

CHAPTER 9

GENERAL DISCUSSION

The primary purpose of this thesis was to evaluate the effectiveness of the BokSmart *Safe Six* injury prevention programme for youth rugby players in South Africa through the “Sequence of Prevention”.

Seven research questions were addressed in this thesis to answer this larger research question on the effectiveness of the BokSmart *Safe Six* injury prevention programme. These chapters extended through all four steps of the “Sequence of Prevention”: 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.

Main Findings

The BokSmart *Safe Six* was designed and launched in 2014 by BokSmart, and in 2015 the research team was given the task of assessing the effectiveness of the *Safe Six* in youth rugby. Although the *Safe Six* programme had already been designed and implemented, this thesis used the “Sequence of Prevention”[1] as a conceptual model to describe the various steps needed to bring about effective sports injury prevention in youth rugby. This section discusses the main findings of each chapter as explored in each stage of the model. It also acknowledges the limitations of the studies conducted, the practical implications and makes suggestions for future research in the area to address unanswered and arising questions.

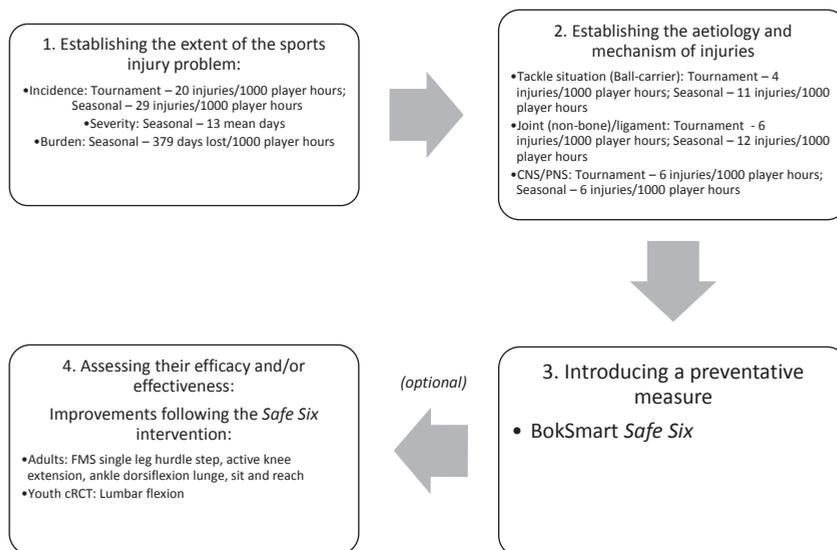


Figure 9.1: “Sequence of Prevention” model as explored in the thesis. (CNS – central nervous system; PNS – peripheral nervous system; FMS – Functional Movement Screen; cRCT – cluster-randomised controlled trial)

Extent and Severity of South African Youth Rugby Injuries

The extent of the problem of injury incidence density (hereinafter referred to as “injury rate”) and aetiology and mechanism of injury in rugby players, and specifically in youth players, is covered in chapters 2 and 7 (step 1 and 2 of the model, respectively).

The injury rate of injuries in senior rugby players has been well documented, but less so in the youth.[2, 3] In the South African context, though, there is limited research on rugby injuries, particularly studies that have used definitions from the consensus statement on rugby injury definitions.[4, 5] In chapter 2, tournament time-loss match injury rates (time-loss match injury rate, hereafter referred to as injury rate) were identified in youth players of ages under-13 to under-18. The tournament injury rate was lower than youth cohorts from previous studies. The tournament injury rate was also lower compared to the injury rate over a season (chapter 7) in under-16 players, which was similar to other seasonal youth cohorts.[6-8] Both studies used prospective cohort designs. The tournament data suggested an increasing trend in injury rate, justifying the need for an intervention. These injury rate differences between tournament and seasonal data in the South African cohort are important, as

they give insight into the differences between South African tournament and season rugby.

The season injury burden (days lost per 1000 player hours) described in chapter 7 is lower than that seen in other youth cohorts. The injury burden in chapter 7 was 379 days lost per 1000 player hours, compared to an English youth cohort with an injury burden of 862 days lost per 1000 player hours.[9] This lower injury burden in the South African under-16 players is explained by a lower severity at a similar injury rate, which equates to a relatively lower injury burden. Therefore, the injury rate and injury burden differences could be explained by players being exposed to better coaching and being better physically conditioned compared to other cohorts, however, chapter 7 was a small sample size and future research should investigate this.

Aetiology and Mechanisms of South African Youth Rugby Injuries

The aetiology and mechanism of injury (step 2 of the “Sequence of Prevention”) in the youth tournament setting (chapter 2) were similar to those over an entire season and in multiple teams. The tackle situation (both ball-carrier and tackler) had the highest injury rate of all phases of play, as has been reported in youth and senior cohorts.[2, 3] A subsequent study in a similar South African cohort has shown an association with tackle technique and tackle-related injuries,[10] indicating that improvement in technique could possibly reduce these injuries.

The type of the injuries sustained at the tournaments was different compared to those sustained over a season. Central/Peripheral nervous system (CNS/PNS) injuries were the most frequently reported injuries at the tournaments, but over a season it was joint (non-bone)/ligament injuries, which is more similar to that of other youth studies.[8] The majority of CNS/PNS injuries are comprised of concussions. However, the CNS/PNS injury rate appears to be increasing when comparing older studies with more recent studies.[9, 8] This phenomenon has been attributed to the increased awareness (through national and international rugby unions) and reporting of confirmed concussions and suspected concussions.[9, 11]

The final associated risk factor investigated was the match quarter when injuries occurred. During the tournaments, the injuries occurred towards the end of the

match (chapter 2), however, during the season the injury rate was highest in the beginning of the match (chapter 7). Previous data showed similar results to the tournament data,[3] which has led to some recommendations (see further research and practical implications section in this General Discussion). However, the *Safe Six* did not target either of these risk factors, which could explain the lack of effectiveness in changes in injury risk profiles, especially the lack of focus on CNS/PNS injuries.

Previous Exercise-Based Injury Prevention Programmes

The systematic review in chapter 3 described previous studies that had used an exercise-based intervention in an attempt to prevent injuries in collision sports (step 3 of the model). This was an important step in the process, as the BokSmart *Safe Six* was developed prior to the initiation of this project and was based on clinical practices and previous research. The systematic review found nine studies that met the inclusion criteria, and furthermore, only seven effective interventions in collision sports. However, these studies were of a variety of methodological qualities, sporting codes and age groups, making an overall interpretation difficult. These effective interventions included balance training and eccentric hamstring curls, both of which are supported by evidence in other sports.[12] This indicates preventive qualities of such interventions, even though they were performed in low-quality studies in these collision sports. [12] An important factor determining intervention effectiveness in these exercise programmes was compliance, and increasing compliance should increase effectiveness.[13] Therefore, to increase compliance, the adoption barriers need to be reduced as much as possible.

Subsequent to the completion of the systematic review (chapter 3), a high-quality exercise-based RCT was conducted in both youth and adult community rugby players in England.[14, 9] This intervention was associated with reductions in injury rate and particularly concussions.[14, 9] This multi-component exercise-based programme included various levels of difficulty for specific age groups of players and further progression of difficulty throughout the season.[14, 9]

Following the findings from the review, the BokSmart *Safe Six* can be compared to these programmes, and specifically the effective components of exercise

programmes. The BokSmart *Safe Six* was designed as a warm-up and therefore can be included in regular practice, requiring no equipment, and therefore potentially increasing compliance.[15] The exercises included in the *Safe Six* had balance exercises and eccentric hamstring curls, that have also been shown to be associated with reductions in injury rate in collision sports.[16, 17] However, the *Safe Six* is missing an exercise component focusing on the neck.[18] This should be considered, as there is a potential association between exercises that strengthen the neck muscles and reductions in concussion injuries.[9] These comparisons between the *Safe Six* and other effective injury prevention programmes indicate that the *Safe Six* should have been associated with a decrease in injury rates. However, the studies included in the review (chapter 3) did not assess the effect of exercise interventions on intermediary measures of injury such as FMS and Musculoskeletal Screening Assessments.

Was the BokSmart *Safe Six* Effective?

Assessing the BokSmart *Safe Six* using Injury Risk Profiles and Injury Rate

A challenge in intervention evaluation research within injury prevention trials is the use of many different outcomes to determine the efficacy of the intervention. To see a significant change in direct injury rate, the trial is required to be performed over a long enough follow-up period and to use a sufficiently powered sample with injury as the primary outcome.[19] To overcome this issue of long study periods sometimes other measures associated with injury are used. The Functional Movement Screening (FMS) protocol and the BokSmart Musculoskeletal Screening Assessment are two such intermediary measures used to assess injury risk.[20-23] Previous studies have established the association between motor control measures and injury, where motor control outcomes mediate injury risk and can thus be seen as a proxy for injury risk.[24-27] The underlying assumption is that an exercise intervention can improve motor control patterns (broad term for neuromuscular control, strength, muscle mass) and range of motion (ROM), and therefore, improve FMS scores or Musculoskeletal Screening Assessment scores.[28] Following the motor control and ROM changes elicited from an exercise intervention and its associated FMS score, injury rates are then assumed to be reduced.[9] There have been studies showing associations between decreased FMS composite

scores and either time-loss injuries, increased injury burden or injury severity. [29, 27, 26] However, so far no direct link between FMS (or Musculoskeletal Screening Assessment) scores and a change in injury rate has been observed in a randomised controlled trial (RCT).

The BokSmart *Safe Six* exercises were assessed in two different cohorts in different study settings: i.e. in non-rugby playing adults under laboratory conditions and in youth rugby players in a more real-world setting. To assess the effectiveness of the *Safe Six*, the FMS scores were measured in both cohorts.

The BokSmart *Safe Six* programme was not associated with improvements in the FMS composite score in both cohorts. In the adult cohort, the single leg hurdle step individual FMS assessment score was associated with an improvement as a result of the *Safe Six*. The lack of improvements in FMS scores in the cRCT (chapter 8), however, indicate that there was a no effect of the *Safe Six* on a youth rugby cohort, one of the targeted populations for the *Safe Six*.

In contrast, the *Safe Six* was associated with improvements in some of the Musculoskeletal Screening Assessment scores in both cohorts. In the adult cohort, the active knee extension score and ankle dorsiflexion lunge scores improved in the intervention, compared to the control period (chapter 5). The lumbar flexion score improved in the youth cohort significantly (chapter 8). Most of the changes in Musculoskeletal Screening Assessment scores can be explained by understanding the muscle groups recruited by the exercises included in the *Safe Six*: i.e. shuttle runs (change of direction recruiting various lower limb structures), two different types of lunges (leading to quadriceps and hamstring muscle recruitment), dynamic reaches (leading to ankle and lower limb muscles recruitment, shoulder muscle recruitment), eccentric hamstring curls and rotational push-ups (shoulder muscle recruitment). The results of the Thomas hip score in the youth cohort appear to contradict the goal of the exercises (such as the lunges), as it decreased.

Referring to the conceptual model of changes occurring due to an exercise intervention, this lack of effect could be attributed to two possibilities: (1) the BokSmart *Safe Six* did not elicit the motor control and/or ROM changes expected from the exercise intervention; (2) the *Safe Six* elicited changes in

motor control and/or ROM, but these changes did not result in improved FMS or Musculoskeletal Screening Assessment scores. If the first assumption is true, and the model is correct, then the *Safe Six* would not result in a decrease in injury either, making the *Safe Six* an ineffective injury prevention programme. However, if the second assumption is true, the *Safe Six* could be eliciting changes in motor control and/or ROM, which may result in decreased injury risk, but the measurement tools applied do not measure changes adequately in FMS or Musculoskeletal Screening Assessment scores. Further investigation into the validity of the FMS and Musculoskeletal Screening Assessment (including the assessment of sensitivity to change), as intermediary measures for injury, should be performed (see Recommendations for Future Research).

The *Safe Six* intervention in the youth study (due to its pragmatic nature) was not sufficiently powered to detect changes in match time-loss injury rates, and therefore the injury rates results cannot be interpreted further (chapter 8). Overall, the *Safe Six* interventions in youth and adult cohorts were associated with modest positive improvements in Musculoskeletal Screening Assessment scores, and minimal-to-no improvements in FMS scores. It can, therefore, be concluded that the *Safe Six* had little injury preventive qualities in this study.

Dissemination of the BokSmart Safe Six

The BokSmart *Safe Six* was launched in 2014, and the reach of the marketing performed by BokSmart regarding the programme needed to be assessed to determine the awareness of the programme and how the information had been disseminated. Whilst this is not a step in the “Sequence of Prevention”, it is of importance to BokSmart and intervention implementation research, and is a component of recent research models such as the TRIPP model.[30] Chapter 4 examined the awareness and knowledge of players and coaches of the BokSmart *Safe Six* over three years, including the specific targeted marketing year. Unsurprisingly, the overall awareness was higher in coaches than players (as BokSmart is a coach-targeted programme),[11] but the awareness in both players and coaches increased significantly following the targeted marketing approach, compared to the launch year. This was maintained after the marketing year. Players whose coaches were aware of the programme were associated with an increased chance of being aware of the programme. This knowledge transfer from coach-to-player is important to evaluate, as this

knowledge transfer is the foundation of the BokSmart coach-targeted model. [11] This concept has already been investigated on a large scale in South Africa. Using injury prevention behaviours, the majority of players reported receiving their information from either their coaches or physiotherapists, illustrating the coach-player knowledge transfer.[31]

In addition to an increased awareness following the targeted-marketing period, reported usage of the programme also increased following this marketing period. The coaches and players reported that they had received most of their information about the *Safe Six* from rugby unions, coaches and social media. All these sources are affordable and an easy means of disseminating an injury prevention programme. The associated increase in reported usage of the BokSmart *Safe Six* following cost-effective social media marketing seems to indicate that the *Safe Six* could be widely adopted in future.

Limitations

There were limitations with each of the studies. However, it must first be reiterated that the research team was only approached to assess the effectiveness of the *Safe Six* programme after the *Safe Six* had been designed and launched by BokSmart. This limited the evaluation of the effectiveness of the *Safe Six* from the start, as no research model could be followed to develop, evaluate and implement an injury prevention programme from scratch. The research team should have been involved from the beginning, allowing the “Sequence of Prevention” to be followed in order by the same researchers, and therefore giving the designed programme the best chance of success based on sound evidence, for instance by following the intervention mapping protocol. [32]

The main limitation of evaluating the *Safe Six* was the lack of statistical power to determine a change in injury rates in chapter 8 (at least 13 schools in the intervention and 13 in the control group with each school contributing 570 match exposure hours were required for a cRCT). The *Safe Six* was designed to reduce injuries in rugby players and unfortunately, the trial could not follow enough teams for the season to reach the number of match exposure hours

required for statistical power to detect changes in injury rates. Furthermore, the compliance of the intervention group was unknown, and therefore whether or not they completed the intervention programme as prescribed is unknown. The control group could have also been performing some of the exercises, as the programme was freely available, providing a confounder.

The systematic review (chapter 3) that was performed at the time that the research team was approached, showed that few studies had investigated the effects of an exercise-based intervention in sports similar to rugby.[16, 33-36, 17, 18, 37, 15] With so few studies, comparisons are difficult to make, and furthermore, there were multiple sporting types and age groups included. However, there were some effective exercise interventions in contact sports; i.e. eccentric hamstring curls, balance training and landing skills.[35, 17, 37] Furthermore, a well performed study in rugby showing a decrease in injury rate, injury burden and specifically, a decrease in concussion incidence, was completed a year after publication,[9] which would have provided a good rationale for rugby-specific exercise interventions.

The assessment of the dissemination of the BokSmart *Safe Six* using the SA Rugby Youth week tournaments had the limitation of an unknown number of repeat participants (chapter 4). The tournaments included multiple age groups and a sub-group of players continued to be selected for two years in a row and therefore may have completed the questionnaire multiple times, increasing their exposure to the programme. The knowledge transfer from coach to the player was also limited, as a subset of players could not be linked to their coaches. Another limitation was that all data on behaviour was self-reported and not observed, and the questionnaire was based on knowledge and perceptions, which are weak predictors of behaviour.

The injury rate studies (chapter 2 and 7) both showed that the tackle phase of play had the highest injury rate compared to the other phases. However, the analysis did not consider the time spent performing each activity during a match. The tackle is the most commonly occurring phase during a match, and therefore the hypothesis is not proven that being involved in a tackle is more “dangerous” than the involvement in any other phase of play.

The studies assessing the effectiveness of the BokSmart *Safe Six* had some limitations. The intervention period for the study in adults may have been too short to elicit further changes in the injury risk profiles. Furthermore, the effect of repetitive testing in the adult cohort must be noted. The study of the youth was not sufficiently powered for the statistical interpretation of differences between the control and intervention group for the injury rate. This reduced the ability to make clinical interpretations of the FMS score changes.

Practical Implications

The *Safe Six* was associated with minimal changes in injury risk profiles in the South African youth rugby population and therefore, BokSmart should be cautious when advocating its use (chapter 8). At the same time Boksmart should understand that '*absence of evidence does not equal evidence of absence*.' BokSmart may also consider adjusting the *Safe Six*: for example, by adding a neck component in an attempt to reduce concussion injuries.[9]

The injury data from both the season and tournament data have shown that the South African youth rugby player is sustaining a high incidence of lower and upper limb joint (non-bone)/ligament injuries (chapter 2 and 7). Concussion injuries also have a high injury rate and need special attention. Therefore, all medical staff must be trained in identification of the signs and symptoms of concussion to ensure the players with suspected and confirmed concussions are removed from play immediately. These injuries need to be addressed by the medical support teams at schools and provincial level. Prevention programmes implemented by these medical support teams need to focus on these injuries. Following from this, the players are sustaining their injuries during the tackle phase of play (regardless of frequency versus risk, this is where the injuries are occurring). Therefore, tackle techniques in the youth need to be addressed from a young age. The younger the players begin practicing and are being taught the correct tackle technique the lower the injury rate in the tackle phase of play will become. Tackle technique and tackle drills could be added to the *Safe Six* to increase the effectiveness of the programme.

During the tournaments, especially, the timing of the injuries is important for the medical staff working at the tournament (chapter 2). The influx of injuries towards the end of the matches (and these injuries are time-loss therefore generally requiring longer medical assessments than medical attention injuries) needs to be catered for by potential increases in medical staff. Furthermore, overall the injury rate during the SA Rugby Youth week tournaments is on an upward trend and this should be considered by SA Rugby and BokSmart when planning the medical staff for the tournaments as the medical demand will be increasing too.

In the school setting, the coaches and conditioning staff should be aware of the increase in injuries at the beginning of the match in the first half of the season (chapter 7). The players are potentially not “match-prepared” at the beginning of the season, and therefore friendly pre-season matches could be implemented, and the conditioning staff should ensure the players are contact-ready at the beginning of the season, as this could be a possible contributor to the injuries.

Recommendations for Future Research

Following the limitations and the practical implications from the studies, there are some recommendations for future research to assist in the evaluation of tackle injuries, implementation of the *Safe Six*, and the effectiveness of an adjusted *Safe Six*.

The *Safe Six* may incorporate a neck strengthening component and then be assessed in differently resourced schools in South Africa for its effectiveness in decreasing injury rate and injury burden. There is the incorporation of eccentric hamstring curls in the *Safe Six*, which are known to reduce injuries, indicating a potential injury preventive effect. Therefore, using a cRCT, the adjusted *Safe Six* can be assessed for effectiveness in injury prevention, using a larger sample to ensure statistical power for detecting changes in injury rates (at least 13 schools in the intervention and control groups with each school contributing 570 match exposure hours). These schools were not recruited in our study as the research team wanted a homogenous sample. Compliance must also be

measured in the groups and per protocol analysis should be performed to determine the effect of compliance to the *Safe Six*.

Following the cRCT, the barriers and facilitators for the implementation of the *Safe Six* in the intervention schools need to be investigated before further studies are conducted. This could provide much-needed data to increase the usability and uptake of the programme. Using qualitative interviews with the coaches responsible for implementing the *Safe Six* in the intervention schools, the barriers and facilitators can be explored.

The lack of changes in the FMS and Musculoskeletal Screening Assessments following an exercise-based intervention call into question the validity of these measures as intermediary outcomes. Further research should investigate, using an already proven injury prevention exercise intervention, whether the FMS and Musculoskeletal Screening Assessments do change commensurate with the injury rates. A validity study will assist future researchers and clinicians to use tests that are valid measures of injury.

The tackle phase of play is claimed to be “the most dangerous phase of play” in rugby. However, the evidence is lacking to assess time spent performing each phase of play and evaluating the phases of play and their injury risk according to the frequency of each phase and number of injuries. Pairing video analysis of rugby matches and the corresponding injury data, the injury risk can be determined for all phases of play in rugby. This can also be performed using teams from different levels of play (age groups and skill level) to further investigate this injury risk.

Conclusion

The BokSmart *Safe Six* was associated with minimal changes in injury risk profile scores in youth.

The SA youth rugby cohort had a similar injury rate to other youth cohorts (and in some instances lower), with the joint (non-bone)/ligament and CNS/PNS injuries having the highest injury rate. The systematic review identified only

one high-level study (out of three) that was effective for injury prevention, but eccentric hamstring curls, plyometric exercises and balance training appeared to have prevention qualities. The players' awareness of the BokSmart *Safe Six*, was associated with the awareness of their specific coaches' awareness and the awareness increased during the targeted-marketing approach.

The youth rugby cohort in South Africa is still in need of an effective intervention, and recent findings indicate a neck strengthening component may increase the effectiveness of the *Safe Six*.