

CHAPTER 1

INTRODUCTION

Background

Rugby Union (hence referred to as 'rugby') is an international sport played in over 100 countries worldwide at professional and amateur levels. Rugby is particularly popular in South Africa, with over 468 000 players in 2016.[1, 2] In 1995 rugby became professional, increasing resulting in an increase in the number of individuals participating in the sport.[3] Each rugby team consists of fifteen players, made up of varying positions, broadly grouped into two categories: eight forwards (number 1 – 8) and seven backs (numbers 9 – 15). Although these different positions are associated with varying anthropometric and physiological demands,[3-8] the injury incidence and types of injuries are not different between forwards and backs.[9]

One major characteristic of rugby is that of the tackle, a bodily collision that is the most effective and legal way to stop the opposing team from scoring points, and as such gaining competitive advantage.[10] The tackle is the most frequently executed manoeuvre in rugby and is defined by "when a ball carrier is contacted (hit and/or held) by an opponent, without reference to whether they went to the ground".[11] Considering that the tackle is a ballistic and high force/momentum-generating manoeuvre, this aspect of play is associated with a high risk for injury and requires a large amount of skill to ensure it is performed safely and effectively.[12] Other major facets of play include the scrum and the line-outs, both of which include the forward players only. The scrum is also associated with a high injury risk as it is a force-producing set piece, and over the years the laws surrounding the scrum have changed numerous times in an attempt to make the scrum safer, including much development in the scrum engagement laws (for example PreBind).[13, 14] With these varying phases of play and set pieces within the sport, the physiological and psychological demands on a player are large, and if the player is not properly prepared, the risk of sustaining an injury will be high.

The "Sequence of Prevention" model is often applied to understand the magnitude, severity and aetiology of injuries in rugby, and to develop safety programs to prevent injuries in rugby (Figure 1.1).[9, 15, 16] The model describes four steps in the process towards successful injury prevention; (1) the identification and description of the extent of the injury problem within

the sport; (2) the factors and mechanisms which contribute to the occurrence of the injuries within the sport; (3) the introduction of preventative measures which are likely to reduce the future risk and/or severity of the injuries; and (4) the evaluation of the effects of the preventative measures in step three by performing step one again.[15] The next few sections will describe these four steps in the context of rugby.

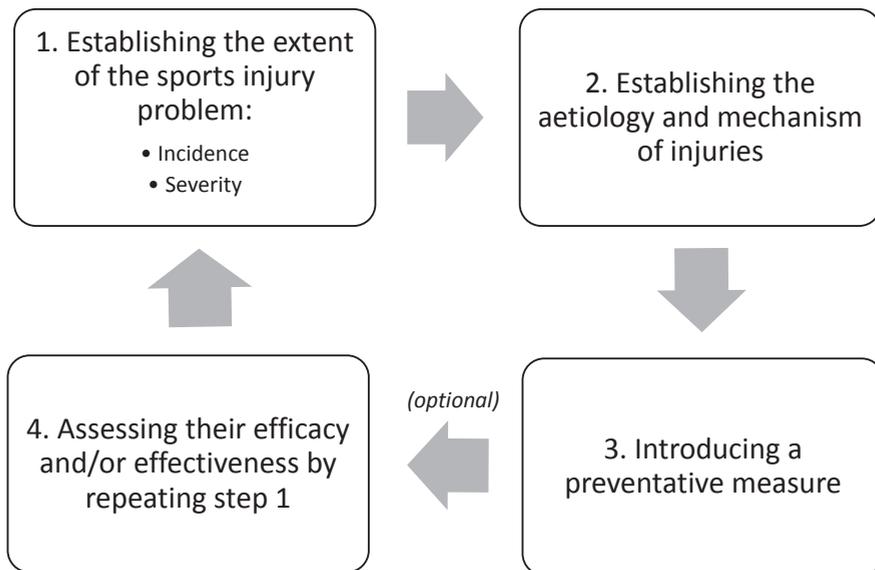


Figure 1.1: "Sequence of Prevention" model.

Step 1) The identification and description of the extent of the of the injury problem within the sport

In 2007, a consensus statement standardized the reporting of injury data within rugby ensuring future data defined according to these criteria would be comparable.[17] According to the consensus statement, for reporting reasons, the operational definition of an injury can be categorised into two different types: 1) a medical attention injury, which is defined as "an injury that results in a player receiving medical attention", or 2) a time-loss injury defined as "an injury that results in a player being unable to take a full part in future rugby training or match play".[17] The consensus statement makes the point that time-loss injuries are more comparable between studies, and therefore, hereinafter a time-loss injury will be referred to as an "injury". The extent of the injury problem in rugby has been investigated and a meta-analysis found

the overall injury incidence density in senior rugby players to be 81 (95% CI 63 – 105) injuries per 1,000 player match hours and 3 (95% CI 2 – 4) injuries per 1,000 player training hours. [9] Going forward, only match injuries will be discussed. Whilst the training injury incidence is low, the incidence of injuries within a rugby match is high in comparison to other sports. For example, in men's collegiate (senior) soccer in the United States a total of 19 injuries per 1,000 player hours was reported (this definition of injury is a game injury "an injury that required medical attention and resulted in at least one day of time loss"),[18] much lower than that in rugby. Furthermore, in youth rugby within the South African context, the average injury incidence was 23 injuries per 1,000 player hours across age group tournaments, which is still higher than that in collegiate soccer (19 injuries per 1,000 player hours).[19] It must be noted that the competitive nature of a tournament could alter the medical decision on a player missing further days to ensure a player can participate in important games. Other youth cohorts (over a season) have reported an injury incidence of between 24 – 35 injuries per 1000 player hours, therefore showing that youth rugby also has a high injury incidence.[20-23]

The types of injuries most commonly occurring at senior level rugby were muscle/tendon injuries at 40 injuries per 1,000 player hours, and joint (non-bone)/ligament at 34 injuries per 1,000 player hours.[9] Besides being the most commonly occurring, these soft-tissue injuries are also regarded as *preventable* injuries,[24] thus providing scope for a preventive intervention to decrease the incidence of injury. Most of the injuries occurred in the lower limbs, followed by the upper limbs, head and lastly the trunk in adults (results from a meta-analysis).[9] A youth systematic review has been conducted, however, it includes up to the ages of 21, and therefore youth cohort studies were preferred when drawing comparisons.[25] In youth rugby cohort studies, similar injury types are common, however, the injury incidence is lower, and central and peripheral nervous system (CNS/PNS) injuries are also common.[20, 22] When using severity of injury (time lost from training and competition) as the measure in seniors, the lower limb remains the most severely injured body part, with trunk next, followed by the head/neck area (the upper limbs were not reported on).[9]

Following the “Sequence of Prevention”, the phases of play (activities performing when injured) when the injuries occur need to be described before the mechanisms of injury can be investigated. The tackle is the largest contributor to injuries, with an average incidence of 29 injuries per 1000 player hours for the ball-carrier (i.e. player getting tackled); this incidence is lower for the tackler, 19 injuries per 1000 player hours.[9, 10, 19, 26-30] The ruck is the second highest after the tackle situation, with 17 injuries per 1000 player hours, followed by collisions (11 per 1000 player hours), scrums (7 per 1000 player hours), other (6 per 1000 player hours) and lineouts (1 per 1000 player hours) in seniors.[9] For youth cohorts, the tackle is still the largest contributor, with an injury incidence of 10 injuries per 1000 player hours and 8 injuries per 1000 player hours for the tackler.[23] These values should be interpreted with caution because the phases of play are presented as “per 1000 player hours” and do not account for the percentage of time spent performing these activities during a match. For example, a greater percentage of time is spent tackling or being tackled compared to scrumming.[3]

The severity of injuries in senior rugby has been thoroughly investigated. In senior rugby, “moderate” injuries (defined as 8 – 28 days lost from training) are most common, and when specific days lost have been reported the mean for a match injury is 20 days lost per 1000 player hours.[9] In youth rugby, a study reported that almost half (49%) of injuries over a season were classified as “severe” (>28 days lost from training).[20] Another study showed the injury burden was 862 days lost per 1000 match player hours,[22] illustrating a higher injury severity in the youth than the seniors.

Using the information from the first step in the “Sequence of Prevention” (incidence and severity of injuries), injury prevention programmes in rugby should focus on muscle/tendon, joint (non-bone)/ligament in both youth and seniors, and CNS/PNS injuries, particularly in the youth.

Step 2) The factors and mechanisms that contribute to the occurrence of the injuries within the sport

The second step of the “Sequence of Prevention” examines the aetiological factors and mechanisms causing the injuries.[10] As described earlier, the various phases of play during the game demand different skill sets and physiological

systems and therefore the number of injuries occurring within them are vastly different. The tackle (both ball-carrier and tackler) has the highest injury incidence of all the phases of play, and therefore the mechanisms underlying this phase of play are of particular interest. Players' technique during the tackle (both tacklers and ball-carriers) is associated with risk of injury. For example, for ball-carriers, using a fend and being aware of the impending contact, have been associated with decreased injury risk.[31]

For tacklers, technique plays a role in injury risk as well. A preferable head position (to the side of the tackle) when contact occurs has also been associated with a decreased injury risk in the tackle situation.[32] In addition to the player's technique, the type of tackle can influence the risk of injury; shoulder tackles are less likely to result in injury compared to an arm tackle (per event).[31] Since the tackle is the most commonly occurring phase of play,[3] and has a high energy expenditure, the development of fatigue as the game progresses may compromise the technique leading to injury. In summary, players have a risk of injury because of the contact nature of the sport, and through both conditioning and correct technique, injury incidences could potentially be decreased. However, it must be noted that some injuries as a result of collisions are unavoidable, independent of conditioning and skill.

Step 3) The introduction of preventative measures which are likely to reduce the future incidence and/or severity of the injuries

The large injury incidence and severity of injuries in both senior and youth rugby shows the need for injury prevention strategies.[29] As a consequence intervention programme have been developed in the major rugby playing countries. For example, Australia has SmartRugby, New Zealand has RugbySmart and South Africa has BokSmart. [16, 33, 34] These programmes have been designed to reduce injuries in rugby, particularly serious catastrophic injuries. RugbySmart specifically, was associated with a decrease in disabling spinal cord injuries in scrums following the educational initiative.[35] The focus will now be on South Africa's BokSmart programme.

BokSmart

The BokSmart programme (adapted from the precursor RugbySmart of New Zealand) [16] was launched in South Africa in July 2009 and has four main

components: 1) the compulsory BokSmart Rugby Safety biennial workshops designed for coaches and referees; 2) the BokSmart rugby Medic programme, a basic first aid course aimed at the lower level/underprivileged schools and clubs to ensure the safety of the players; 3) the toll-free BokSmart SpineLine, telephone number available for all head/neck and spine injuries to assist in getting the injured players to the nearest and best medical facility in the quickest time; and 4) the online website (www.boksmart.com) that covers issues about rugby safety – the resources are freely available.[16] BokSmart's distributed material is evidence-based, as much as possible.[16] Historically, BokSmart's primary focus was safe technique and education of referees and coaches around the risk of rugby and how to decrease that risk. BokSmart includes mandatory biennial courses for coaches and referees of coaches at all levels.[16, 36] The BokSmart programme is implemented and continually improved and new aspects added. BokSmart attempts to address the injury incidence and severity in South African rugby, by using the information gathered in the previous two steps, by specifically targeting scrum and tackle technique.

Step 4) The evaluation of the effects of the preventative measures, the repetition of step 1

BokSmart has begun to evaluate the overall BokSmart rugby safety programme, however, presently there is minimal data available.[37, 38] BokSmart has performed injury surveillance at the South Africa Youth Week tournaments, as well as nationwide data collection of catastrophic injuries (in conjunction with the Chris Burger/Petro Jackson Players Fund) and assessments of player's knowledge/attitudes/behaviours towards injury prevention strategies. [19, 37, 38] The BokSmart programme has been associated with significant improvements in players' injury-preventing behaviours,[37] which will hopefully lead to a decrease in the injury incidence and severity within South Africa. Furthermore, the BokSmart programme has been associated with a reduction in catastrophic injuries in youth players in South Africa,[38] but has not been assessed for its effect on general (non-catastrophic) injuries. Although the BokSmart programme has addressed technique and medical support, it has not focussed on the connection between specific skill, strength and motor control training to fully address the injury aetiology. This final connection was highlighted by World Rugby and further initiated by BokSmart. The final step

in the “Sequence of Prevention” re-assesses the injury incidence to determine if the BokSmart programme is effective. The final step is important to provide information that can improve the BokSmart programme as an evolving injury prevention national safety programme.

Development of effective exercise-based injury prevention programmes

Based on the high injury risk and available evidence of injury risk factors, World Rugby (the sport’s international organization) challenged all national rugby unions to develop an exercise-based intervention to reduce injury incidence rates within the game. Exercise-based interventions are hypothesized to elicit favourable changes in neuromuscular function, motor control and range of motion.[24] These changes are then assumed to decrease injuries in sports. Intermediary measures of injury, such as the Functional Movement Screening, have also been shown to be affected by exercise-based interventions through the changes in motor control and range of motion.[39] Exercise-based injury prevention programmes have been effective in other non-collision sports, such as ankle stability training in volleyball,[40] and the more recent developments in football with the FIFA 11+ programme.[41] In response to World Rugby’s challenge, BokSmart (and thus the South African Rugby Union) developed the *Safe Six* exercises. The *Safe Six* exercises were developed in conjunction with available data from research, and the clinical knowledge of professionals experienced in rugby injuries. The exercises were chosen specifically to match the common sites of injury on rugby.[9] In accordance, the targeted areas of injury prevention were the knee, hamstring, lower limb, ankle and shoulder. The exercises were designed to increase strength, joint stability, balance and control, with the overall goal of reducing the rate and severity of injuries. This exercise-based intervention was launched in 2014 (Appendix I).

The exercises were designed to be included as part of the regular team warm-up. In particular, they were designed to optimise the implementation of these exercises, meaning that they can be performed without any equipment and are of short duration, so they would not interfere with regular training.

Thesis Outline

Seven research questions are described in this thesis to answer the larger research question on the effectiveness and implementation of the BokSmart *Safe Six* injury prevention programme. These chapters extend through all four steps of the “Sequence of Prevention” model, providing an overview of the youth rugby injury rates and severity of injuries, the aetiology of injuries, the development of an injury prevention programme, and finally the establishment of efficacy and effectiveness of the *Safe Six* programme.

Chapter 2 addresses the first and second steps of the “Sequence of Prevention”, establishing the extent of the injury problem in the specific youth rugby player population in South Africa and further investigating the aetiology and mechanisms of these injuries in their specific context. This chapter uses data from the SARU injury surveillance project at the annual youth week tournaments.

Chapter 3 explores the literature currently available for exercise-based interventions performed in collision sports, forming the basis for the BokSmart *Safe Six*. This study completes the third step of the “Sequence of Prevention”.

Following the launch of the BokSmart *Safe Six*, Chapter 4 uses three years of questionnaire data to determine the changes in knowledge and awareness of the injury prevention programme to investigate the knowledge dissemination of the BokSmart *Safe Six*.

Chapter 5 is an efficacy study, to determine the associations of the BokSmart *Safe Six* with injury risk profile changes (i.e. changes in FMS scores) in the non-rugby playing community, using the injury risk profiles as a proxy for injuries (thereby completing step four).

Chapter 6 – 8 describe the cluster-randomized controlled trial of the BokSmart *Safe Six* and its association with injury risk profiles and rates.

Chapter 9 – the overall Discussion – summarises all the studies performed from Chapter 2 – 8.

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