number of players injured at any one moment in time (Knowles et al., 2006). (Chapter 6)

### 3.9 Analysis and Outcome Measures

All statistical analyses were performed using SPSS software (SPSS for Windows: Version 16.0) or Microsoft Excel (Version 14.6.6).

#### 3.9.1 Premiership (Chapter 4)

Injury data and match exposure for the three seasons were combined and analysed using pivot tables within Microsoft Excel. Injury incidence was reported in terms of the number of injuries per 1000 player match or training hours with 95% confidence intervals (CIs).

Injury severity was defined by the number of days a player was not available for full participation in training or match play (days absence) with the mean (days; 95% CI) and median figures (days; Inter-quarter range (IQR)) presented and then grouped according to the following severity categories; minimal (2-3 days); mild (4-7 days); moderate (8-28 days); severe (>28 days) and “career ending” and “non-fatal catastrophic injuries”. Mean injury severity and CIs were reported to permit comparison with other studies and to allow
calculation of injury burden. In addition, due to the non-parametric nature of the severity
data it was appropriate to calculate and report the median and inter-quartile values
(McCluskey and Lalkhen, 2007).

Injury burden, calculated by multiplying the injury incidence by mean severity (Orchard
and Seward, 2002), was reported as total days’ absence per 1000 player-hours with 95%
CIs.

An analysis of subsequent injuries was completed using the ‘Subsequent Injury
Definition’ taxonomy, with the following definitions: an ‘index’ injury was a player’s
first injury sustained during the study period; any further injuries sustained by that same
player during the study period were categorised as a ‘subsequent’ injury. Subsequent
injuries were then further split into ‘new’ (different location to index injury), ‘local’ (same
location as index injury but different type) and ‘recurrences’ (same location and same
type) (Hamilton et al., 2011). Following a review of data from all three seasons at the
end of the study, it was decided to include all players regardless of whether they
participated in one, two or all three seasons in this analysis. As a consequence, the index
and the associated subsequent injury did not necessarily occur in the same season (i.e.
subsequent injuries were allowed to cross-over seasons). Incidence for subsequent
injuries was reported in terms of the number of injuries per 1000 player match or training
hours with 95% confidence intervals (CI’s)

3.9.2 England Squads (Chapters 5,6 &7)

Injury incidence is reported as the number of injuries per 1000 player-hours with 95%
confidence intervals (CIs), with both time-loss and medical attention variations calculated
from injury data and either match or training exposure. Incidence proportion represents
the number of players sustaining injuries/illness as a proportion of the entire population
over the study period and prevalence is the number of players injured at any one moment
in time (Knowles et al., 2006). The severity of time-loss and medical attention
injury/illness is presented as the number of days absence (or under treatment for medical
attention injuries) from full training (i.e. training typically planned for that day) or match
play, due to the reported injury/illness (Fuller et al., 2007c) with the mean (days; 95% CI)
and median values (days; 1st and 3rd inter-quartile range (IQR) presented due to non-normal distribution of the severity measure. Injury burden is reported as total days’ absence per 1000 player-hours for time-loss injuries (injury incidence multiplied by mean severity) and total days under treatment for medical attention injuries. Illness is reported as the number of illnesses per 1000 player-days with 95% CIs.

Significant differences in values for injury incidence were calculated using two-tailed Z test for comparison of rates (Kirkwood and Sterne, 2003); significance was accepted at the 5% level (equal variances assumed). Differences in injury severity were calculated using a Kruskal-Wallis Test for multiple groupings and significance was accepted at the 5% level (Kirkwood and Sterne, 2003). Differences for injury burden were assumed if 95% confidence intervals (CI) did not overlap.
Chapter 4: Epidemiology of match injuries in elite female rugby union players.

4.1 Introduction

Rugby union (rugby) is a full contact sport that is characterised by frequent bouts of high-intensity activities such as running and sprinting along with contact events such as tackling, scrummaging, rucking and mauling (Roberts et al., 2008). These physical demands, and in particular the regular exposure to collisions and physical contact, mean that the inherent risk of injury in elite men’s rugby union is considered substantial (Williams et al., 2013), albeit comparable with other full-contact team sports such as Ice Hockey (Lorentzon et al., 1988), American Football (Meyers and Barnhill, 2004), Australian Rules Football (Orchard and Seward, 2002) and Rugby League (Phillips et al., 1998).

Rugby Union is played by over 2 million women worldwide and women compete under the same rules as their male counterparts both at community levels and at the elite level (world Rugby, 2016a). Despite the increasing popularity of the women’s game (RFU, 2014, ARU, 2014), relatively little evidence is available regarding the incidence, causes or severity of injuries sustained by female players during match play. Moreover, from those studies published, the variability in the adopted methodologies, particularly with regard to the injury definition, unfortunately restricts the ability to generalise and make cross-study comparisons. Indeed, a search of current women's 15-a-side rugby literature yields only seven injury surveillance papers examining the incidence of injuries in women’s rugby, with injury incidence varying from as much as 3.6 to 37.5 injuries per 1000 player-hours (Carson et al., 1999, Taylor et al., 2011a, Doyle and George, 2004, Kerr et al., 2008, Bird et al., 1998, Schick et al., 2008, Peck et al., 2013).

Patterns of injuries have been reported to differ between men and women in sports such as football (Waldén et al., 2011), handball (Langevoort et al., 2007) and basketball (Deitch et al., 2006). Consequently, determining whether female rugby players have a similar or different injury profile, in terms of rate, severity and location as their male counterparts is important in informing the focus of any future injury prevention strategies. The aim of this longitudinal study was to characterise the nature of injuries sustained by
elite club-level (English Premiership) adult female rugby union players during 15-a-side match play.

4.2 Methods

Utilising an observational prospective cohort design, this study recruited separate cohorts in each of three consecutive seasons (Season One, 2011-12: 5 clubs, 125 players; Season Two, 2012-13: 7 clubs, 180 players; Season Three, 2013-14: 7 clubs, 172 players). Although some players participated in more than one season (Figure 4.1), each player season was considered independently for the purposes of analysis. All eight clubs in the English Women’s Premiership were invited to take part in the study, but in season one, the medical staff at three clubs were unable to provide sufficient information, and one club was unable to provide the required information in both season two and three. The study adopted the definitions and methodologies prescribed in the consensus statement for reporting rugby injuries (Fuller et al., 2007c). Ethical approval for the study was obtained from the University of Bath’s Research Ethics Approval Committee for Health (REACH) in June 2011, and written informed consent collected from all players.

Figure 4.1 Number of players participating in each season with cross-over shown between seasons.
Using the injury definition “any injury that prevents a player from taking a full part in all training and match activities typically planned for that day for a period of greater than 24 hours from midnight at the end of the day the injury was sustained”, team medical staff (all physiotherapists or experienced sports therapists) recorded all time-loss match injuries using standardised forms (Fuller et al., 2007c). Details of each individual injury included the date of the injury, classification of the injury at two levels (body site and type of injury) using the Orchard Sports Injury Classification System V.8 (Rae et al., 2005), information on injury event, an indication of the nature of onset, and the date of return from injury. Grouped match exposure was calculated based on 15 players (7 backs; 8 forwards) exposed for 80 minutes per match for the participating teams.

4.3 Data Analysis

Injury incidence is reported as the number of time-loss injuries per 1000 player-hours with 95% confidence intervals (CIs), derived from match exposure and injury count data. Injury severity is presented as the number of days absence from full training (i.e. training typically planned for that day) or match play due to the reported injury (days absence) (Fuller et al., 2007c) with the mean (days; 95% CI) and median values (days; 1st and 3rd inter-quartile range (IQR)) presented due to non-normal distribution of the severity measure. Injury burden is reported as total days’ absence per 1000 player-hours (injury incidence multiplied by mean severity). Significant differences in values for injury incidence for player position (comparing backs versus forwards) and between the individual seasons observed, were calculated using two-tailed Z test for comparison of rates (Kirkwood and Sterne, 2003); significance was accepted at the 5% level (equal variances assumed). Significant differences in injury severity were calculated using a Mann-Whitney U Test when comparing backs versus forwards and a Kruskal-Wallis Test for multiple groupings; significance was accepted at the 5% level (Kirkwood and Sterne, 2003). Significant differences for injury burden were assumed if 95% confidence intervals (CI) did not overlap.

Combining data from the three seasons, an analysis of subsequent injuries was completed with individual player data being linked between seasons. Using the following definitions
an analysis of subsequent injuries was completed: an ‘index’ injury was a player’s first injury sustained during the study period; any further injuries sustained by that same player during the study period were categorised as a ‘subsequent’ injury. Subsequent injuries were then further split into ‘new’ (different location to index injury), ‘local’ (same location as index injury but different type) and ‘recurrences’ (same location and same type). (Hamilton et al., 2011) Following a review of data from all three seasons at the end of the study, it was decided to include all players regardless of whether they competed in one, two or all three seasons in this analysis. As a consequence, the index and the associated subsequent injury did not necessarily occur in the same season (i.e. subsequent injuries were allowed to cross-over seasons). Furthermore, where multiple subsequent injuries occurred the most recent past injury was used as the index injury for the purposes of calculating the time that had elapsed to the injury. Consequently, the incidence of subsequent injuries is reported as the number of injuries per 1000 player-hours with 95% confidence intervals (CIs), derived from total match exposure of all players across the 3 seasons and the respective subsequent injury count data.

4.4 Results

4.4.1 Incidence

There were 226 match injuries in total, sustained by 136 different players across the three seasons of the study, during 5280 hours of match exposure. Consequently, the injury incidence for the study period was 43 injuries per 1000 player-hours (95% CI: 38 - 49), with no significant difference observed between seasons (Table 4.1). Injury incidence was significantly higher for forwards (50 injuries per 1000 player-hours, 95% CI: 42-50) than for backs (35 injuries per 1000 player-hours, 95% CI: 28-43) when data from all three seasons were combined (P=0.007).
Table 4.1 Frequency (n) and incidence (injuries per 1000/player-hours) of all match injuries reported by season and player positions (backs/forwards).

<table>
<thead>
<tr>
<th>Season</th>
<th>No. of Injuries (n)</th>
<th>Exposure (hours)</th>
<th>Backs Injuries per 1000 hours (95% CI)</th>
<th>Forwards Injuries per 1000 hours (95% CI)</th>
<th>Total Injuries per 1000 hours (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Season One</td>
<td>48</td>
<td>1380</td>
<td>31 (20 - 48)</td>
<td>38 (26 - 55)</td>
<td>35 (26 - 46)</td>
</tr>
<tr>
<td>Season Two</td>
<td>94</td>
<td>1940</td>
<td>42 (30 - 56)</td>
<td>55 (41 - 71)</td>
<td>48 (40 – 59)</td>
</tr>
<tr>
<td>Season Three</td>
<td>84</td>
<td>1960</td>
<td>31 (21 - 44)</td>
<td>54* (41 - 70)</td>
<td>43 (35 - 53)</td>
</tr>
<tr>
<td>Combined 3 Seasons</td>
<td>226</td>
<td>5280</td>
<td>35 (28 - 43)</td>
<td>50* (42 - 59)</td>
<td>43 (38 - 49)</td>
</tr>
</tbody>
</table>

Note: *Significant difference between forwards and backs at P=≤0.05

4.4.2 Injury Severity

A total of 8189 days were lost from training or match play as a result of the match injuries sustained during the study period. Mean injury severity across the three seasons was 36 days (95% CI: 29 - 44) (Table 4.2) with no significant differences found between seasons (p=0.10). A comparison between positional groups revealed that mean severity was not different between backs and forwards (U= 5726, Z=-0.582, p= 0.574, r= 0.4).

4.4.3 Injury Burden

Injury burden was 1551 days per 1000 player-hours (95% CI: 1518 - 1585), with forwards experiencing a significantly higher injury burden than backs (Table 4.2). When analysed by season, injury burden was significantly higher in season one (1873 days/1000 player-hours, 95% CI: 1802 -1947) than seasons two (1430 days/1000 player-hours, 95% CI: 1375 -1481) and three (1447 days/1000 player-hours, 95% CI: 1395 -1501), respectively).
Table 4.2 Injury severity and injury burden of all match injuries reported by player positions (backs/forwards).

<table>
<thead>
<tr>
<th>Positional Group</th>
<th>Mean Severity (95% CI)</th>
<th>Median Severity (IQR)</th>
<th>Injury Burden /1000 hrs (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backs</td>
<td>39 (26 - 53)</td>
<td>15 (6 - 41)</td>
<td>1346 (1301 - 1392)</td>
</tr>
<tr>
<td>Forwards</td>
<td>35 (25 - 44)</td>
<td>13 (6 - 34)</td>
<td>1731* (1683 - 1780)</td>
</tr>
<tr>
<td>All Players</td>
<td>36 (29 - 44)</td>
<td>15 (6 - 39)</td>
<td>1551 (1518 - 1585)</td>
</tr>
</tbody>
</table>

Note: *Significant difference between forwards and backs at 95% CI.

4.4.4 Nature of Injury

The lower limbs sustained a significantly higher incidence of injuries than any other body region (Figure 4.2), and the most commonly injured lower limb structure was the knee (Table 4.3). Injuries to the lower limbs resulted in a greater injury burden than any other location (Lower Limbs: 862 days/1000 player-hours, 95% CI: 838 – 888; Upper Limbs: 467 days/1000 player-hours, 95% CI: 449 – 486; Head & Neck: 149 days/1000 player-hours, 95% CI: 138 – 159; Trunk: 73 days/1000 player-hours, 95% CI: 66 – 81). More specifically, the knee resulted in a significantly greater number of days lost from training or competition than other lower limb structures, followed by the ankle and lower limb/Achilles tendon (Table 4.3).
Incidence of Injuries (injury/1000 player hours)

♯ Significantly higher incidence than all other body regions at \( P = \leq 0.01 \)

* Significantly higher incidence than trunk region (\( P=0.0006 \))

Figure 4.2 Incidence (injuries per 1000/player-hours) of match injuries reported by body region.

Table 4.3 Incidence, mean severity and injury burden of match injuries reported by lower limb structure (\( n=113 \)).

<table>
<thead>
<tr>
<th>Lower Limb Structure</th>
<th>Incidence injuries/1000 player hours (95% CI)</th>
<th>Mean Severity days (95% CI)</th>
<th>Injury Burden days lost/1000 player hours (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee</td>
<td>5* (4 – 8)</td>
<td>90* (48 – 132)</td>
<td>478 * (460 – 497)</td>
</tr>
<tr>
<td>Ankle</td>
<td>5* (3 – 7)</td>
<td>24 (17 – 31)</td>
<td>115 * (106 – 124)</td>
</tr>
<tr>
<td>Lower Leg/Achilles</td>
<td>4 (2 – 6)</td>
<td>24 (15 – 32)</td>
<td>90 * (83 – 99)</td>
</tr>
<tr>
<td>Hip/Groin</td>
<td>2 (1 – 4)</td>
<td>23 (12 – 34)</td>
<td>53 (47 – 59)</td>
</tr>
<tr>
<td>Anterior Thigh</td>
<td>2 (1 – 4)</td>
<td>23 (11 – 35)</td>
<td>52 (46 – 58)</td>
</tr>
<tr>
<td>Posterior thigh</td>
<td>2 (1 – 3)</td>
<td>34 (21 – 47)</td>
<td>58 (51 – 64)</td>
</tr>
<tr>
<td>Foot/Toe</td>
<td>1 (1 – 3)</td>
<td>13 (3 – 23)</td>
<td>53 (47 – 59)</td>
</tr>
</tbody>
</table>

\* Incidence of injuries was significantly greater than: hip/groin, anterior thigh, posterior thigh, foot/toe at \( P \leq 0.05 \)

\* Significantly higher mean severity of injuries than all other lower limb structures at 95% CI

\§ Significantly higher injury burden than all other lower limb structures at 95% CI

\# Significantly higher injury burden than lower leg/Achilles, hip/groin, anterior thigh, posterior thigh, foot/toe at 95% CI

\$ Significantly higher injury burden than hip/groin, anterior thigh, posterior thigh, foot/toe at 95% CI
The three most common injury types were joint/ligament, muscle/tendon and contusions (bruises) (Table 4.4). The incidence of joint and ligament injuries reported for all players was significantly greater than any other injury type (P<0.05) and also resulted in a significantly greater injury burden than any other pathology (894 days/1000 player-hours, 95% CI: 869 – 920).

Table 4.4 Incidence of match injuries as a function of Injury type

<table>
<thead>
<tr>
<th>Injury Type</th>
<th>Incidence injuries/1000 player hours (95% CI)</th>
<th>Mean Severity days (95% CI)</th>
<th>Injury Burden days lost/1000 player hours (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joint &amp; Ligament</td>
<td>15 (12 – 19)</td>
<td>60 (41 – 79)</td>
<td>894 (869 – 920)</td>
</tr>
<tr>
<td>Muscle &amp; Tendon</td>
<td>9 (7 – 12)</td>
<td>23 (16 – 30)†</td>
<td>213 (201 – 226)</td>
</tr>
<tr>
<td>Contusions</td>
<td>9 (7 – 12)</td>
<td>16 (11 – 21)</td>
<td>185 (174 – 197)</td>
</tr>
<tr>
<td>Fracture &amp; Bone Stress</td>
<td>4 (2 – 6)</td>
<td>49 (28 – 69)</td>
<td>185 (174 – 197)</td>
</tr>
<tr>
<td>Concussion</td>
<td>3 (2 – 5)</td>
<td>30 (15 – 44)</td>
<td>90 (82 – 98)</td>
</tr>
<tr>
<td>Central/peripheral nervous system - Other</td>
<td>1 (0 – 2)</td>
<td>9 (7 – 11)</td>
<td>8 (6 – 11)</td>
</tr>
<tr>
<td>Laceration and Skin Lesion</td>
<td>1 (1 – 3)</td>
<td>11 (5 – 16)</td>
<td>14 (11 – 18)</td>
</tr>
<tr>
<td>Other</td>
<td>&lt;1 (0 – 2)</td>
<td>10 (6 – 14)</td>
<td>4 (2 – 6)</td>
</tr>
</tbody>
</table>

† Significantly higher incidence than all other Injury types at P = ≤0.01
§ Significantly higher Injury Burden than all other Injury types at 95% CI
⌘ Significantly greater severity than Muscle/Tendon, Contusions, Other, Laceration/skin lesion and Concussion at P≤0.01 (recalculated alpha level for post-hoc test)
* Significantly greater severity than Contusions, Other, Laceration’s and Concussion at P≤0.0125 (recalculated alpha level for post-hoc test)

Considering pathologies by individual lower limb structures (Figure 4.3), joint and ligament injuries to the knee (n=19, 3.6 injuries/1000 player-hours, 95% CI: 2 – 6) and ankle (n=22, 4.2 injuries/1000 player-hours, 95% CI: 3 – 6) were the most common. Medial collateral (MCL) (n=8, 2 injuries/1000 player-hours, 95% CI: 1-3) and anterior cruciate ligament (ACL) (n=4, 0.8 injury/1000 player-hours, 95% CI: 0.3-2.0) injuries accounted for the highest incidence of knee injuries and lateral ankle ligament injuries
accounted for the highest incidence of ankle injuries (n=14, 3 injuries/1000 player-hours, 95% CI: 2-5).

![Figure 4.3 Incidence of match injuries as a function of Injury type and by lower-limb structure.](image)

4.4.5 Injury Event

The tackle was the match event associated with the greatest proportion of injuries, with both forwards (P = ≤0.01) and backs (P = ≤0.05) sustaining a significantly greater number of injuries from ‘being tackled’ than from any other match event; no significant difference was found between positional groupings and so results are reported for all players combined (Figure 4.4).

In terms of mean severity, the top three injury events were running (side-stepping), scrummaging and being tackled; although no significant differences were observed
between events (Figure 4.4). The mean severity of injuries from being tackled was 43 days (95% CI: 28-58) and the injury burden was found to be significantly higher than any other injury event (626 days per injury, 95% CI: 605-648).

![Graph showing incidence and severity of match injuries]

**Figure 4.4** Incidence (injuries per 1000/player-hours) and severity (mean) of match injuries reported by injury event.
4.4.6 Subsequent Injuries

136 players sustained 226 injuries across the three seasons, with 92 individuals sustaining one injury and 44 players sustaining two or more injuries (20 players = 2 injuries; 13 players = 3 injuries; 5 players = 4 injuries; 2 players = 5 injuries, 3 players = 6 injuries, 1 player = 7 injuries). Subsequent injuries therefore accounted for 90 of the 226 injuries reported within this cohort; 75 were new injuries, 5 were local injuries and 10 were recurrent injuries. The incidence of subsequent injuries was 17 injuries/1000 player hours (95% CI: 14-21), which was significantly lower than index injuries with an incidence of 26 injuries/1000 player hours (96% CI: 22-31). The mean severities for subsequent and index injuries were comparable at 35 and 37 days lost from training/competition per injury, respectively (95% CI: 28-41 and 32-42); similarly the median severities were comparable at 14 and 17 days lost per injury (IQR: 6-34 and 3-40 days), respectively. Of the 10 recurrent injuries, 9 were sustained ≤ 2 weeks following return to play from the index injury (the remaining recurrent injury recurred >8 months later). On average (mean), when comparing the injury severity of each index injury with its equivalent recurrence, an additional 10 days (95% CI: 3-17), was required to recover from the recurrence of an injury (median = 7 days; IQR: 3-14), when compared to the recovery time taken for the initial/index injury.

4.5 Discussion

This is the first prospective longitudinal study of match injuries sustained by elite club-level female rugby union players. The principal findings are that (1) match injury incidence was 43 injuries per 1000 player-hours (95% CI: 38-49); (2) mean severity of injuries was 36 days (95% CI: 29-44); (3) the lower limb sustained the highest incidence of injuries with the knee having the greatest proportion of these injuries; (4) being tackled was associated with a significantly higher injury incidence than any other match event; (5) early recurrent injuries result in more days absence than their index injury.

The incidence of match injuries within this study is similar to that previously observed at the Women’s 2006 and 2010 World Cup (38 injuries/1000 player-hours, 95% CI: 28-50
and 36 injuries/1000 player-hours, 95% CI: 26-49, respectively) (Taylor et al., 2011b, Schick et al., 2008) and similar to that previously reported for both male elite academy players (47 per 1000 hours, 95% CI: 39-57) (Palmer-Green et al., 2013) and for the second tier of men’s club matches (35 per 1000 hours, 95% CI: 27-45) (Williams et al., 2013). Incidence was, however, significantly lower than has previously been reported for the elite level or top tier of men’s club rugby (81 injuries per 1000 player-hours; 95% CI: 75-104) (Williams et al., 2013). Importantly, the results of these comparisons provide a gauge as to whether it is appropriate or optimal to generalise findings from the men’s game to the women’s game or whether sex specific research is required.

The mean severity of injury was 36 days (95% CI: 29-44) which is significantly higher than was reported in a meta-analysis of men’s rugby (26 days; 95% CI: 14-27, P<0.05) (Williams et al., 2013). Moreover, the median of 15 days, which is less influenced by the small number of high severity injuries observed within this cohort, was also found to be higher than the southern hemisphere men’s Super-14 competition and South African Vodacom cup (median = 5 and 12, respectively) (Fuller et al., 2009). As a predominantly amateur playing group, it is perhaps unsurprising that women rugby players are taking longer to return to play than their professional male counterparts, although the reasons are likely to be multifactorial. For example, medical staff are typically only available during training and match days due to economic constraints, reducing access to treatment and rehabilitation by players which may result in less than optimal treatment/rehabilitation of injuries (van Beijsterveldt et al., 2014); in contrast, professional male players are likely to have daily contact with their club medical staff. There is also the time constraint placed on the amateur female players themselves when attempting to balance rehabilitation activities with their normal day-to-day employment; again this is likely to be quite different from their professional male counterparts who are able to focus more fully on the rehabilitation process. Finally, there is the potential for under-reporting of minor (≤3) day injuries within this cohort with only 10% of injuries falling into this category compared with 35% reported in the men’s Super Rugby tournament (Schwellnus et al., 2014); this may be a consequence of the reduced access to team medical staff, which may lead to minor injuries (1-3 days) not being reported and players recovering before their next contact with club medical staff.
In the present cohort, MCL injuries accounted for the greatest proportion (44%, n=8) of all knee injuries. This is perhaps unsurprising given that MCL injuries are frequently associated with cutting movements or a direct valgus force (applied to the lateral aspect of the joint) to the knee (Chen et al., 2008), which are both common events in rugby union. MCL injuries are often associated with lower severity when compared with ACL injuries; in this cohort the injury burden of MCL injuries was sizeable at 138 days /1000 player-hours (95% CI: 128-148), but it was significantly lower than the injury burden for ACL injuries (252 days /1000 player-hours; 95% CI: 238-266) despite only 4 ACL injuries being sustained (0.8 injuries/1000 player-hours). Data from the men’s 2014-15 England Professional Rugby Injury Surveillance Project (PRISP) similarly observed a greater number of MCL (n=27) than ACL match injuries (n=8); in contrast to their female counterparts, the PRISP reported a significantly greater injury burden from MCL injuries (458 days /1000 player-hours; 95% CI: 443-472) than ACL from injuries (240 days /1000 player-hours; 95% CI: 230-251) and this was largely due to the relatively big difference in the number of MCL injuries (n=27) sustained when compared to ACL injuries (n=8).

The severity of ACL injuries are notoriously high, with players potentially remaining absent from competition / training for substantial periods of time (7-14 months) (Brophy et al., 2012), indeed the mean severity was 315 days for each ACL injury sustained within this cohort which is within the range observed in the men’s Premiership Rugby Injury Surveillance Project (PRISP) 8 year study (Williams, 2015). The outcomes for individuals following reconstructive ACL surgery or conservative management are mixed, with as many as 38% of individuals not returning to sport at their pre-injury level 2-7 years post-surgery (Simoneau and Wilk, 2012, Ardern et al., 2011). The long term health consequence of these types of injuries is also very important, with as many as 87% of ACL injuries (in injuries requiring surgical repair) resulting in post-traumatic Osteoarthritis (OA) (Friel and Chu, 2013). ACL injuries may represent just a small proportion of the total number of injuries sustained, but from a player wellbeing and player availability perspective these are injuries for which effective injury prevention strategies are likely to offer a significant benefit. Indeed, movement control training has yielded significant reductions in ACL injury rates in female football players, albeit with a key factor to the long-term success of the programmes being the continued adherence and compliance of players (Hägglund et al., 2013a).
Injury burden is often considered to be the total cost (or absolute injury risk) of injury to a sport or team, where cost can be represented in terms of monetary value (in the professional game) or time lost from participation (Verhagen and Van Mechelen, 2010). In order to maximise their impact, it has been suggested that injury prevention strategies should target those injuries or areas of the game associated with the greatest injury burden (Brooks and Kemp, 2008). In the present study, the tackle was the injury event associated with the greatest burden of injuries, primarily as a consequence of a high injury incidence; which is unsurprisingly given that the tackle has widely been cited as a high injury risk event (Williams et al., 2013). Given that women’s rugby is in its relative infancy compared to the men’s game, it is possible that the tackling technique has yet to be optimally developed by some players due to their level of experience. The level of experience, in this context, makes an assumption that less experience results in a lower level of proficiency in events such as the tackle. Burger et al. (2016), reported an association between ‘better’ or more proficient tackling and ball-carrying technique and a reduction in the risk of injury during tackle events; consequently the priority should be to improve the tackling technique of all players in order to reduce the risk of injury. Given Gabbett and Ryan (2009), in a study of rugby league players, noted that technique could be significantly improved through coaching the key technical components of tackling over a sustained period (Gabbett and Ryan, 2009), programmes similar to the New Zealand community rugby programme, which concentrated on improving technique in specific contact elements of rugby (tackling and scrummaging mainly) (Gianotti et al., 2009) could be adopted.

With the myriad of injuries that occur in the tackle and the relative difficulty of influencing injury risk in this event compared with more controlled aspects of the game such as the scrum, an alternative (or complimentary) approach would be to concentrate on the conditioning of commonly injured specific regions/structures of the body. The lower limb is the region of the body consistently recording the highest incidence of injuries and consequently it may be prudent to adopt a neuromuscular training programmes such as FIFA 11+ where efforts to enhance a number of different physical attributes can be made including: improving dynamic/static balance, neuromuscular control and proprioception of knee and hip (Longo et al., 2012); and these programmes
have been shown to be beneficial for injury risk reduction in a number of team sports, reducing injury incidence by 30-50% (Soligard et al., 2008, Hislop et al., 2017). However, as Rugby Union demands that players perform a wide range of physically demanding athletic movements in addition to mastering and performing very specific game techniques (i.e. the tackle, scrum) it could be argued that an injury prevention programme which addresses both improvements in physical attributes (i.e. functional movement competence) and technique should be developed and investigated.

Concussion had a combined incidence for the three seasons of 3 injuries per 1000 player-hours (95% CI: 2-5). Making a direct comparison between men’s and women’s English Premiership’s for both the 2012-2013 and 2013-2014 seasons, the results confirmed that concussion injury incidence in the women’s game (3.3 injuries/1000 player-hours; 95% CI: 1.9-5.7) was less than had been reported for the men’s English Premiership across the same period of time (8.9 injuries/1000 player-hours; 95% CI: 7.7-10.3) (Cross, 2016). Female athletes have previously been reported to be at a higher risk of sustaining a concussion than their male counterparts in US collegiate soccer, basketball and ice-hockey based on similar definitions (Covassin and Elbin, 2011), with suggestions that this might be associated with lower neck strength of females compared with males (Tierney et al., 2005). Given the small number of concussions sustained throughout the 3 seasons, further surveillance is required if comparisons between the men’s and women’s game are to be reliably assessed. There is evidence of under-reporting of concussion within men’s rugby union with possible factors being the player not believing the injury was severe enough to seek medical advice or not wanting to be removed from the game (Fraas et al., 2014). Positively in the time that has past since this study, regulations and laws within the elite level men’s game have advanced in order to minimise the number of under-reported or more importantly un-treated concussions. The level of compliance to concussion management guidelines within women’s rugby union is yet to be studied.

In the current study, the median number of days absence from training or competition because of concussion was 20 days (mean = 30 days), with 5 out of 16 concussed players returning to full participation within 20 days. Prior to the study period, the International Rugby Board (now World Rugby) guidelines had promoted a 3-week stand-down period following a concussion, but in 2010 the guidelines changed to enable players to return
sooner where a ‘competent medical professional’ fully managed a graduated return to
play and consequently players could legitimately return to play within one week (IRB,
2013b). Further work is required to investigate the level of compliance with concussion
management guidelines, since non-compliance would be of particular concern given the
uncertainty surrounding the possible links between concussion and long-term
neurodegenerative conditions (Raftery, 2014). There is a need for continued focus on
improving players’, coaches’ and medics’ knowledge about and attitudes towards
concussion through appropriate education. In a recent study assessing the experience and
knowledge of adult concussion among players, coaches, medical staff, and referees, the
results found that almost half of player and coaches didn’t acknowledge that performance
could be impaired by concussion) (Mathema et al., 2015).

Additionally, there is encouraging evidence that the use of exercise programmes that
target the strengthening of neck muscles, can be effective at reducing the incidence of
concussion. A recent study of schoolboy rugby players found that a preventive movement
control exercise programme, completed three or more times a week, was effective at
reducing the match concussion incidence compared to a control group. The researchers,
suggested that the exercise programme, which included neck resistance exercises to
enhance neck muscle strength, may have helped reduce the incidences of concussion
through the dissipation of impact forces transmitted to the brain. (Hislop et al., 2017)

4.6 Conclusion

This is the first longitudinal study of match injuries in elite level women’s rugby union
players. The injury incidence was similar to that previously reported for women’s
international tournament match play (Taylor et al., 2011b, Schick et al., 2008). In
addition, mean severity of injures was significantly higher than reported for men’s elite
rugby (Williams et al., 2013) which is perhaps partly a consequence of women’s 15-a-
side rugby remaining an amateur sport even at elite club level, with limited time and
resources available for appropriate rehabilitation. Injuries to the knee, specifically to
knee ligaments, resulted in the greatest number of days lost from competition and
training. Borrowing evidence from other team sports, the introduction of movement
control training into the routine warm-ups of female rugby players may provide a
sustainable injury prevention strategy that is effective at reducing the incidence of lower limb and concussion injuries and consequently should be targeted for future injury prevention studies.
Chapter 5: Match injuries in female international rugby union players

5.1 Introduction

Rugby union is a full contact sport characterised by frequent bouts of high-intensity activities (Roberts et al., 2008) and is frequently categorised as a collision sport. Distinctly different from contact sports (e.g. football and basketball), collision sports allow its participants to purposely hit or collide repeatedly, in direct and intense physical contact, with each other (Maxwell and Visek, 2009). The force of these impacts can be as great as 10G in situations such as the tackle (Coughlan et al., 2011).

Growth in participation figures for women’s rugby has been dramatic, with more than 2 million women and girls estimated to be playing rugby worldwide (World Rugby, 2016a). A limited amount of literature has been published on the Incidence of injuries sustained in the women’s International tournament environment and although chapter 4 does provide longitudinal data for injuries sustained across a season, this captures players competing at club level rather than purely at International level. Given that there is evidence from the men’s game that higher levels/standards of play are associated with higher injury incidence, it cannot be assumed that players competing in international matches encounter the same risk of injury as that observed in Premiership club matches (chapter 4). Throughout women’s rugby union the game has predominantly been amateur in nature, recent developments at international level have seen several national rugby unions offer part and/or full time contracts to some or all their representative squad members. In addition, with the continued evolution/growth in the women’s games and perhaps better financed International unions, has come an expansion in the number of matches and tournaments in which top level International squads are competing. Consequently, it has become important to capture not only the risk of injury at individual tournaments but also the accumulative effect of whole seasons on player’s well-being. Capturing longitudinal data will help to ensure that appropriate measures are being taken to consider all aspects of risk to women competing at International level Rugby Union and thus provide a contemporary injury profile to provide guidance to those managing the elite women’s game. Consequently, the aim of this study was to describe the pattern
of match-related injuries sustained by International level female rugby union players across two seasons.

5.2 Methods

5.2.1 Study Design

Utilising an observational prospective cohort design, this study recruited separate cohorts in each of two seasons (49 players 2012/13 season; 50 players – 2013/14 season). Although some players participated in both seasons (Figure 5.1), each player season was considered independently for the purposes of analysis. All Elite Playing Squad (EPS) members were invited to join the study, provided written informed consent, and all given the opportunity to withdraw at any time. Ethical approval for the study was obtained from the University of Bath’s Research Ethics Approval Committee for Health (REACH) in June 2011.

The total number of players included within the study cohort was 61, with a large proportion of these players selected in both the 2012/13 and 2013/14 elite playing squads (Figure 5.1). Not all players selected into the respective playing squads gained match exposure during the two seasons, with 45 of 49 members in the 2012/13 season and 36 of 50 members in the 2013/14 season taking part in match play. The total match exposure for the EPS cohort across the study period was 539 hours, which was accumulated during 28 matches.

The study, which commenced in the 2012-13 season, adopted the definitions and methodologies prescribed in the World Rugby consensus statement for reporting injury data in rugby union (Fuller et al., 2007c).
Using the 24-hour time-loss injury definition, team medical staff (Doctors or physiotherapists) recorded all time-loss injuries using a standardised format (Fuller et al., 2007c) onto either paper forms (2012/13 season) or into an electronic performance management system (2013/14 season). Details of each individual injury included the date of the injury, classification of the injury at two levels (body site and type of injury) using the Orchard Sports Injury Classification System V.8 (Rae et al., 2005), information on injury event, an indication of the nature of onset, and the date of return from injury. Player match exposure was taken from official team sheets provided by the RFU (women’s) competitions officer. Individual playing time was accumulated and an overall team total calculated. The use of official match team sheets, provided a more accurate calculation of team exposure with player suspension periods omitted from the final team total.

5.2.2 Data Analysis

Injury incidence is reported as the number of time-loss injuries per 1000 player-hours with 95% confidence intervals (CIs). Injury severity is presented as the number of days absence from full training (i.e. training typically planned for that day) or match play due to the reported injury (days absence) (Fuller et al., 2007c) with the mean (days; 95% CI) and median values (days; 1st and 3rd inter-quartile range (IQR)) presented due to non-normal distribution of the severity measure. Injury burden is reported as total days’ absence per 1000 player-hours (injury incidence multiplied by mean severity).
Significant differences for injury incidence between positional groups and seasons were calculated using two-tailed Z test for comparison of rates (Kirkwood and Sterne, 2003); significance was accepted at the 5% level (equal variances assumed). Significant differences in injury severity were calculated using a Mann-Whitney U Test when comparing backs/forwards and a Kruskal-Wallis Test for multiple groupings; significance was accepted at the 5% level (Kirkwood and Sterne, 2003). Significant differences for injury burden were assumed if 95% confidence intervals (CI) did not overlap.

5.3 Results

5.3.1 Incidence and Severity

There were 69 injuries in total, sustained by 34 different players across the two seasons of the study, during 539 hours of match exposure. The injury incidence for the study period was 128 injuries per 1000 player-hours (95% CI: 101 – 162) with no significant difference (p=0.91) between seasons (Table 5.1). Injury incidence tended to be higher for backs than for forwards across the study period but this was not significant (p=0.079).

Table 5.1 Number (n) and incidence (injuries per 1000 player-hours) of all match injuries reported by season

<table>
<thead>
<tr>
<th></th>
<th>Backs</th>
<th>Forwards</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Injuries per 1000 hours (95% CI)</td>
<td>Injuries per 1000 hours (95% CI)</td>
<td>Injuries per 1000 hours (95% CI)</td>
</tr>
<tr>
<td>2012/13</td>
<td>162 (107 - 247)</td>
<td>103 (64 - 165)</td>
<td>130 (95 - 177)</td>
</tr>
<tr>
<td>2013/14</td>
<td>152 (94 - 244)</td>
<td>103 (60 - 178)</td>
<td>126 (88 - 180)</td>
</tr>
<tr>
<td>Overall a</td>
<td>158 (115 - 216)</td>
<td>103 (72 - 147)</td>
<td>128 (101 - 162)</td>
</tr>
</tbody>
</table>

Note: a where each player season was considered as an independent entity
5.3.2 Injury Severity

A total of 1706 days were lost from full training and/or competition as a result of the match injuries sustained during the study period with a mean injury severity across the two seasons of 25 days (CI: 14 - 35) with no significant difference found between seasons (P=0.66) (Table 5.2). Mean severity was not different between backs and forwards (p= 0.92).

5.3.3 Injury Burden

Injury burden was 3167 days per 1000 player-hours (95% CI: 3020 – 3321) over both seasons of the study (Table 5.2). When analysed by season, injury burden was significantly higher in the 2012/13 season than the 2013/14 season. Considering positional groups, backs experienced a significantly higher injury burden than forwards (non-overlapping 95% CI, Table 5.3).

<table>
<thead>
<tr>
<th>Season</th>
<th>Mean Severity (95% CI)</th>
<th>Median Severity (IQR)</th>
<th>Injury Burden/1000 hrs (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012/13</td>
<td>31 (13-48)</td>
<td>13 (3-31)</td>
<td>3960 (3742 - 4192)*</td>
</tr>
<tr>
<td>2013/14</td>
<td>17 (10-25)</td>
<td>7 (4 – 22)</td>
<td>2160 (1981 - 2355)</td>
</tr>
<tr>
<td>Overall*</td>
<td>25 (14 – 35)</td>
<td>10 (3 – 28)</td>
<td>3167 (3020 - 3321)</td>
</tr>
</tbody>
</table>

*where each player season was considered as an independent entity

*significant difference between seasons 2012/13 and 2013/14 at non-overlapping 95% CI.
Table 5.3 Injury severity and injury burden of all match injuries reported by player position groups (backs/forwards).

<table>
<thead>
<tr>
<th>Positional Group</th>
<th>Mean Severity (95% CI)</th>
<th>Median Severity (IQR)</th>
<th>Injury Burden /1000 hrs (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backs</td>
<td>27 (10 - 45)</td>
<td>13 (4 - 25)</td>
<td>4315* (4063 - 4581)</td>
</tr>
<tr>
<td>Forwards</td>
<td>21 (12 - 31)</td>
<td>7 (3 - 31)</td>
<td>2193 (2029 - 2369)</td>
</tr>
<tr>
<td>All Players</td>
<td>25 (14 - 35)</td>
<td>10 (3 - 28)</td>
<td>3167 (3020 - 3321)</td>
</tr>
</tbody>
</table>

*significant difference between forwards and backs at non-overlapping 95% CI.

5.3.4 Nature of Injury

The lower limbs sustained a significantly higher incidence of injuries than other body regions (P<0.01) (Figure 5.2). Individual lower limb structures sustaining the highest incidence of injuries were the anterior thigh and knee, albeit the burden from knee injuries was significantly greater than any other lower limb structure (P<0.05). Injury burden was significantly greater in the lower limb than any other body region (Lower Limb: 2194 days/1000 player-hours, 95% CI: 2072 – 2323; Upper Limb: 715 days/1000 player-hours, 95% CI: 647 – 790; Head & Neck: 113 days/1000 player-hours, 95% CI: 88 – 146; P<0.05).

* P ≤0.01 versus all other body regions

Figure 5.2 Incidence (injuries per 1000/player-hours) of match injuries reported by body region.
**Table 5.4  Incidence, mean severity and injury burden of match injuries reported by lower limb structure (n=45).**

<table>
<thead>
<tr>
<th></th>
<th>Incidence injuries/1000 player hours (95% CI)</th>
<th>Mean Severity days (95% CI)</th>
<th>Injury Burden days lost/1000 player hours (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee</td>
<td>20 (11 – 37) *</td>
<td>38 (0 – 95)</td>
<td>776 (705 – 854) §</td>
</tr>
<tr>
<td>Ankle</td>
<td>17 (9 – 32)</td>
<td>24 (12 – 36)</td>
<td>399 (349 – 456) §</td>
</tr>
<tr>
<td>Lower Leg/Achilles</td>
<td>6 (3 – 20)</td>
<td>9 (0 – 18)</td>
<td>48 (33 – 71)</td>
</tr>
<tr>
<td>Hip/Groin</td>
<td>7 (1 – 4)</td>
<td>35 (0 – 76)</td>
<td>262 (222 – 309)</td>
</tr>
<tr>
<td>Anterior Thigh</td>
<td>20 (1 – 4) *</td>
<td>12 (4 – 20)</td>
<td>243 (205 – 289)</td>
</tr>
<tr>
<td>Posterior thigh</td>
<td>6 (1 – 3)</td>
<td>20 (0 – 55)</td>
<td>111 (87 – 143)</td>
</tr>
<tr>
<td>Foot/Toe</td>
<td>7 (1 – 3)</td>
<td>48 (0 – 106)</td>
<td>355 (205 – 289)</td>
</tr>
</tbody>
</table>

*Incidence of injuries significantly greater than injuries to lower leg/achillies and posterior thigh at P ≤ 0.05
§ significantly higher injury burden than all other lower limb structures at 95% CI
♯ significantly higher injury burden than lower leg/achilles, hip/groin, anterior thigh, posterior thigh, foot/toe at 95% CI

Considering pathologies by individual lower limb structures (Figure 3), joint and ligament injuries to the ankle (n=8, 15 injuries/1000 player-hours (95% CI: 7 – 30) and contusion injuries to the anterior thigh (n=8, 15 injuries/1000 player-hours (95% CI: 7 – 30) were the most common. When injury burden was considered, joint and ligament injuries (308 injuries/1000 player-hours; 95% CI: 265 – 359) resulted in a significantly greater burden than contusion injuries (143 injuries/1000 player-hours; 95% CI: 114 – 179).
Figure 5.3 Incidence of match injuries as a function of injury type and by lower-limb structure

5.35 Injury Event

More than 4 times as many injuries (71%) resulted from contact events (e.g. scrum, ruck, tackle) compared with injuries (16%) resulting from non-contact events (e.g. running or passing). The mean severity for both contact and non-contact injuries were similar, with 26 (95% CI: 12 – 41) and 29 (95% CI: 11 – 47) days lost from all competitions and training, respectively. The significantly higher incidence coupled with a similar average severity as that of non-contact injuries resulted in the injury burden of contact injuries being significantly greater, with non-overlapping 95% CI, than injuries sustained in non-contact phases of play (2396 days per 1000 player-hours; 95% CI: 2269-2530 and 598 days per 1000 player-hours; 95% CI: 536 – 667, respectively).

The ruck was the match event associated with the greatest incidence of injuries (Figure 5.4), with forwards sustaining a significantly (P = 0.039) greater number of injuries from the ruck than from any other identified match event with 24 injuries per 1000 player-hours (95% CI: 14 - 42). In terms of mean severity, the top three injury events were...
scrummaging (one injury), being tackled and tackling; although no significant differences were observed (Figure 5.4). The mean severity of injuries from being tackled was 38 days lost from all competition and training with a resultant injury burden of 1205 days per 1000 player-hours (95% CI: 1115 – 1301 days per 1000 hours). The ruck, however, despite its incidence rate of 41 injuries per 1000 player hours (95% CI: 27 – 62), was associated with a burden of 580 days per 1000 player-days (95% CI: 510-637) due to an average severity of just 14 days (95% CI: 8 – 20).
No significant difference found between positional groupings, consequently results reported for all players combined.

Only one scrum related injury reported therefore no confidence interval could be calculated.

Figure 5.4 Incidence (injuries per 1000/player-hours) and severity (mean) of match injuries reported by Injury event.
5.4 Discussion

This prospective longitudinal study is the first to investigate match injuries sustained by international level female rugby union players over an extended period (two seasons). The principal findings are that match injuries incidence was 128 injuries per 1000 player-hours with a mean severity of 25 days. The lower limb sustained significantly more injuries than other regions of the body with injuries to the knee resulting in the greatest burden. The ruck was associated with the highest injury incidence and being tackled was the match event associated with the greatest injury burden.

The incidence of match injuries within this study is significantly higher than was reported for premiership players in chapter 4 and also compared with the current body of published literature for elite women’s rugby (Taylor et al., 2011b, Schick et al., 2008, Doyle and George, 2004, Carson et al., 1999). The two most recently published surveillance studies are, however based on world cup tournament play (2006 and 2010) (Taylor et al., 2011b, Schick et al., 2008) and as has been previously observed, injury incidence is higher in surveillance studies of one team rather than multiples teams (Moore et al., 2015). A possible explanation for the difference in injury incidence between single and multiple teams is that less rigorous reporting may occur at major tournaments (Moore et al., 2015) with players and/or medics not reporting all injuries (Schick et al., 2008) and this may have been particularly so for the predominantly amateur era, where teams travelled to tournaments with either minimal or no medical cover (Schick et al., 2008). Furthermore, the nature of English women’s rugby has changed in recent years with the introduction of professional contracts and greater access to medical resources; these changes may well have contributed to more rigorous capturing of injury data for this single team cohort.

The injury incidence reported within this study, when compared with the findings from a meta-analysis of international men’s rugby, (123 injuries per 1000 player-hours; 95% CI: 85-177) elicited no significant difference in injury incidence between sexes (P=0.852) (Williams et al., 2013). Previous comparative injury surveillance data between men and women has found the incidence of injuries in the women’s game to be significantly lower than that reported in the men’s game. Given that data reported from the International men’s game is predominantly from world cup tournaments, the comparative injury risks
noted in this study to the men’s game, may simply reflect a difference in risk associated with tournament versus a 2 season long study of injuries.

In terms of the specific region of the body most affected by injuries, there were more injuries to the lower limb than to any other region of the body, an observation that has been noted in much of the previous rugby injury surveillance literature regardless of sex or playing level (Chapter 2). More specifically, contusion injuries to the anterior thigh alongside injuries to ankle ligaments were the most commonly reported specific injuries within this cohort. The severity of ankle ligament injuries was substantially greater than anterior thigh contusion injuries and consequently the injury burden from this type of ankle injury was significantly greater for this cohort than were contusion injuries to the anterior thigh.

Observations of injury events, found that contact phases of play accounted for a significantly greater number of injuries than non-contact activities. In terms of specific contact events, the ruck resulted in the highest injury incidence within this cohort with 41 injuries per 1000 player-hours, whilst ‘being tackled’ was the second most frequent injury event with an incidence of 32 injuries per 1000 player-hours. A ruck, unlike the set-play scrum, is an unstructured and spontaneous event, which can take place anywhere on the field of play and involve any player. Formed when the player in possession of the ball is grounded following contact from an opponent, the principle of the ruck is to obtain/maintain possession of the ball, by driving the opposition players backwards revealing the ball (Bird et al., 1997). The ruck, similar to the maul, is unstructured and combative in nature but together the ruck and maul have increasingly become a frequent part of the modern game with as many as 178 rucks/mauls occurring per game at the Men’s Rugby World Cup 2015 (World Rugby, 2016b). The nature and frequency of the ruck may well contribute to the high injury rate observed within this study, which is a departure from observations in much of the extant literature where ‘being tackled’ has been identified as the event resulting in more injuries than any other incident. This might be due to the approach this specific squad took to the ruck during the study period, as results from the study of injuries within the English women’s premiership are comparable with, the aforementioned, extant literature (Chapter 4). In terms of the types of injuries sustained in the ruck, 64% (n=14) were contusions, with the majority of these contusion
injuries (n=9) sustained to the lower limb. The average severity for injuries sustained in
the ruck is relatively low, with 14 days being lost from all training and competition,
compared with the mean 38 days lost from ‘being tackled’. The relatively low severity
likely links with the contusion type of injuries observed. Consequently, injury burden for
ruck-related injuries (570 days per 1000 player-hours; 95% CI: 510-637) is significantly
lower than for injuries sustained when being tackled (1205 days per 1000 player-hours;
95%CI: 1115 – 1301).

Analysis of the specific categories (e.g. injury event, body region), whilst highlighting
the magnitude of injury risk and consequently the injury burden, also importantly
provides evidence as to the importance of reducing injuries for those who are in a position
to influence injury prevention strategies. The by-product of this analysis is a better
understanding of the mechanisms with which injuries, both in terms of type and severity,
occur; this in turn will make targeting those particularly high burden areas of the sport
much easier for those managing both the sport and the players. Furthermore, although
the health and well-being of players alone is enough justification for such a process, there
is also evidence that injury burden is associated with team success in both soccer and
rugby (Hägglund et al., 2013b, Williams et al., 2015, Carling et al., 2014); consequently,
where team performance is increasingly an outcome measure, used to determine
continued selection/employment and future funding, it may also provide additional
motivation/justification to address high injury risk areas, particularly where financial
investment is required to progress such projects.

5.5 Conclusion

This study provides the first longitudinal study of match injuries in international level
women’s rugby union players. The injury incidence although similar to that previously
reported for men’s rugby union international match play (Williams et al., 2013), does
highlight when even standard methodologies and definitions are adopted, data may not
be directly comparable if it has been collected across different time periods or
competitions. More specifically to the cohort in this study, it was observed that the lower
limb sustained a significantly higher proportion of injuries than other body regions with
a substantial number of these injuries sustained in contact phases of play. Unsurprisingly,
therefore, it was observed that a significant number of injuries, regardless of body region, were sustained in contact phases of play. Given that the ‘ruck’ and ‘being tackled’ were observed to be the highest risk injury events, efforts should be targeted towards identifying where technique is sub-optimal and more-focused coaching concentrating on safe and effective techniques should be introduced or developed.
Chapter 6: Impact of injury and illness on the preparation of a Rugby World Cup winning squad

6.1 Introduction

Rugby Union is a physically demanding sport, and the combination of high intensity activity and regular contact events results in a substantial risk of injury (Williams et al., 2013). Injury is the most common reason for player unavailability (Parry and Drust, 2006), with consequent impacts upon preparation and team performance. Indeed, injury burden has been shown to be associated with team success in both soccer and rugby (Hägglund et al., 2013b, Williams et al., 2015, Carling et al., 2014). To compound the issue in the women’s game, the pool of international standard players is relatively small and the resources available to manage and prepare these players are limited. Despite this, a great deal of attention has been focused on time-loss injuries in men’s rugby union (Williams et al., 2013), with much less information available regarding women’s rugby union (Chapter 2). Furthermore, the impact of non-time-loss injuries and illness on player availability has not been described in detail.

Growth in participation figures for women’s rugby has been dramatic, with more than 2 million women and girls estimated to be playing rugby worldwide (World Rugby, 2016a). The first Women’s Rugby World Cup was played in 1991, then in 1994 and subsequently on a 4-yearly cycle. Previously, World Cup squads were chiefly amateur in nature, but at the 2014 World Cup there was a mixture of amateur and professional players. In preparation for the 2014 competition, the England women’s rugby squad of 26 players entered an intense 8-month training and competition programme, which ultimately resulted in them being crowned World Champions.

The aim of this study is to report the impact of injury and illness on player availability during an intense period of training and competition prior to and during the Women’s Rugby World Cup.
6.2  Method

6.2.1  Study Design

Utilising an observational prospective cohort design, injuries and illnesses sustained by the 26 players of England Women’s World up winning squad (age (mean ± SD), 27.6 ± 3.9 years; height, 170 ± 6 cm; body mass, 75.3 ± 6.8 kg; sum of eight skin folds, 100 ± 20 mm) were recorded throughout the eight-month preparation period for, and during, the 2014 Rugby World Cup. The final squad of 26 players were part of a larger pool of 31 players who were in a centralised training programme for the 8-month preparation period (January to August 2014); neither injury or illness prevented any player from the larger 31 player pool from being selected for the final world cup squad (n=26). The preparation phase, of 212 days incorporated the Six Nations European competition and culminated on the 1 August 2014 at the start of the 2014 Women’s Rugby World Cup. The Women’s Rugby World Cup tournament itself, lasted 17 days with the first matches being played on the 1 August 2014 and the final on the 17 August 2014.

Extracting individual exposure from match reports and training diaries across both the preparation period and world cup tournament period, the 26-player squad completed 237 match hours and 4723 training hours. Ethical approval for the study was obtained from the University of Bath’s Research Ethics Approval Committee for Health (REACH) in June 2011, and written informed consent collected from all players.

6.2.2  Injury and Exposure Reporting

The study adopted the definitions and methods prescribed in the consensus statement for reporting time-loss and medical attention injuries in rugby union (Fuller et al., 2007c) and were adapted to incorporate illnesses. All injuries and illnesses sustained during the study period were reported and categorised into:

- **time-loss injury/illness** - “...prevents a player from taking a full part in all training and match activities typically planned for that day for a period of greater than 24 hours”

- **medical attention injury/illness** – “... results in a player receiving medical attention but did not result in any time-loss or restriction in participation”.
Details of all injuries and illnesses reported to team medical staff (time-loss and medical attention) were captured within a performance management system. Details of each individual injury/illness included: the date of the injury/illness, its classification using the Orchard Sports Injury Classification System V.10.1 (Orchard et al., 2010), whether there was a change to the players injury status (i.e., prevented/restricted training, player continued to fully train/compete under treatment or simply received one off medical attention), the date of return from injury/illness, and information on the injury event.

Individual match exposure was taken from official tournament records throughout both the preparation phase (match exposure = 137 hours) and world cup tournament period (match exposure = 100 hours). Training exposure was extracted from players’ individual training diaries using an online diary system throughout the preparation phase (total training exposure = 4723 hours), with monthly checks throughout the study period to monitor and encourage compliance.

6.2.3 Data Analysis

Injury incidence is reported as the number of injuries per 1000 player-hours with 95% confidence intervals (CIs), with both time-loss and medical attention incidence calculated from injury data and either match or training exposure. Incidence proportion represents the number of players sustaining injuries/illness as a proportion of the entire population (n=26) over the study period and prevalence is the number of players injured at any one moment in time (Knowles et al., 2006). The severity of time-loss and medical attention injury/illness is presented as the number of days absence (or under treatment for medical attention injuries) from full training (i.e. training typically planned for that day) or match play, due to the reported injury/illness (Fuller et al., 2007c) with the mean (days; 95% CI) and median values (days; 1st and 3rd inter-quartile range (IQR)) presented due to non-normal distribution of the severity measure.

Significant differences in values for injury incidence between positional groups were calculated using two-tailed Z test for comparison of rates (Kirkwood and Sterne, 2003); significance was accepted at the 5% level (equal variances assumed). Differences in
injury severity were calculated using a Kruskal-Wallis Test for multiple groupings and significance was accepted at the 5% level (Kirkwood and Sterne, 2003).

6.3 Results

6.3.1 All injuries and illnesses – training and match

A total of 160 injuries and illnesses (112 injuries, 48 illnesses) were recorded during 229 days of preparation and competition. Of these, 46 injuries and 6 illnesses resulted in at least one day of time-loss from competition and/or full-training. The remaining 66 injuries and 42 illnesses required medical attention but did not result in time loss. Combining match and training injuries, Table 6.1 illustrates the effect of all injuries on the total number of days lost from training/competition, in addition to the proportion of the entire population who sustained an injury or illness at any point during the study period. Table 6.2 provides a breakdown of the incidence of injuries, broken down more conventionally, by training or match exposure.

6.3.2 Injuries

The 66 non-time-loss injuries were sustained by 23 players (incidence proportion of 88%) with an associated time under treatment of 1973 days during the study period. The incidence of non-time-loss match injuries (n=6) was 25 injuries per 1000 player-hours (95% CI: 11-56) and the incidence of non-time-loss training injuries (n=60) was 13 injuries per 1000 player-hours (95% CI: 10-16). The mean time spent playing/competing under treatment for each non-time-loss injury was 32 days (95% CI: 24-40). When comparing incidence based on the severity of injury, non-time-loss injuries had a higher incidence than both minor (1≤7 days) and moderate/severe (>7 days) time loss injuries (P<0.05) (Table 6.2).
Table 6.1  Number, incidence proportion and total number of days lost/under treatment, due to all illness and injuries (match and training combined) sustained during the surveillance period.

<table>
<thead>
<tr>
<th>Injury/Illness</th>
<th>Number</th>
<th>Incidence Proportion (%)</th>
<th>Total days lost/under-treatment&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical Attention Injury</td>
<td>66</td>
<td>88</td>
<td>1973</td>
</tr>
<tr>
<td>Time Loss Injury</td>
<td>46</td>
<td>77</td>
<td>529</td>
</tr>
</tbody>
</table>

**Total (Injury)<sup>c</sup>** | **112** | **96** | **2502** |

| Medical Attention Illness  | 42     | 81                       | 1020                                        |
| Time Loss Illness         | 6      | 19                       | 29                                          |

**Total (Illness)<sup>c</sup>** | **48** | **85** | **1049** |

<sup>a</sup> Sustained during surveillance period of 5954 days  
<sup>b</sup> Number of illnesses per 1000 player-days  
<sup>c</sup> Players receiving treatment

The 46 time-loss injuries were sustained by 20 players (incidence proportion of 77%) with a total of 529 days lost from training/competition during the study period. The incidence of time-loss match injuries (n=26) was 110 injuries per 1000 hours (95% CI: 75-161) and the incidence of training injuries (n=20) was 4 injuries per 1000 hours (95% CI: 3-7). The match injuries resulting in time-loss were sustained by 16 players (incidence proportion of 62%) and resulted in players being absent from full training and/or competition for a mean of 17 days per injury (95% CI: 7-26). Time-loss training injuries were sustained by 10 players (incidence proportion of 38%) and resulted in players being absent from full training and/or competition for a mean of 16 days (95% CI: 9-24).
Table 6.2 Number and incidence of injuries by severity (non-time-loss, >1≤7days, >7days, All time-loss).

<table>
<thead>
<tr>
<th></th>
<th>Non-time-loss</th>
<th>Time-loss</th>
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<tr>
<td></td>
<td>n</td>
<td>Incidence</td>
<td>n</td>
<td>Incidence</td>
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<td>Incidence</td>
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<tr>
<td></td>
<td></td>
<td>(95% CI)</td>
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<td>(95% CI)</td>
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<td>(95% CI)</td>
</tr>
<tr>
<td>Match</td>
<td>6</td>
<td>26 (11-57)</td>
<td>16</td>
<td>68 (42-111)</td>
<td>10</td>
<td>43 (23-79)</td>
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<td></td>
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<td></td>
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<tr>
<td>Training</td>
<td>60</td>
<td>13 (10-16)</td>
<td>8</td>
<td>2 (1-3)</td>
<td>12</td>
<td>3 (1-4)</td>
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</table>

6.3.3 Illness

The 42 reported medical attention illnesses were contracted by 21 players (incidence proportion of 81%). Time under-treatment for medical-attention illnesses amounted to 1020 days with a mean severity of 24 days (95% CI: 13-36) for each illness contracted. The 6 reported time-loss illnesses were contracted by 5 players (incidence proportion of 19%) with a total of 29 days lost from training/competition. Each time-loss illness resulted in a mean of 5 days (95% CI: 2-8) lost from training/competition. Respiratory illness was the most common illness, with 4 time-loss occurrences and 10 medical attention illnesses. The other two time-loss illnesses were a viral infection and a fatigue-related medical problem. Dysmenorrhoea was the second most commonly reported illness, but of the 11 reported cases there was no resultant time-loss. The remaining medical attention illnesses included: sleep related complaints, gastrointestinal problems, haematological issues, dermatological complaints, viral infections and headaches.

6.3.4 Impact of injury/illness on player availability during the preparation period

In total, 3410 player-days (62%) were compromised by either time-loss or non-time-loss injuries/illnesses during the 5512 player-days of the world cup preparation period, when all concurrent injuries/illnesses were removed. This included 2693 player-days
(49%) affected by non-time-loss injuries/illnesses and 717 player-days (13%) lost due to time loss injuries/illnesses (Figure 6.1).

From the squad of 26 players, only 6 players started the world cup preparation phase fully fit with 10 players unavailable due to pre-existing time-loss injuries/illnesses and 10 players fit to train/compete under-treatment. There were no injuries that resulted in players withdrawing from the squad prior to the World Cup tournament.

Figure 6.1 Monthly Fitness status of an International rugby squad during the preparation phase (up to the first day of competition) for the Women’s Rugby World Cup.

6.3.5 Impact of injury/illness on player availability during the World Cup competition

In total 156 player-days (35%) were compromised by either time-loss or non-time-loss injuries/illnesses during the 442 player-days of the World Cup competition. This included 100 player-days (23%) affected by non-time-loss injuries/illnesses and 56 player-days (13%) lost due to time loss injuries/illnesses.

From the squad of 26 players, 9 players were unavailable to participate in full training or competition for one or more days during the 17-day World Cup competition, with one player unavailable on two separate occasions. In addition, 8 players were treated for 11
separate non-time-loss injuries/illnesses during this period. There were on average 24 players (95% CI: 24-25) available for selection on each match day; however, the number of players fit for selection and not receiving any medical interventions on match days was on average 16 players (95% CI: 14 – 18). During the 17 days of the world cup tournament, the proportion of players compromised by injuries/illnesses across the entire period was 50% (incidence proportion); whereas the prevalence of injury/illness amongst the squad, on the days immediately prior to World Cup matches, (time-loss and non-time-loss) ranged from 31% to 46% (Figure 6.2).

6.3.6 Post Competition

Six players were medically managed during part/all of the competition with injuries that subsequently required a period of time-loss from full training (at least one requiring surgery). Two further players were fit under treatment in the post-competition period as a result of injuries sustained during the World Cup. In addition, there was one player who retired immediately following the world cup due to medical advice received following injuries.

![Figure 6.2 Player fitness status during Women’s World Cup rugby tournament](image)

*Figure 6.2 Player fitness status during Women’s World Cup rugby tournament*
6.3.7 Concurrent participation in 7s and 15s

Four players competed in both international 7s and 15s competitions during the study period; in total they sustained 14 time-loss injuries with the remaining 22 players, who only competed in 15s, sustaining 32 time-loss injuries. The incidence proportion of time-loss injuries for 7s players across the study period was 100% compared to 77% for players who only competed in 15s. When all 26 players were included, the incidence of injury in all 15s and 7s rugby matches combined was 110 injuries per 1000 player-hours (95% CI: 75-161), whereas the incidence for 15s rugby matches alone was 90 injuries per 1000 player-hours (95% CI: 58-139).

6.4 Discussion

The aim of this study was to report the impact of injury and illness on player availability during an intense period of training and competition prior to and during the 2014 Women’s Rugby World Cup. In total 5512 player-days were available to the squad during the preparation period, of which 3410 (62%) player-days were compromised due to injury or illness. During the 17-day World Cup tournament, 9 of the squad of 26 players required a period of time-loss from training/competition. Time-loss injuries reduced the number of players available for selection on match days to between 23 and 25 players, although the number of players free from medical management on match days ranged between 14 and 18.

During the preparation phase, 49% of the available training and competition time was compromised by non-time-loss injuries and ongoing treatment and a further 13% of the time lost due to time-loss injuries. The nature of rugby union dictates that preparation is complex, with coaches employing training periodization strategies to balance a number of components (e.g., general and specific conditioning, tactics, general and specific skills) necessary to maximise both individual and ultimately squad performance (Robertson and Joyce, 2015). Restrictions to training due to injury and illness are likely to reduce the benefit gained from carefully designed periodization programmes, potentially compromising physical preparedness, restricting skill development, and limiting team
preparation. In this particular setting, the players transitioned from part-time, amateur status into a period of intensive training in order to achieve the desired performance improvements. Such a change in training approach and training intensity may have increased the risk of injury for these players, since there is a substantial association between both weekly training load and magnitude of change in weekly training load with injury risk in men’s rugby union (Cross et al., 2015). Furthermore, this is a relatively small training squad, and therefore a small number of absent or compromised players might have a large impact on squad preparation. For example, within a group of forwards, the development of scrum performance requires a specific number of specialist players to be available. As such, just two injuries to this player group might mean that specific scrum sessions might not be viable. Alternatively, any available players in key positions might be required to perform more work in a given session, with shorter recovery periods, to cover for an absent player, which in turn may increase their own risk of injury. When the proportion of days compromised in the present study is considered alongside the limited squad side and the transition in training approach, the importance of managing player load is highlighted and should be afforded high priority in scheduling considerations.

The preparation period was affected not only by those injuries sustained during the preparation period itself, but also by pre-existing injuries, with just 6 from the squad of 26 players starting the preparation period fully fit (10 players with time-loss injuries/illnesses and 10 under on-going treatment). The impact of pre-existing injuries on the preparation for and performance during major international tournaments has not previously been well documented within rugby union, with much of the injury surveillance literature concentrating on the injuries sustained during the international tournaments or competitions themselves, and is a challenging factor to isolate in any analysis. However, given that some level of pre-existing injuries are likely to be an inevitable factor amongst a group of elite athletes, coaches need to recognise this and find strategies to minimise the carry-over effect of these injuries both for the individual and the team as a whole (e.g., a carefully managed increase in magnitude/intensity of training for players carrying injuries and/or larger training squads to minimise the disruptions of injured players on training practices). In this particular group, preventative strategies were introduced and implemented during the study period in an attempt to minimise the impact of injury and illness on players. Such strategies included: screening for vitamin D and ferritin levels with dietary advice and/or supplements prescribed as appropriate; advice
and education on the management of menstrual cycles; individually tailored advice and monitoring of players’ nutritional input, and; wellness monitoring to enable early intervention of injury and illness management. The management of the World Cup squad appears to have been effective, based on 25 players being available for selection on the first day of the World Cup competition phase. Moreover, only 31% of the squad were receiving medical treatment at the start of the Rugby World Cup, compared with a study in aquatics (swimming, diving, synchronised swimming, water polo and open water swimming) where 70% of athletes surveyed had reportable injury symptoms prior to a World Championship competition (Mountjoy et al., 2014).

The incidence of illness in female rugby players has not previously been reported, and yet evidence from multi-sport elite events suggests that females may be at higher risk of contracting an illness compared with males (Palmer-Green and Elliott, 2015). The incidence of 8 illnesses per 1000 player-days (95% CI: 6-11) is lower than previously reported from the Men’s Super 14 Rugby Union competition (21 illnesses per 1000 player-days; 95% CI: 19-23) but is very similar to the incidence (8 per 1000 player-days; 95% CI: 6-9) reported in both Men’s football (Dvorak et al., 2011) and athletics literature (Alonso et al., 2010). In common with reports from other elite sporting events, respiratory infections were the most common time-loss and medical attention illness. Factors believed to contribute to respiratory illnesses include physical stress and dehydration of the airways of athletes during severe exercise hyperpnoea (Kippelen et al., 2012). Little can be done to reduce the physical stress of competition, and training needs to be sufficiently demanding to elicit adaptation. As such, measures which may help reduce the risk to athletes, particularly when squads are accommodated in close proximity to each other, should be implemented and monitored for compliance (e.g., isolating players with infections from other members of the squad (Kippelen et al., 2012), education on hand washing techniques, the use of prophylactic nasal sprays (Palmer-Green and Elliott, 2015)).

There were 6 players of the 26-player squad who were medically managed through the World Cup tournament and then immediately withdrawn from full-training/competition following the conclusion of the competition. Given the nature of a 4-year competition cycle and importance of tournaments such as the Rugby World Cup and Olympics, it is likely that some injuries will be medically managed through critical training phases and
the competition period itself, whereas in the off-season those injuries may well have been treated with a period of time-loss in order to ensure their complete recovery. In addition, where squads are relatively small the ability to maintain the medical fitness and availability of every player will be even more essential to team success (Hägglund et al., 2013b). The Rugby World Cup competition structure, with only three days of recovery between matches, ensures that medical management is even more challenging with ‘complete rest’ or ‘time-loss recovery time’ often removed as a viable medical treatment strategy during the key matches or stages of the tournament. The consequences of medically managing players whilst competing may be difficult to quantify, but the number of medical attention injuries that post-tournament require a period of time-loss rehabilitation can be monitored. However, caution must be exercised within any analysis of the severity of subsequent time loss periods as medical and coaching staff are able to afford players generous periods of treatment/rehabilitation and pre-habilitation during the off-season which may overly inflate the severity of what would normally be considered minor injuries.

Four of the World Cup winning squad played in both the England 7s and 15s squads during the study period, as despite England having a comparatively broad playing number base, the pool of international level rugby players remains relatively small. The incidence of time-loss match injuries for 15s rugby during the study period was 90 injuries per 1000 player-hours (95% CI: 58-139), which is higher than previously reported in international women’s rugby literature (36 injuries per 1000 player-hours; CI: 26-49) (Taylor et al., 2011b) but similar to the 123 injuries per 1000 player-hours (95% CI: 85-177) reported in a meta-analysis of international men’s professional rugby (Williams et al., 2013). However, the incidence of match injuries for the players who competed in both 7s and 15s rugby, was 110 injuries per 1000 player-hours (95% CI: 75-161) and whilst this figure is only based on 4 players it is consistent with previous literature reporting higher incidence of injuries in 7s rugby (Fuller and Taylor, 2013a, Fuller and Taylor, 2013b). There are clear challenges for managing the player health and availability of international women’s rugby squads who rely on the same pool of player for both 15s and 7s tournaments and although this study simply provides a point estimate of the risk of injury to this specific group of players, it does suggest that further surveillance is required to monitor and protect the welfare of players playing in both 7s and 15s rugby union.
In order to minimise the risk of injury, team coaches should monitor the magnitude of changes to training loads as players enter into intense periods of preparation for international competitions. The impact of injuries on both the individual and the squad should be minimised through strategies such as increasing the size of training squads, which will serve to minimise the disruptions on training practices and/or reduce the risk of placing additional load on available players who might cover key positions for injured players during training practices. Finally, where squads are accommodated in close proximity to each other, measures to reduce the risk of illness should be implemented.

6.5 Conclusion

This is the first study to report upon the impact of injuries and illness on the availability of players during an intense preparation period prior to an international competition. Injuries and illness reduced squad availability for the England women’s rugby union squad during both the preparation and the competition phases of their World Cup winning campaign. Restrictions on training, due to injury and illness, are likely to have reduced the benefit gained from the carefully constructed periodization programmes potentially compromising both individual physical preparedness and skill development, and overall team preparation. Consideration should be given to both injuries sustained during any preparation period but also to pre-existing injuries which players have sustained prior to commencing any intense period of training. This study highlights, how a sport that relies on a relatively small talent pool, needs to manage player load, particularly for those players who compete in both 15s and 7s rugby union.
Chapter 7: Epidemiology of injuries in a women’s international rugby sevens World Cup squad.

7.1 Introduction

The profile of rugby sevens is rapidly growing, and the inclusion of sevens in the Olympic Games will likely lead to further growth. Injury incidence in elite men’s rugby sevens players is higher than men’s 15-a-side rugby (Fuller et al., 2010), possibly due to the different physical demands in matches and training experienced by sevens players (Takahashi et al., 2007). Indeed, sevens players cover greater distances (relative to match duration), at greater average running speeds and with less rest between phases of play (Suarez-Aromon et al., 2012b). Little is known about injury risk in women’s rugby sevens, but the differences in physical demands compared with women’s 15-a-side rugby mirrors those for men (Suarez-Aromon et al., 2012a), so it is expected that the injury incidence will also be substantially higher than in the women’s 15-a-side game. At the point when the study was designed, the only available data pertaining to International women’s rugby sevens was from a World Rugby (previously International Rugby Board) injury surveillance report from the Women’s World Cup/Series tournaments between 2011-13, in which the reported incidence of match injuries was 108 injuries per 1000 player-match hours (82 – 143) (Fuller and Taylor, 2013a). Consequently, the aim of this study was to provide a longitudinal description of the incidence, nature and severity of injuries sustained by elite international women’s rugby sevens players during a 6-month period of intensive training and competition.

7.2 Method

7.2.1 Study Design

Utilising an observational prospective cohort design, match and training injuries sustained by 17 members of an international rugby sevens squad (age (mean ± SD), 25 ± 3 years; height, 169 ± 6 cm; body mass, 69 ± 6 kg; body mass index, 24.1 ± 1.9 kg/m²) were reported throughout six months of preparation for, and during, the IRB 2013 Rugby
Sevens World Cup. The squad were in a centralised training programme for the 6-month preparation period (January to July 2013) which included six international tournaments. Team medical staff recorded all injuries. Injury incidence is reported as the number of time-loss injuries (>24 hours definition (Fuller et al., 2007c)) per 1000 player-hours with 95% confidence intervals (CIs). Injury severity is presented as the number of days a player was not available for training or match play (days absence) with the mean (days; 95% CI) and median values (days; inter-quartile range (IQR)) provided. Injury burden is reported as total days’ absence per 1000 player-hours (injury incidence multiplied by mean severity). Individual match exposure was taken from official tournament records and training exposure was extracted from player training diaries. Significant differences for injury data (incidence and proportions) between positional groups were assumed if 95% confidence intervals (CI) did not overlap.

Ethical approval for the study was obtained from the University of Bath’s Research Ethics Approval Committee for Health (REACH) in June 2011 and written informed consent was collected from all players.

7.3 Results

7.3.1 Match Injuries

Sixty-four player-match hours were recorded, with 12 match injuries reported and 403 days lost because of match injuries. Match injury incidence was 187 injuries per 1000 player-match hours (95% CI, 106 - 329) with a mean severity of 34 days (95% CI, 7-61) and median of 14 days (IQR, 7-34). Injury burden of match injuries was 6273 days per 1000 player-match hours (95% CI, 4474 -8798). The lower limb was the body region most commonly injured, with the highest injury severity and consequently a significantly greater injury burden than other body regions (Table 7.1). The match event associated with the greatest number of injuries and greatest injury burden (Table 7.2) was ‘being tackled’, with all but one of these injuries being sustained to the lower limbs (n=5).
### Table 7.1 Match injuries by location, injury type and nature of onset

<table>
<thead>
<tr>
<th>Location</th>
<th>Incidence, n Injuries/1000hrs (95% CI)</th>
<th>Severity, d, mean (95% CI)</th>
<th>Injury Burden, days lost/1000 hrs (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head / Neck</td>
<td>2 31 (8 – 124)</td>
<td>16 (0 - 32)</td>
<td>498 (305 – 813)</td>
</tr>
<tr>
<td>Lower Limbs</td>
<td>7 109 (52 – 229)</td>
<td>48 (4 - 92)</td>
<td>5228 (3940 – 6938)*</td>
</tr>
<tr>
<td>Trunk</td>
<td>1 16</td>
<td>13</td>
<td>202</td>
</tr>
<tr>
<td>Upper Limbs</td>
<td>2 31 (8 – 124)</td>
<td>11 (5 – 17)</td>
<td>342 (190 – 618)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Injury Type</th>
<th>Incidence, n Injuries/1000hrs (95% CI)</th>
<th>Severity, d, mean (95% CI)</th>
<th>Injury Burden, days lost/1000 hrs (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central/peripheral nervous system</td>
<td>1 16</td>
<td>8</td>
<td>124</td>
</tr>
<tr>
<td>Contusions</td>
<td>2 31 (8 – 124)</td>
<td>4 (2 – 6)</td>
<td>124 (47 – 124)</td>
</tr>
<tr>
<td>Bone</td>
<td>3 47 (15 – 145)</td>
<td>83 (3 – 163)</td>
<td>3874 (3125 – 4805)*</td>
</tr>
<tr>
<td>Joint (non-bone) / Ligament</td>
<td>3 47 (15 – 145)</td>
<td>36 (0 – 84)</td>
<td>1666 (1200 – 2314)</td>
</tr>
<tr>
<td>Muscle &amp; Tendon</td>
<td>3 47 (15 – 145)</td>
<td>10 (1 – 15)</td>
<td>481 (261 – 886)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Onset</th>
<th>Incidence, n Injuries/1000hrs (95% CI)</th>
<th>Severity, d, mean (95% CI)</th>
<th>Injury Burden, days lost/1000 hrs (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute</td>
<td>1 156 (84 – 289)</td>
<td>38 (6 – 70)</td>
<td>5913 (5053 – 6919)*</td>
</tr>
<tr>
<td>Gradual</td>
<td>2 31 (8 – 124)</td>
<td>12 (5 – 18)</td>
<td>373 (263 – 530)</td>
</tr>
</tbody>
</table>

**Note:**

* Significantly different from all other injury types based on non-overlapping 95% CIs

# Significantly different from contusions and muscle & tendon injury types based on non-overlapping 95% CIs.

Confidence intervals were not calculated where there was only one injury.
Table 7.2 Match injury – associated event

<table>
<thead>
<tr>
<th>Injury Event</th>
<th>Incidence injuries/1000 hrs (95% CI)</th>
<th>Severity, d, (95% CI)</th>
<th>Injury Burden, days lost/1000 hrs (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tackled</td>
<td>93 (42 – 208)</td>
<td>54 (4 – 105)</td>
<td>5069 (2278 – 11,284) *</td>
</tr>
<tr>
<td>Running</td>
<td>31 (8 – 124)</td>
<td>9 (0 – 21)</td>
<td>280 (70 – 1120)</td>
</tr>
<tr>
<td>Ruck</td>
<td>16</td>
<td>13</td>
<td>202</td>
</tr>
<tr>
<td>Tackling</td>
<td>16</td>
<td>24</td>
<td>373</td>
</tr>
<tr>
<td>Other</td>
<td>31 (8 – 124)</td>
<td>11 (5 – 17)</td>
<td>342 (86 – 1369)</td>
</tr>
</tbody>
</table>

* Significantly different from running and ‘other’ Injury events, based on non-lapping 95% CIs
Confidence intervals were not calculated where there was only one injury.

7.32 Training Injuries

In total, 2244 player-training hours were recorded, with 22 training injuries reported and 986 days of time lost due to training injuries. Training injury incidence was 10 injuries per 1000 player-training hours (95% CI, 7 - 15) with a mean severity of 45 days (95% CI, 18-71) and a median of 15 days (IQR, 7-54). Injury burden of training injuries was 439 days per 1000 player-training hours (95% CI, 235 - 822).

There were significantly more injuries to the lower limbs (n=20) than to the upper limbs (n=2, Table 7.3), with lower limb injuries resulting in a mean of 49 days lost from match or training activities. Running injuries had a significantly higher injury burden than all other injury events (Table 7.4).

A greater number of gradual onset, rather than acute, injuries occurred during training.
activities (Table 7.3) but no significant difference was determined. Of the 14 gradual onset injuries observed, 7 injuries were reported to be related to running activities (i.e., cumulative effect of repeated bouts of running), with the cause of the remaining 7 injuries undetermined.

Table 7.3 Training Injury by location, Injury type and nature of onset

<table>
<thead>
<tr>
<th></th>
<th>Incidence, Injuries/1000 hrs (95% CI)</th>
<th>Severity, mean (95% CI)</th>
<th>d, days lost/1000 hrs (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head/Neck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Limbs</td>
<td>20</td>
<td>8.9 (5.7 – 13.8)*</td>
<td>49 (20 – 78)*</td>
</tr>
<tr>
<td>Trunk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Limbs</td>
<td>2</td>
<td>0.9 (0.2 – 3.6)</td>
<td>7 (2 – 11)</td>
</tr>
<tr>
<td>Injury Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central/peripheral nervous system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contusions</td>
<td>2</td>
<td>0.9 (0.2 – 3.6)</td>
<td>99 (0 – 282)</td>
</tr>
<tr>
<td>Bone</td>
<td>6</td>
<td>2.7 (1.2 – 6.0)</td>
<td>24 (6 – 42)</td>
</tr>
<tr>
<td>Joint (non-bone) / Ligament</td>
<td>7</td>
<td>3.1 (1.5 – 6.5)</td>
<td>67 (3 – 131)</td>
</tr>
<tr>
<td>Muscle &amp; Tendon</td>
<td>5</td>
<td>2.2 (0.9 – 5.4)</td>
<td>30 (0 – 63)</td>
</tr>
<tr>
<td>Other Injuries</td>
<td>2</td>
<td>0.9 (0.2 – 3.6)</td>
<td>12 (6 – 18)</td>
</tr>
<tr>
<td>Onset</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute</td>
<td>8</td>
<td>3.6 (1.8 – 7.1)</td>
<td>57 (0 – 116)</td>
</tr>
<tr>
<td>Gradual</td>
<td>14</td>
<td>6.2 (3.7 – 10.5)</td>
<td>38 (11 – 64)</td>
</tr>
</tbody>
</table>

* Significantly different from the upper limbs based on non-overlapping 95% CIs
Table 7.4 Training injury-associated event

<table>
<thead>
<tr>
<th>Injury Event</th>
<th>n</th>
<th>Incidence, injuries/1000 hrs (95% CI)</th>
<th>Severity, d, mean (95% CI)</th>
<th>Injury Burden, days lost/1000 hrs (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running</td>
<td>10</td>
<td>4.5 (2.4 - 8.3)</td>
<td>38 (10 – 67)</td>
<td>172 (126 - 237)*</td>
</tr>
<tr>
<td>Collision</td>
<td>2</td>
<td>0.9 (0.2 - 3.6)</td>
<td>5 (0 – 11)</td>
<td>4 (2 - 10)</td>
</tr>
<tr>
<td>Ruck</td>
<td>1</td>
<td>0.4</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Side-Step</td>
<td>1</td>
<td>0.4</td>
<td>226</td>
<td>90</td>
</tr>
<tr>
<td>Tackling</td>
<td>1</td>
<td>0.4</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
<td>3.1 (1.5 – 6.5)</td>
<td>51 (2 – 100)</td>
<td>159 (121 - 209)#</td>
</tr>
</tbody>
</table>

* Significantly different from collision injury events based on non-overlapping 95% CIs
# Significantly different from collision, injury events based on non-overlapping 95% CIs.

Confidence intervals were not calculated where there was only one injury.

7.4 Discussion

The aim of this study was to provide the first longitudinal description of the incidence, nature and severity of injuries sustained by elite international women’s rugby sevens players during a 6-month period of intensive training and competition. The match and training injury incidence rates were 187/1000 hours (95% CI: 106 – 330) and 10/1000 hours (95% CI: 7 – 15), respectively.

The match injury incidence of 187 injuries per 1000 player-match hours (95% CI: 106-329) is substantially higher than previously reported for both women’s sevens (71 - 109 injuries per 1000 player-hours) (Fuller et al., 2017) and 15-a-side rugby (36 injuries per 1000 player-hours) (Taylor et al., 2011b) (as discussed in Chapters 4,5 and 6). Higher
match injury incidence in sevens compared with the 15-a-side game is consistent with findings in the men’s game (IRB, 2013a) and is likely related to the higher intensity of sevens in terms of running demands (greater mean distances run per unit time, greater % of time running at high intensities and reduced recovery periods between game events) (Suarez-Arrones et al., 2012a). This increased match intensity, with a greater number of short-duration high intensity stretch-shortening cycle based movement efforts combined with physical collisions and limited rest may lead to fatigue. This fatigue may serve to increase injury risk through the amplification of existing intrinsic risk factors, for example, diminishing dynamic balance, detrimentally affecting joint stability and increasing the forces on passive tissues (Liederbach et al., 2014). The results from the present study indicate that this cohort were at higher risk of injury than their male counterparts; however, it must be remembered, that these results are based on a small sample of players following a specific training schedule and consequently caution should be taken before generalising or making definitive statements.

Incidence rates observed for both match and training injuries (187 and 10 injuries per 1000 player-hours, respectively) were also substantially higher than those reported for match injuries in men’s sevens (106 injuries per 1000 player-match hours; 95% CI: 96.4 - 116.4)(Fuller and Taylor, 2013b) and for training injuries sustained during a similarly intense period of training for an international women’s 15-a-side squad (4 injuries per 1000 player-training hours; 95% CI: 3 - 7) (reported in Chapter 6). Women appear to be at greater risk from soft-tissue injuries than men (Magnusson et al., 2007), and data from basketball (Deitch et al., 2006), soccer (Arendt and Dick, 1995) and handball (Langevoort et al., 2007) indicate that women are at greater risk of specific lower limb soft tissue injuries (e.g., ACL injuries) than men.

The lower limb was the body region that sustained the highest proportion of injuries during both match and training activities. Noticeably, the lower limb training injuries were predominantly due to non-contact mechanisms, which has similarly been found in studies following individual International men’s squads building up to 15 a-side RWCs (Moore et al., 2015, Brooks et al., 2005c). Importantly, with a scarcity of data pertaining to training injuries within rugby sevens (Fuller and Taylor, 2015), this provides the first indication of the scale of non-contact training injuries in women’s rugby sevens; this is potentially important given that non-contact injuries have been suggested to be to some
extent modifiable (Gabbett, 2010), particularly as the training environment is more controllable. For example, the use of neuromuscular training programmes has been found to reduce the incidence of lower limb injuries in general (Kamper and Moseley, 2011) and ACL injuries specifically (Myer et al., 2013).

The sevens competition programme affords full-time squads an opportunity, often not available to 15s teams, to plan and periodise training between competition blocks and to deliver higher training loads. This has the potential to mitigate the risk of match injury by better conditioning to reduce the effect of fatigue. However, prior to the study period these players were training on an amateur basis, typically two club-training sessions per week plus regular strength & conditioning training. Therefore, the transition to a concentrated period of training, coupled with the different physiological demands associated with rugby sevens compared with the 15-a-side format (Suarez-Arrones et al., 2012b), may have been associated with training overload and an increased risk of training injury. Windt and Gabbett (2017) argue that it is not simply the type of high training load (e.g. volume, intensity, frequency of training) that contributes to an increased injury risk but also the magnitude of the changes (rate of change) to an individuals training load from the previous week, that are the likely predictors of injury.

7.5 Conclusion

While overall exposure and injury count were relatively low, this study provides the first longitudinal description of both training and match injuries in women’s sevens. The main finding is that the incidence of match and training injury for this group was higher than previously reported in both men’s rugby sevens (Fuller et al., 2010) and women’s 15-a-side rugby union (Taylor et al., 2011b) and provides a point estimate for future studies to build upon. Furthermore, these initial findings suggest that injury prevention strategies targeting training-related lower limb soft tissue injuries, in addition to carefully graded changes to prescribed high intensity training loads may be beneficial.
Chapter 8: General Discussion

8.1 Addressing the research objectives

The series of studies contained within this thesis were conducted to expand upon the body of knowledge relating to the nature of injuries in elite women’s rugby with a long-term aspiration of identifying appropriate routes for injury reduction. To achieve this aim a number of specific research questions were developed and a brief summary of the principle findings are detailed below.

Research Question 1: What is the incidence, severity, nature and events of match injuries in women’s rugby union for elite level club players?

Principal Findings (Study 1, Chapter 4):

- Match injury incidence was 43 injuries per 1000 player-hours (95% CI: 38-49).
- Mean severity of injuries was 36 days (95% CI: 29-44).
- The lower limb sustained the highest incidence of injuries with knee injuries accounting for the greatest proportion of these injuries.
- ‘Being Tackled’ was associated with a significantly higher injury incidence than any other match event.
- Early recurrent injuries incur higher severity than their index injury.

Research Question 2: What is the incidence, severity, nature and events of match injuries in women’s rugby union for International level players?

Principal Findings (Study 2, Chapter 5):

- Match injury incidence was 128 injuries per 1000 player-hours (95% CI: 101-162).
- Mean severity of injuries was 25 days (95% CI: 14-35).
- The lower limb sustained significantly more injuries than other regions of the body with injuries to the knee resulting in the greatest burden.
- The ‘Ruck’ was associated with the highest injury incidence and ‘being tackled’ was the match event associated with the greatest injury burden.

**Research Question 3:** What is the impact of injury and illness on player availability during an intense period of training and competition prior to and during the Women’s Rugby World Cup?

Principal Findings (Study 3, Chapter 6):

- 62% of the total days available during the preparation period were compromised due to illness or injury.
- During the 17-day World Cup tournament, 9 of the squad of 26 players required a period of time-loss from training/competition and 50% of the squad were affected by either time-loss or non-time-loss injuries.
- On match days, time-loss injuries reduced the number of players available for selection to between 23 and 25 players out of 26.
- The number of squad players (n=26) free from medical management on match days ranged from 14 to 18.

**Research Question 4:** What is the incidence, nature and causes of match and training injuries sustained by elite female rugby sevens players during preparation for and during the rugby Sevens World Cup?

Principal Findings (Study 3, Chapter 7):

- Match and training injury incidence rates were 187/1000 hours (95% CI: 106 – 330) and 10/1000 hours (95% CI: 7 – 15), respectively.
- The match injury incidence of 187 injuries per 1000 player-match hours (95% CI: 106-329) is substantially higher than previously reported for both women’s sevens and 15-a-side rugby
- There lower limb sustained significantly more training injuries 8.9/1000 hours (95% CI: 5.7 – 13.8) than other regions of the body with the highest proportion of these injuries predominantly due to non-contact mechanisms.

8.2 Contribution to Knowledge

There is a paucity of data relating to the risk of injury to elite women’s rugby union players both in the 15-a-side and 7s formats. The findings from Chapter 4 suggest that the incidence of injury in elite level 15-a-side club rugby is similar to that previously reported for women’s rugby union international tournament match play (Taylor et al., 2011b, Schick et al., 2008) but significantly lower than has previously been reported for the elite level or top tier of men’s club rugby (Williams et al., 2013). In contrast, the mean severity of injuries was significantly higher than was reported in a meta-analysis of men’s rugby (Williams et al., 2013) and perhaps reflects the amateur nature of women’s rugby union compared with the professional environment of their male counterparts. The professional environment of the men’s game, allows players to prioritise their training and match days; no longer are they trying to balance the demands of full or part-time employment alongside the twice weekly training sessions, commonly found in the amateur game. Those managing professional players, are thus able to carefully plan and prioritise training and rest, around key matches and/or periods of the season. The medical management of players is also a key component when discussing the professional game and is likely to have contributed to some of the differences seen within this thesis when comparing club and international injury data (Chapters 4 and 5 respectively) but also between the women’s and the professional men’s game. The availability of specially trained medical staff, managing players health and rehabilitation on an often daily basis in the professional arena, can act as both a preventative measure and help to reduce the severity of injuries which are sustained by administering immediate assessment and treatment. The medical cover available in the amateur environment can vary vastly and can be dependant not only on the availability of medical staff but also on players themselves. The comparison between the professional and amateur environments is very much situation specific, with different levels of medical management and player availability issues arising for different clubs/squads. However, being able to make direct comparisons between club squads (Chapter 4) and international squads (Chapter 5,6 and
7) is certainly a starting point from where to further develop the rationale for greater medical support, if not the complete transition to the professional game.

The incidence of injuries was significantly different for women competing in club competitions when compared with those competing in international rugby matches. In addition, there was also a difference in the incidence of injuries sustained in the Women’s international 15-a-side game compared with women’s rugby sevens, where the incidence was reported to be higher. Level of play has previously been shown to have a correlation with incidence of injuries (low level = lower incidence, high Level = higher Incidence) and thus the significant difference in the incidence of injuries sustained by players competing in club rather than international matches would be expected. The difference noted between club players in the women’s and men’s games, although unsurprising given the amateur versus professional status, does provide some initial evidence of the need for sex specific injury surveillance research. The relatively high incidence of injuries noted in women’s rugby sevens compared with the 15-a-side game is similar to that seen in the men’s game; the incidence noted is however, higher than that reported for the men’s game which, as was noted above, contrasts with the 15-a-side game. However, injury incidence is higher in surveillance studies of one team rather than multiples teams (Moore et al., 2015), which may in part me due to the relationship a researcher can establish with a single squad; which might be more challenging for multiple teams particularly where language barriers and physical distances can be a hindrance.

The elevated incidence of injuries in sevens rugby, compared to 15-a-side rugby, is likely related to the high intensity nature of the game, predominantly due to the intense running demands (greater mean distances run per unit time, greater % of time running at high intensities) and reduced recovery periods between game events (Suarez-Arrones et al., 2012a). However, these reasons are equally relevant for both men and women, and consequently does not explain the higher incidence of injuries for women compared to their male counterparts in Chapter 7. One explanation could be that women are at greater risk of certain types of injuries, e.g. soft tissue injuries, which are more common in sevens rugby; evidence from the fast and aggressive game of basketball revealed similar findings particularly in respect of ACL injuries with women sustaining four-fold more ACL injuries than their male counterparts (Deitch et al., 2006). An alternative hypothesis,
could simply be that the speed of transition, from amateur to full time training, may well have been too quick/severe for the cohort studied in Chapter 7; which in turn may have been associated with training overload and an increased risk of injury. This phenomenon is more easily avoided in the elite men’s game which is entirely professional. This research provides a point estimate from where to move forward, the requirement is now to continue to monitor injuries which occur in women’s sevens rugby; thus, providing the opportunity to not only add to this research but also help guide the development, application and then re-assessment of appropriate preventative strategies.

Figure 8. 1 Incidence rates recorded across the rugby playing population in each of the four experimental studies.

Given the nature of women’s club rugby and its amateur nature, it is perhaps unsurprising that the mean severity of injuries is higher for women than for their professional male counterparts. The severity measure used throughout this thesis does however represent the number of playing/training days lost due to a player’s injury rather than a measure based on the diagnosed seriousness of the injury (e.g., fracture scoring higher than abrasion). Consequently, the reason for the higher severity observed in chapter 4 is likely to be multifactorial. For example, medical staff at club level are typically only available
during training and match days due to economic constraints, reducing access to treatment and rehabilitation by players which may result in less than optimal treatment/rehabilitation of injuries (van Beijsterveldt et al., 2014). In contrast, professional male players are likely to have daily contact with their club medical staff. There is also the time constraint placed on the amateur female players themselves when attempting to balance rehabilitation activities with their normal day-to-day employment; again this is likely to be quite different from their professional male counterparts who are able to focus more fully on the rehabilitation process.

Mean severity of injuries was higher at club (chapter 4) than international level (Chapter 5 and 6). Whereas, when comparing the different international environments in chapters 5 and 6, the results indicate that there is a lower injury severity associated with tournament play when compared to injury severity for players across multiple seasons. Again, this is perhaps unsurprising given the importance placed on these relatively short duration competitions, coupled with the 4-year cyclical nature of tournaments such as the World Cup. Players and indeed team management are likely to take a less therapeutic approach to injuries in the short-term to maximise the likelihood of winning or meeting pre-agreed tournament goals/aims. Moreover, there is also the risk that players that seek medical help after the conclusion of the tournament are either not reporting their injuries to their respective squad medical teams or their injuries are simply not being reported by their medical teams back to the researcher. Continued and persistent communication with squad medical staff post tournaments is therefore essential if this unreporting is to be minimised.

In Chapters 4,5 and 7 there were significantly more injuries to the lower limb than to any other region of the body, an observation that has been noted in much of the previous rugby injury surveillance literature regardless of sex or playing level (Gabb et al., 2014). The cost or impact of these injuries to the individual must be considered, there is also the injury burden of losing a team or squad member; this is an important consideration in the modern era where success dictates future funding and injury burden has been shown to be associated with team success in both soccer and rugby (Hägglund et al., 2013b, Williams et al., 2015, Carling et al., 2014). In chapter 7, injuries to the lower limb resulted in the greatest injury burden with running injuries being the main cause. In contrast to
the lower limb injuries noted in Chapters 4 and 5, match and training injuries were captured in Chapter 7.

As training environments are perceived to be more controllable and modifiable, the aetiology of injuries which occur in this area are an important consideration from an injury prevention perspective. What is more, in Chapter 7, the lower limb training injuries were predominantly due to non-contact mechanisms, which has similarly been found in studies following individual international men’s squads building up to 15 a-side RWCs (Moore et al., 2015, Brooks et al., 2005c). Given that non-contact injuries also have been suggested to be to some extent modifiable (Gabbett, 2010) this is definitely an area where further research and/or modification of practices, would have the potential to reduce the number and severity of injuries. Preventative strategies, such as those adopted in movement control training protocols, have been successfully utilised in female football; indeed published research has found that the use of neuromuscular training programmes to be effective in reducing the incidence of lower limb injuries in general (Kamper and Moseley, 2011) and ACL injuries specifically (Myer et al., 2013).

Soft tissue lower limb injuries are not the only injury type helped by exercise programmes, with encouraging evidence published in 2017 advocating the use of neck strengthening exercise programmes to reduce the incidence of concussion (Hislop et al., 2017). The study involving schoolboy rugby players found that a preventive movement control exercise programme, completed three or more times a week, was effective at reducing the match concussion incidence compared to a control (Hislop et al., 2017). The researchers, suggested that the exercise programme, which included neck resistance exercises to enhance neck muscle strength, may have helped reduce the incidences of concussion through the dissipation of impact forces transmitted to the brain. There has been a substantial amount of publicity surrounding both the short-term and long-term detrimental effects of concussion, with some researchers calling for considerable changes to inherent parts of the rugby union game such as the tackle (Pollock et al., 2017).

In this thesis and specifically Chapter 4, the incidence of concussion was found to be 3 injuries per 1000 player-hours (95% CI: 2-5) and when a direct comparison between men’s and women’s English Premiership’s was investigated, it was established that the incidence of injuries in the women’s game was less than had been reported for the men’s
English Premiership across the same period of time (Cross, 2016). This result is not consistent with research from other sports, where female athletes have previously been reported to be at a higher risk of sustaining a concussion than their male counterparts in US collegiate soccer, basketball and ice-hockey based on similar definitions (Covassin and Elbin, 2011), with suggestions that this might be associated with lower neck strength of females compared with males (Tierney et al., 2005). Given the small number of concussions sustained throughout the 3 seasons (Chapter 4), further surveillance is required to provide those who manage the game the opportunity to monitor season-on-season trends as the women’s game develops. The organic by-product of continuous monitoring is an increase to the sample size, which in turn may provide further reassurance as to the risk of concussion in the women’s game, particularly where under-reporting is suspected. It will also give all those concerned with the welfare of the players, the opportunity to introduce and monitor measures aimed at, increasing neck muscle strength and increasing compliance through. rule adaptations, enhanced medical cover for match days and player/management education.

There are those that would like to ban the tackle in some parts of the game (Pollock et al., 2017), but tackling and being tackled are integral parts of what makes the game of rugby a collision sport. In Chapter 4, the tackle and specifically ‘being tackled’ was the match event associated with the greatest proportion of injuries. The severity of injuries sustained whilst ‘being tackled’ was also one of the top mechanism’s for sustaining an injury with a mean severity of 43 days recorded. As a consequence, the injury burden of ‘being tackled’ was significantly higher than any other injury event. Interestingly, in international rugby (Chapter 5), the ruck was the event associated with greatest incidence of injuries but injuries from ‘being tackled’ were, on average more severe than ruck related injuries. The difference between standards of play in Chapters 4 (club) and 5 (international) may in part explain why more tackle injuries are noted in club matches; as it is possible that the tackling technique has yet to be optimally developed by some players due to their level of experience. Burger et al. (2016), reported an association between ‘better’ or more proficient tackling and ball-carrying technique and a reduction in the risk of injury during tackle events. Consequently, the priority should be to improve the tackling technique of all players in order to reduce the risk of injury, through practice and coach education. As its relative difficulty to influence injury risk in the tackle compared
with more controlled aspects of the game such as the scrum, an alternative approach would be to concentrate on the conditioning of commonly injured specific regions/structures of the body, in the hope that they would be less susceptible to injury. Although training programmes such as the RFU’s Activate warm-up programme has reported to be of benefit for injury risk reduction in both youth and community men’s rugby (Hislop et al., 2017, Attwood et al., 2017), the demands on Rugby Union players includes repetitive completion of demanding athletic movements in addition to mastering and performing very specific game techniques (i.e. the tackle, scrum). Consequently, it could be argued that an injury prevention programme which addresses both improvements in physical attributes (i.e. functional movement competence) and technique should be developed and investigated.

The sevens game (Chapter 7) has a very different structure from the 15-a-side game, with a greater amount of time with the ball in play (55% v 44%) but also with approximately 45% less rucks and mauls than an equivalent 15-a-side tournament. As with the tackle, rucks and mauls are unstructured and combative in nature, but together the ruck and maul have increasingly become a frequent part of the modern game.

Illness is another relatively unexplored area within the women’s game, although evidence from multi-sport elite events suggests that females may be at higher risk of contracting an illness compared with males (Palmer-Green and Elliott, 2015). The incidence of illness noted in Chapter 6, was lower than previously reported from the Men’s Super 14 Rugby Union competition but similar to the incidence reported in both Men’s football (Dvorak et al., 2011) and athletics literature (Alonso et al., 2010). In common with reports from other elite sporting events, respiratory infections were the most common illness. Factors believed to contribute to respiratory illnesses include physical stress and dehydration of the airways of athletes during severe exercise hyperpnoea (Kippelen et al., 2012). Although little can be done to reduce the physical stress of competition and training, monitoring illnesses and contributory factors is an important aspect to injury prevention. The reason for players missing training and/or competition is practically irrelevant, regardless as to whether its due to injury or illness. The reduced benefit gained from the carefully constructed periodization programmes potentially compromising both individual physical preparedness and skill development, and overall team preparation is a hindrance for any squad aiming to perform to their highest level at international level.
competitions. But more so for squads who rely on small talent pools and thus losing players to injury or illness can have catastrophic effects on team performance.

8.3 Methodological Considerations and Recommendations for Future Directions

The introduction of injury surveillance into the English women’s rugby premiership was the first step in completing this research. Following a similar format to that adopted by England Men’s Rugby Football Union, clubs as gatekeepers and then individual players were recruited into the study. Unlike the English rugby union professional men’s game, the medics and team managers completing the surveillance paperwork were a mixture of volunteers and sessional staff. Consequently, across the 3 seasons it was necessary to exclude clubs who were not able to provide sufficient information (e.g. where physiotherapists were not regularly attending training). The evolution of the injury surveillance protocol from paper to electronic reporting, in season two and three, anecdotally reduced the work load required of the club staff and improved the efficiency of the entire reporting process. Consequently, if future studies are to be completed it is advocated that funding be sought to directly compensate medics specifically for the provision of injury surveillance services, through either direct payments to the medics themselves or through centrally controlled RFU contracts. Furthermore, the utilisation of electronic medical notes systems are also recommended, where possible, in order to reduce the amount of duplication in reporting and reduce the risk of errors when transposing details of injuries from medics notes to the injury reporting format (proforma, spreadsheet etc) chosen by the respective injury surveillance researchers.

The current scope of elite English women’s club rugby is relatively small with just 8 clubs competing in the Premiership each season. Given that researchers’ estimate that more than 200 cases are needed to identify small to moderate associations between risk factors and injury occurrence, the only available option to increase the sample size was to observe more than one season. The disadvantage of extending the time-period, rather than increasing the number of participants, lies in the occurrence of repeated observations and thereby the amount of independence associated with recurrent injuries sustained by
players. Although the proportion of injuries which are reported to be recurrent in nature, has previously been reported to be relatively small (~12%), when aggregated the severity of these injuries appears be noticeably greater than all new injuries (Williams et al., 2013). More positively, observing more than one season does have the advantage of helping to combat the season-to-season variations in injury patterns, that have been noted by some researchers (Gabbett, 2000, Gabbett, 2008, Phillips et al., 1998, Holder et al., 2002). Hence it is recommended that whilst continuing to complete season-on-season injury surveillance within the English Premiership Clubs, further work should be completed in respect of identifying and monitoring the occurrence and effect of subsequent injuries. The introduction of self-reporting by the players through simple phone apps or even texts is certainly one possibility. It would allow researchers the opportunity to corroborate the data provided by medical staffs.

The two studies which incorporated the World Cup squads, for both 15-a-side and rugby sevens, are similarly restricted by the size of the population, but in contrast to both the multiple season long studies (Chapter 4 & 5) the time-period across which they were studied could not be extended. As a consequence, these studies provide a point estimate of the risk of injury to each of the respective cohorts within their own bespoke environment. The disadvantage of the unique nature of these studies is that is provides difficulty when generalising to the wider population due to the specificity of the training environment and the participants studied. To some extent this is inevitable given the four-yearly cycle of this level of competition which makes any longitudinal monitoring impractical. The advantage, however, of having completed surveillance over the specific training and competition period is the ability to gain in-depth knowledge of English women’s international rugby, at a time when the sport is rapidly evolving at the international level from amateur to professional. This itself helps to develop further hypothesis and adapt ideas for future research.

In terms of recommendations for future research, the aim would be to both expand upon and advance the knowledge gained from these initial investigations. Firstly, the importance of continuing with the current surveillance cannot be under-estimated. Year-on-year monitoring, enables longitudinal analyses of an ever-increasing population and aids the review process for any intervention or law changes encountered across multiple seasons. As Van Mechelen’s (1992) Injury prevention framework
highlights, assessing the effectiveness of an intervention is an integral part of the injury prevention process. The next step having reviewed each study from within this thesis, would be to prioritise which areas of women’s elite rugby union to address with further research. Given that the common theme throughout the thesis has been the need to develop an injury prevention strategy to minimise the risk of injury to the lower limbs this would be the starting point. As has been identified within the thesis, injuries to the lower-limb potentially have both long-term consequences (e.g., osteoarthritis (Drawer and Fuller, 2001)) and short term consequences in terms of squad availability. The subsequent consideration must then be how realistic and therefore appropriate is the delivery of an intervention aimed at reducing the incidence of injury to the lower limbs. Having established the feasibility of such a study, there are then a number of options in terms of the intervention to be introduced including: well established and researched FIFA 11+, the rugby specific RFU Activate, or an individually tailored intervention based on extant research pertaining to both women’s sport and more specifically women’s rugby. Clearly at this point, each option needs to be assessed for suitability and limitations, for such areas as: meeting the research questions aims, delivery and compliance feasibility and cost. This will then allow a pilot study to be planned and executed before rolling it out to the identified population. The RFU Activate programme, is a movement control injury prevention programme, developed specifically for the game of rugby union and with a protocol that has proved successful at reducing the incidence of both lower limb injuries and concussion. Furthermore, with the high level of compliance reported in the study of men’s community level rugby (Attwood et al., 2017), the availability of free resources for clubs through the RFU (RFU, 2017) and the additional benefit in terms of reducing the incidence of concussion; this programme would be worthy of further exploration in terms of planning and execution of a pilot study.

8.4 Thesis Conclusion

Rugby Union is a physically demanding game that has a reputation for being a high risk sport, in terms of injury. The current evidence base is almost exclusively from the men’s game and consequently does not provide an accurate representation of the injury risk in
women’s rugby union. Hence, the aim of this programme of work was to provide a more accurate and up-to-date representation of the risk of injury to women competing at the elite level of this sport both in the 15-a-side and rugby sevens format of the game.

Through the introduction of injury surveillance and subsequent collection of data, areas of concern in terms of high-risk events, vulnerable body regions/structures and potentially problematic training methodologies have been identified. This information can thus be used to inform the injury prevention strategies and training methodologies for English Women’s Rugby, in addition to addressing the resources required to manage the treatment and rehabilitation of those injuries, which are sustained.

Finally, returning to the Injury prevention model described by Van Mechelen’s et al. (1992), whilst the data collected during the course of the thesis serves to complete the first two stages of the model, two more stages are required to complete the cycle. Consequently, the implementation of the preventative measures, identified within this thesis, alongside continued monitoring and surveillance of English women’s rugby are required to complete the cycle. It is only through continued assessment and re-evaluation that the effectiveness of any injury prevention interventions or law changes can be accurately evaluated.
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Appendices

Appendix A1. RFU Injury Surveillance - Player Information Sheets
Appendix A2. RFU Injury Surveillance - Consent – Premiership Club
Appendix A3. RFU Injury Surveillance - Consent - England
Appendix A4. RFU Injury Surveillance - Baseline Form - Season One
Appendix A5. RFU Injury Surveillance - Baseline Form - Season Two & Three
Appendix B. RFU Women’s Premiership Club Contracts/Toolkit
Appendix C1. RFU Injury Surveillance - Weekly Injury Form
Appendix C2. RFU Injury Surveillance - Main Injury Form
Appendix A1. RFU Injury Surveillance - Player Information Sheets

RFUW Injury Audit
Player Information Sheet

An investigation of injuries sustained by rugby union players.

Principal Investigator: Keith Stokes
Lead Investigator: Niki Gabb

You are invited to take part in a research study of injuries sustained during training and matches involving all first team squad players in the premiership. The study is fully supported by the Rugby Football Union for Women. Before deciding whether to take part, it is important that you understand why the study is being undertaken and how it will affect you. Take time to the read the following information carefully; if there are any aspects of the study that you do not understand, please discuss them with a member of your medical team or contact us for further information. When you have read and fully understood the information and you wish to be included in the study, you will be asked to sign a Player Consent Form for the 2013-2014 season. The Principal Investigator responsible for the study is Dr Keith Stokes at the University of Bath and he has been and is currently involved in similar injury surveillance studies in rugby union.

Background to the study
The aim of this study is to determine the incidence, types and causes of injuries sustained by female rugby union players. This will enable comparisons to be made with similar data collected at the elite level of the men’s game. The study will run for two years, beginning during the 2011 pre-season period. Injury surveillance studies of this type provide data that help to monitor levels of injury risk and to develop injury prevention, treatment and rehabilitation programmes in rugby union.

What does the study involve?
Medical personnel at each club will record the details of all match and training injuries sustained by first team players. This data will be analysed by researchers in the Department for Health at the University of Bath.

Who is being asked to participate in the study?
Any player selected within one or more of the following squads will be asked to take part in the study: England Senior; England Under 20; England 7’s; first team squad player at a premiership rugby club.

Do players have to take part?
Participation in the study is voluntary. You do not have to take part in the study but the more players who take part, the more comprehensive the data will be. If you decide to take part, you must sign a consent form that confirms you have been provided with this information and you agree to be included in the study. You are free to withdraw from the study by contacting us at any time without giving a reason.

What do I have to do?
Your club’s medical staff will collect baseline information during pre-season and will record information about any injuries you sustain during training and competition throughout the season. If you currently use the RFU Elite Hub to record training and match exposure and menstrual cycle status you will be asked to continue to do this. If you do not currently use the RFU Elite Hub, training staff at your club will record training and match exposure for you.

Are there any risks from taking part?
You will not be doing anything in addition to your normal rugby activities with the club.

Will information about my injuries be kept confidential?
In accordance with the Data Protection Act, we must obtain your permission to collect information about your injuries during the course of this study. All information collected in the study is recorded and stored anonymously using a player identification code on a database at the University of Bath.

What will happen to the data obtained from the research study?
The data collected will be collated and analysed by researchers at the University of Bath in order to produce summary information about the incidence, severity, types and causes of injuries sustained.

For further information, or if you have any questions, contact Niki Gabb, University of Bath. (Tel: 01225 385469; e-mail:rfuw-audit@bath.ac.uk)
Appendix A2. RFU Injury Surveillance - Consent – Premiership Club

RFUW Injury Audit
Player Information Sheet

Player consent form

I confirm that I have read and understood the player information sheet for the above study and that I have had an opportunity to ask questions.

I agree to take part in the above study and give my consent for doctors, physiotherapists and fitness/conditioning staff to supply medical and training information to the University of Bath. I acknowledge that such information will only be used for research, statistical and other analysis purposes, and that personal references shall not be made in any report or other published material.

I understand that all the information provided on my injuries, training and menstrual cycle status (if self-reported) will be treated in strict confidence and will remain anonymous.

I understand that I have the right to withdraw from this study at any stage and that I will not be required to explain my reasons for withdrawing.

Following up certain injuries
As this project progresses, certain injuries and treatments might stand out as being particularly interesting because they become common, are easily preventable or because one specific type of treatment appears more effective than another. Understanding more about examples such as these will help to reduce the amount of time players are out of the game due to injury in future.

With your permission we would like to follow up some injuries and specific treatments for injuries in more detail as the extra information that we collect improves our understanding of preventing and treating injuries in rugby union. We would like your permission to keep your contact details on file so that in future we can ask you whether you would like to fill in a questionnaire about an injury that you sustain or a treatment that you receive that might be of particular interest.

If you are happy for us to do this, please provide your email address on the consent form. It does not mean that you are committed to completing any questionnaires or answering any questions in the future, just that you consent to us contacting you at a later date if there is a specific injury that is particular interest.

If you do not wish to be contacted in future, please DO NOT provide your email address on the consent form. You can still be part of the main study.

E-mail address

________________________
Name

________________________
Date

________________________
Signature

OFFICE USE ONLY

________________________
CLUB

________________________
PLAYER REGISTRATION NUMBER

For further information, or if you have any questions, contact Niki Gabb, University of Bath. (Tel: 01225 385469; e-mail:rfuw-audit@bath.ac.uk)
Appendix A3. RFU Injury Surveillance - Consent - England

An investigation of injuries sustained by England Senior rugby union players.

Principal Investigator: Keith Stokes  
Lead Investigator: Niki Gabb

You are invited to take part in a research study of injuries sustained during training and matches involving all first team squad players in the premiership. The study is fully supported by the Rugby Football Union for Women. Before deciding whether to take part, it is important that you understand why the study is being undertaken and how it will affect you. Take time to read the following information carefully; if there are any aspects of the study that you do not understand, please discuss them with a member of your medical team or contact us for further information. When you have read and fully understood the information and you wish to be included in the study, you will be asked to sign a Player Consent Form for the 2013-2014 season. The Principal Investigator responsible for the study is Dr Keith Stokes at the University of Bath and he has been and is currently involved in similar injury surveillance studies in rugby union.

Background to the study
The aim of this study is to determine the incidence, types and causes of injuries sustained by female rugby union players. This will enable comparisons to be made with similar data collected at the elite level of the men’s game. The study will run for two years, beginning during the 2011 pre-season period. Injury surveillance studies of this type provide data that help to monitor levels of injury risk and to develop injury prevention, treatment and rehabilitation programmes in rugby union.

What does the study involve?
Medical personnel at each club will record the details of all match and training injuries sustained by first team players. This data will be analysed by researchers in the Department for Health at the University of Bath.

Who is being asked to participate in the study?
Any player selected within one or more of the following squads will be asked to take part in the study: England Senior; England Under 20; England 7’s; first team squad player at a premiership rugby club.

Do players have to take part?
Participation in the study is voluntary. You do not have to take part in the study but the more players who take part, the more comprehensive the data will be. If you decide to take part, you must sign a consent form that confirms you have been provided with this information and you agree to be included in the study. You are free to withdraw from the study by contacting us at any time without giving a reason.

What do I have to do?
Your club’s medical staff will collect baseline information during pre-season and will record information about any injuries you sustain during training and competition throughout the season. If you currently use the RFU Elite Hub to record training and match exposure and menstrual cycle status you will be asked to continue to do this. If you do not currently use the RFU Elite Hub, training staff at your club will record training and match exposure for you. In addition, data pertaining to any illness for which medical attention is sought will be recorded by the medical staff for all Senior England World Cup squad members using the secure medical system.

Are there any risks from taking part?
You will not be doing anything in addition to your normal rugby activities with the club.

Will information about my injuries be kept confidential?
In accordance with the Data Protection Act, we must obtain your permission to collect information about your injuries during the course of this study. All information collected in the study is recorded and stored anonymously using a player identification code on a database at the University of Bath.

What will happen to the data obtained from the research study?
The data collected will be collated and analysed by researchers at the University of Bath in order to produce summary information about the incidence, severity, types and causes of injuries sustained.
Player consent form

I confirm that I have read and understood the player information sheet for the above study and that I have had an opportunity to ask questions.

I agree to take part in the above study and give my consent for doctors, physiotherapists and fitness/conditioning staff to supply medical and training information to the University of Bath. I acknowledge that such information will only be used for research, statistical and other analysis purposes, and that personal references shall not be made in any report or other published material.

I understand that all the information provided on my injuries, training and menstrual cycle status (if self-reported) will be treated in strict confidence and will remain anonymous.

I understand that I have the right to withdraw from this study at any stage and that I will not be required to explain my reasons for withdrawing.

Following up certain injuries
As this project progresses, certain injuries and treatments might stand out as being particularly interesting because they become common, are easily preventable or because one specific type of treatment appears more effective than another. Understanding more about examples such as these will help to reduce the amount of time players are out of the game due to injury in future.

With your permission we would like to follow up some injuries and specific treatments for injuries in more detail as the extra information that we collect improves our understanding of preventing and treating injuries in rugby union. We would like your permission to keep your contact details on file so that in future we can ask you whether you would like to fill in a questionnaire about an injury that you sustain or a treatment that you receive that might be of particular interest.

If you are happy for us to do this, please provide your email address on the consent form. It does not mean that you are committed to completing any questionnaires or answering any questions in the future, just that you consent to us contacting you at a later date if there is a specific injury that is of particular interest.

If you do not wish to be contacted in future, please DO NOT provide your email address on the consent form. You can still be part of the main study.

_______________________
E-mail address

_______________________
Name

_______________________
Date

_______________________
Signature

OFFICE USE ONLY

_______________________
CLUB

_______________________
PLAYER REGISTRATION NUMBER
## RFUW Injury Audit
### Player Baseline Information Form

<table>
<thead>
<tr>
<th>SQUAD REF NO:</th>
<th>SEASON: 2012/2013</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Player (Family name, initial)</th>
<th>Player's Registration No.</th>
<th>Normal playing position</th>
<th>Date of birth (dd/mm/yyyy)</th>
<th>Playing Experience (Yrs/Mths)</th>
<th>Height (cm)</th>
<th>Body mass (Kg)</th>
<th>Dom Leg</th>
<th>Dom Arm</th>
<th>Ethnic origin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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For enquiries or clarification please contact: Niki Gabb, RFUW Injury Audit, Applied Biomechanics Suite, Department for Health, University of Bath, Bath, BA2 7AY. Tel: 01225 385469; email: rfuw-audit@bath.ac.uk

RETAIN A COPY OF THE COMPLETED FORM FOR REFERENCE PURPOSES

(Reviewed: May 2012)
RFUW Injury Audit
Player Baseline Information Form

GUIDELINES FOR COMPLETION

1. This Form should be completed during the pre-season period.
2. Each player must be provided with and read a copy of the ‘Player Information Sheet’ and then sign an ‘Individual consent form’.
3. Please enter the information for every player who has been identified as part of the eligible study group.
   Eligible Study Group – All 1st team Squad registered players
   Notes: Players should be considered to be in eligible study group if they train regularly with the 1st team squad and / or are considered eligible for 1st team selection in any competitive match at any time during the season.
4. Please return the completed Form by the start of the season to:
   RFUW Injury Audit, Applied Biomechanics Suite, Department for Health, University of Bath, Bath, BA2 7AY

Notes:

1. In order to comply with University of Bath ethics and confidentiality requirements, players’ data are recorded in the audit using player’s RFU seven digit registration number.
2. Identify a player’s ‘Normal playing position’ as:
   Forwards: LH Prop; Hooker; TH Prop; Left Lock; Right Lock; BS Flanker; OS Flanker; No 8
   Backs: Full Back; Right Wing; Left Wing; Outside Centre; Inside Centre; Fly Half; Scrum Half.
3. Identify how many years/months the player has been participating in Rugby Union
4. Record players hypermobility score based on the Beighton 0-9 scale.
5. Identify a player’s dominant leg/arm (preferred kicking leg and writing hand) as: Right, Left or Ambidextrous
6. Ethnic Origin – Caucasian/Black African/Black Caribbean/Asian/Maori/Aboriginal/Samoan/Tongan/Fijian/Other (please specify)

For enquiries or clarification please contact: Niki Gabb, RFUW Injury Audit,
Applied Biomechanics Suite, Department for Health, University of Bath, Bath, BA2 7AY.
Tel: 01225 384190; email: rfuw-audit@bath.ac.uk

RETAIN A COPY OF THE COMPLETED FORM FOR REFERENCE PURPOSES
(Reviewed: June 2013)
# RFUW Injury Audit
## Player Baseline Information Form

<table>
<thead>
<tr>
<th>Player (Family name, initial)</th>
<th>Player's Registration No.</th>
<th>Normal playing position</th>
<th>Date of birth (dd/mm/yyyy)</th>
<th>Playing Experience (Yrs/Mths)</th>
<th>Beighton Score (0 – 9)</th>
<th>Height (cm)</th>
<th>Body mass (Kg)</th>
<th>Dom Leg</th>
<th>Dom Arm</th>
<th>Ethnic origin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

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RETAINT A COPY OF THE COMPLETED FORM FOR REFERENCE PURPOSES

(Reviewed: June 2013)
<table>
<thead>
<tr>
<th>Name of Club</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan Start Date</td>
<td></td>
</tr>
<tr>
<td>Plan End Date</td>
<td></td>
</tr>
</tbody>
</table>

**CLUD DEVELOPMENT PLAN - MISSION:**

<table>
<thead>
<tr>
<th>OVERALL AIMS</th>
<th>1. To provide a high level of service to increase the standard of players across the women’s game and provide a sustainable Women’s section which will benefit the club as a whole.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.</td>
</tr>
<tr>
<td></td>
<td>3.</td>
</tr>
<tr>
<td>TASKS</td>
<td>ACTION</td>
</tr>
<tr>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>COMMUNICATION</td>
<td></td>
</tr>
<tr>
<td>Officials of the club will meet with their WRDM twice during the plan period – Sept and April.</td>
<td></td>
</tr>
<tr>
<td>At least one club official will attend the RFUW Performance Seminars.</td>
<td></td>
</tr>
<tr>
<td>At least one of the Premierships coaching team will attend the coach development sessions run by the RFUW Performance Department during the season.</td>
<td></td>
</tr>
<tr>
<td>At least one club official will attend the local Women’s and Girls forum.</td>
<td></td>
</tr>
<tr>
<td>England Coaches may attend Premierships Club sessions twice a year to support coaches where requested</td>
<td></td>
</tr>
<tr>
<td>Ensure all players within your club are aware of the player pathway and what is expected from them</td>
<td></td>
</tr>
<tr>
<td>Club to actively support the CB and Divisional programme</td>
<td></td>
</tr>
<tr>
<td>Where possible the Ladies section to link with Club Coach Coordinator for the club</td>
<td></td>
</tr>
<tr>
<td>CLUB DEVELOPMENT</td>
<td></td>
</tr>
</tbody>
</table>
Premiership clubs that have a 2nd team must show that there is an open and supported pathway between the teams.

Premiership clubs that have junior set ups provide links and mentoring to the teams and provide an effective transitional link for players leaving the U18 into senior rugby.

<table>
<thead>
<tr>
<th><strong>PLAYER MANAGEMENT</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>England Elite 44 players will be released by the club to attend RFUW skills sessions. (Minimum Levels)</strong></td>
<td>Dates to be agreed with player, club and RFUW as part of the individual player programme.</td>
<td>Club / RFUW</td>
</tr>
<tr>
<td><strong>England identified development players will be released to attend satellite Divisional Training sessions.</strong></td>
<td>Dates to be agreed with player, club and RFUW as part of the individual player programme.</td>
<td>Club</td>
</tr>
<tr>
<td><strong>England Elite 44 and England identified development players should not participate in more than 2 rugby training sessions per week (club and Academy / Divisional).</strong></td>
<td>Players may participate in individual skills sessions, over and above the 2 sessions per week as part of their individual player programme.</td>
<td>Club / RFUW</td>
</tr>
<tr>
<td><strong>Clubs will provide written or verbal feedback to England Elite 44 players and RFUW monthly.</strong></td>
<td></td>
<td>Club</td>
</tr>
<tr>
<td><strong>England Elite 44 Player feedback will be provided to club coaches within 14 days of an England Match / Tournament.</strong></td>
<td></td>
<td>RFUW</td>
</tr>
</tbody>
</table>
### MEDICAL SUPPORT

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
<th>Responsible Party</th>
</tr>
</thead>
<tbody>
<tr>
<td>An agreed chartered physiotherapist will be present at training and home games and will be accessible to England Elite 44 players on a regular basis at a reduced cost or through medical insurance.</td>
<td>This chartered physiotherapist will be the main point of contact with the England Doctor. The England Doctor will provide feedback to appointed physio within 7 days of the injury being sustained (on Tuesday am during season). Club medics should feedback to England Doctor as soon as possible if there are any injuries to England Elite squad players at club training or matches (by Monday am).</td>
<td>Club Physio / England Doctor</td>
</tr>
<tr>
<td>England Elite 44 Players who are injured and out of training for more than 3 days will complete a Return to Train assessment before returning to full training. Players will complete a full contact training session before returning to match play.</td>
<td>Return to Train assessment will be conducted by English Institute of Sport (EIS) in normal circumstances for England Elite 44 players but in certain circumstance elite squad players will be assessed by club medics. Clubs to conduct Return to Train for non-elite squad players.</td>
<td>Club / Player</td>
</tr>
<tr>
<td>Club medic/s to attend at least one CPD session run by the RFUW each year.</td>
<td></td>
<td>Club / RFUW</td>
</tr>
</tbody>
</table>

### INJURY AUDIT

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
<th>Responsible Party</th>
</tr>
</thead>
<tbody>
<tr>
<td>The success of the RFUW Injury audit relies upon the accurate and timely completion of all RFUW Injury Audit forms. Clubs will be provided with all the requisite forms in either</td>
<td>1. Nominate an Injury Audit Representative</td>
<td>Club</td>
</tr>
<tr>
<td></td>
<td>2. Complete and return the following forms: Beginning of season:</td>
<td>Club</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24-Jun-12</td>
</tr>
</tbody>
</table>
### Action Plan Template 2011-2012

<table>
<thead>
<tr>
<th>Task</th>
<th>Responsible</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consent Form</td>
<td>Club Coach</td>
<td>Sep 2012</td>
</tr>
<tr>
<td>Baseline</td>
<td>Club Medic</td>
<td>Sep 2012</td>
</tr>
<tr>
<td>Menstrual Forms</td>
<td>Club Medic</td>
<td>Sep 2012</td>
</tr>
<tr>
<td>Training</td>
<td>Club Coach</td>
<td>Sep 2012</td>
</tr>
<tr>
<td>Complete &amp; return 'weekly injury form'</td>
<td>Club Coach</td>
<td>Weekly</td>
</tr>
<tr>
<td>Complete &amp; return 'main injury form'</td>
<td>Club Coach</td>
<td>Weekly</td>
</tr>
<tr>
<td>Completion &amp; return 'weekly training &amp; match exposure form'</td>
<td>Club Coach</td>
<td>As required</td>
</tr>
<tr>
<td>Complete match report (ensure the time of all substitutions annotated)</td>
<td>Club Coach</td>
<td>Weekly</td>
</tr>
<tr>
<td>Complete match report (ensure the time of all substitutions annotated)</td>
<td>Club Coach</td>
<td>As required</td>
</tr>
</tbody>
</table>

### VIDEO ANALYSIS

The home team will provide a copy of the game to England Head Coach within 7 days of the match, in DVD format. Filming should be from an elevated position and not ground level.

<table>
<thead>
<tr>
<th>Task</th>
<th>Responsible</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Club</td>
<td>Club Coach</td>
<td>Post-Match</td>
</tr>
</tbody>
</table>

### COACHING

Club to have needs analysis and CPD programme in place for all coaches.

<table>
<thead>
<tr>
<th>Task</th>
<th>Responsible</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Club</td>
<td>Club</td>
<td></td>
</tr>
</tbody>
</table>
# Appendix C1. RFU Injury Surveillance - Weekly Injury Form

## RFUW Injury Audit

**WEEKLY Master Return Form 2012/2013**

### CLUB REF No: [ ]

### INJURIES SUSTAINED THIS WEEK

<table>
<thead>
<tr>
<th>Date of injury</th>
<th>Injured player’s Registration Number</th>
<th>Activity when injured</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Match Training No form</td>
</tr>
</tbody>
</table>

Please record any injury that prevents a player from taking a full part in all training activities typically planned for that day and/or match play for more than one day following the day of injury.

Absence through illness or other medical conditions should not be included.

---

Enquiries / clarification please contact:  
Niki Gabb  
University of Bath  
Tel: 01225 385469  
E-mail: rfuw-audit@bath.ac.uk

Please return the top copy WEEKLY in the pre-paid envelope provided.
# RFUW Injury Audit – Injury Report Form 2012-2013

**CLUB Ref No.** | **PLAYER Reg No.** | **Date of injury:** \( \dd/mm/yy \) | **Date of return from injury:** \( \dd/mm/yy \) | **First day of last period:** \( \dd/mm/yy \) | **No. of matches player missed:** 
--- | --- | --- | --- | --- | 
RETURN ONE FORM FOR EACH INJURY TO: Niki Gabb, RFUW Injury Audit, Department for Health, University of Bath, Bath, BA2 7AY. Email: rfuw-audit@bath.ac.uk

## 1. ACTIVITY at TIME of INJURY (Complete either the match or training section):

<table>
<thead>
<tr>
<th>Match with Club:</th>
<th>Premiership</th>
<th>Divisional</th>
</tr>
</thead>
<tbody>
<tr>
<td>with England:</td>
<td>Full</td>
<td>U20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Match</th>
<th>Time of injury (mins)</th>
<th>Warm-up</th>
<th>0 – 20</th>
<th>21 – 40+</th>
<th>41 – 60</th>
<th>61 – 80+</th>
<th>Cool-down</th>
<th>Unknown</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Playing position at time of injury</th>
<th>Please be specific – see Table A</th>
<th>Player</th>
</tr>
</thead>
<tbody>
<tr>
<td>Match &amp; Event causing injury</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maul</td>
<td>Collapsed maul</td>
<td>Tackled - behind</td>
</tr>
<tr>
<td>First-set scrum</td>
<td>Collapsed first-set scrum</td>
<td>Tackling - behind</td>
</tr>
<tr>
<td>Re-set scrum</td>
<td>Collapsed re-set scrum</td>
<td>Lineout</td>
</tr>
<tr>
<td>Collision (not-accidental)</td>
<td>Collision (accidental)</td>
<td>Ruck</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Match</th>
<th>Event causing injury</th>
<th>Warm-up</th>
<th>0 – 20</th>
<th>21 – 40+</th>
<th>41 – 60</th>
<th>61 – 80+</th>
<th>Cool-down</th>
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<th>41 – 60</th>
<th>61 – 80+</th>
<th>Cool-down</th>
<th>Unknown</th>
</tr>
</thead>
</table>

## 2. CLASSIFICATION of INJURY (Refer to Information inside cover for body location and type of injury)

<table>
<thead>
<tr>
<th>Body location</th>
<th>See Table B</th>
<th>Type of injury</th>
<th>See Table C</th>
<th>Player removed from play/training?</th>
<th>Immediately</th>
<th>Later</th>
<th>Not at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orchard code</td>
<td>See Table B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Was the injury?</th>
<th>Acute</th>
<th>Gradual onset</th>
<th>Player removed from play/training?</th>
<th>Immediately</th>
<th>Later</th>
<th>Not at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body location</td>
<td>See Table B</td>
<td>Type of injury</td>
<td>See Table C</td>
<td>Side of body injured</td>
<td>Left</td>
<td>Right</td>
</tr>
<tr>
<td>Orchard code</td>
<td>See Table B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Was diagnostic investigations used?</th>
<th>Yes</th>
<th>No</th>
<th>If YES, please specify</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Were invasive procedures used?</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Is this injury a recurrence (see definition)?</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

RETURN ONE FORM FOR EACH INJURY TO: Niki Gabb, RFUW Injury Audit, Department for Health, University of Bath, Bath, BA2 7AY. Email: rfuw-audit@bath.ac.uk.