

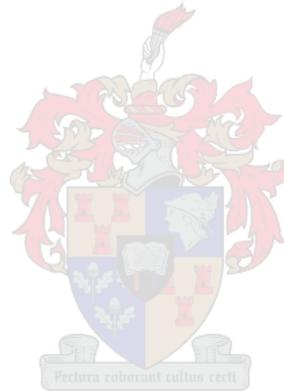
Performance indicators and success factors of the South African men's rugby sevens team during the 2017/2018 World Rugby Sevens Series

by

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in Sport Science at Stellenbosch University*

(Article-Format Thesis)



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DECLARATION

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SUMMARY

Background: Rugby sevens consists of a complex interaction of various actions and events. For trainers to distinguish between events that are more likely to lead to a successful match outcome is a difficult task. Success factors are Performance Indicators (PIs) that were significantly prominent during matches won when compared to matches lost and most likely contributed to a successful match outcome.

Aim: The aim of this study was to determine the PIs that significantly related to successful match outcome during the 2017/2018 World Rugby Sevens Series of the Blitzboks.

Methods: Broadcasted video footage of 59 matches played by the South African men's rugby sevens team during the 2017/2018 World Rugby Sevens Series were analysed using rugby video analysing software (Stratus V3.6.3, Mobii, South Africa). Matches were divided into two categories; matches won versus matches lost. *One-way ANOVA* was used to test for significant differences in PIs between the groups.

Results: Success factors were displayed for the higher number of successful tackles made ($p = 0.03$) and fewer tackles missed ($p = <0.01$) as well as a higher number of restart kicks ($p <0.01$) during matches won. Success factors for the breakdown included more turnovers won ($p = 0.05$), fewer rucks retained by infringement ($p = 0.04$), more defensive breakdowns formed ($p < 0.01$) as well as committing one player to defensive

breakdowns ($p = 0.02$). During matches won, significantly fewer breakdowns were formed in zone B and zone D.

Conclusion: During the 2017/2018 World Rugby Sevens Series, it was shown the most successful team relied on a strong effective tackling ability. To attack successfully, teams need to seek turnovers by optimally committing players to the contest without sacrificing defence, adopt aggressive risk-reward tactics and play in the correct areas of the field (zone A and zone C) to be in control of the territory.

Keywords: rugby sevens; performance indicators; success factors; performance analysis; World Rugby Sevens Series; breakdowns, rucks

OPSOMMING

Agtergrond: Sewesrugby bestaan uit 'n komplekse wisselwerking tussen verskeie aksies en gebeure. Gevolglik is dit vir afrigters moeilik om te onderskei watter aksies aanleiding gee tot 'n suksesvolle wedstryduitskoms. Suksesfaktore is die prestasie-aanwysers wat beduidend verskillend was tydens wedstryde wat gewen is teenoor wedstryde wat verloor is en waarskynlik bygedra het tot die suksesvolle wedstryduitskoms.

Doel: Die doel van hierdie studie was om die prestasie-aanwysers te bepaal wat 'n beduidende verwantskap gehad het met 'n suksesvolle wedstryduitskoms tydens die Blitsbokke se deelname in die 2017/2018 Wêreldrugbysewessreeks.

Metodes: Met behulp van rugbyvideo-ontledingssagteware (Stratus V 3.6.3, Mobii, Suid-Afrika) is uitsendings se videobeeldmateriaal van 59 wedstryde wat deur die Suid-Afrikaanse rugbysewesspan gespeel is tydens die 2017/2018 Wêreldrugbysewessreeks geanaliseer. Wedstryde is in twee kategorieë verdeel, naamlik wedstryde wat gewen is en wedstryde wat verloor is. *Eenrigting ANOVA* is gebruik om te toets vir beduidende verskille in prestasie-aanwysers tussen die twee groepe.

Resultate: Suksesfaktore is vertoon vir 'n hoër aantal suksesvolle duikslae ($p = 0.03$) en vir minder verbeurde duikslae ($p = <0.01$) sowel as vir 'n hoër aantal afskoppe ($p = 0.05$) tydens suksesvolle wedstryde. Suksesfaktore vir die afbreekpunt tydens suksesvolle wedstryde sluit in dat meer omgekeerde besit gewen is ($p = 0.05$), minder losskrums

behou is deur oortredings van die opponente ($p = 0.04$), meer verdedigende afbreekpunte gevorm is ($p < 0.01$) en dat een speler tydens 'n verdedigende afbreekpunt afgestaan is ($p = 0.02$). Tydens suksesvolle wedstryde was dit beduidend dat minder afbreekpunte in sone B en sone D plaasgevind het.

Gevolgtrekking: Gedurende die 2017/2018 Wêreldrugbysewesreeks is bevind dat die suksesvolste span staatgemaak het op 'n sterk effektiewe verdedigingsstelsel. Ten einde suksesvol te wees, moet spanne omgekeerde besit identifiseer deur optimaal spelers aan die afbreekpunt af te staan, maar nie ten koste van die verdediging nie. Die gebruik van aggressief risiko-beloonde speltaktiek in die korrekte areas van die veld (sone A en sone C) om gebiedsvoordeel optimaal te benut kan ook tot voordeel wees vir spanne met 'n sterk verdedigings stelsel.

Sleutelwoorde: sewesrugby; prestasie-aanwysers; suksesfaktore; prestasie-analise; Wêreldrugbysewesreeks; afbreekpunt

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ABBREVIATIONS

HR	Heart Rate
GPS	Global Positioning System
KPI	Key Performance Indicator
PIs	Performance Indicators
SFs	Success Factors

KEY TERMINOLOGY

Advantage line	An imaginary line created by the ball position on the previous breakdown, splitting the field from side-line to side-line. The line is used to assess if the ball carrier made territorial progress from the previous phase.
Ball carry	A player who is in possession of the ball (World Rugby, 2018).
Blitsboks	The name for the South African National men's rugby sevens team.
Breakdown	A term used to describe the contest between two teams for the ball on the ground. The breakdown usually commences after a tackled player takes the ball to the ground and ends when the ball is deemed "out" and general play continues or play is stopped due to a penalty. The breakdown includes the ruck and maul.
Breakdown ball-out	Producing the ball from the breakdown after retaining it during entry.
Breakdown location	Area of the field where the breakdown occurred presented in zones.

Breakdown ball retained	Successfully retaining possession of the ball after the ruck is considered to be over.
Rucks ball retained	Successfully retaining the ball after a ruck is formed and deemed to be over.
Breakdown / ruck lost due to infringement	Losing possession of the ball during the breakdown / ruck contest due to infringement by the Blitzboks.
Breakdown / ruck retained due to infringement	Retaining possession in the breakdown / ruck by means of the opponent infringing.
Breakdown speed	The total time of a breakdown presented in seconds (refer to breakdown definition).
Incomplete passes	The player passes the ball and misses the target.
Infringements	Action by a team that is against the laws of the game.
Key performance indicator	A group of performance indicators that are relevant to a desired outcome.
Line break	A ball carrier that clearly breaks the defensive line towards the opposition try-line.
Lineout	A lineout is a set piece consisting of a line of at least two players from each team waiting to receive a throw from touch (World Rugby, 2018).

Offload	Passing the ball while in contact with opposition players.
Pass	A player throws or hands the ball to another player (World Rugby, 2018).
Performance indicator	Event marker referring to as a selection, or combination, of action variables that aim to define some or all aspects of performance.
Possession	An individual or team in control of the ball or who are attempting to bring it under control (World Rugby, 2018).
Restarts 50m	The method of restarting play with a drop-kick after a score or a touch-down (World Rugby, 2018).
Ruck	A phase of play where one or more players from each team, who are on their feet and in physical contact, close around the ball, which is on the ground (World Rugby, 2018).
Ruck speed	The total time of a ruck presented in seconds. The ruck time starts as per ruck definition and ends when the ball is out or an infringement stops play.
Scrum	A set piece, normally consisting of eight players from each team bound together in formation (World Rugby, 2018).

Set pieces	Structured play that both teams engage in during the start of playing events.
Success factors	Performance indicators that are shown to significantly contribute to successful match outcomes.
Successful match outcome	Referring to successful match outcome refers to winning a match.
Tackle	The method of holding a ball-carrier and bringing that player to ground (World Rugby, 2018).
Tackle made	Includes all successful tackles where the tackle was deemed to be completed.
Tackle missed	A missed tackle allowing the opposition player to gain meters while the tackler did not complete the tackle.
Territory	Gained field possession while on attack.
Turnover conceded	Losing possession of the ball to the opposition.
Turnover won/ gained	Gaining possession of the ball from opposition attack.

OVERVIEW OF THESIS

The present thesis is an article-format thesis. The Introduction provides basic information as background to the study, as well as the aims and objectives which guided the research. An in-depth explanation of research pertaining to the current study will be discussed in Chapter Two. Chapter Three contains Article One: *Performance indicators relating to successful match outcome in professional rugby sevens*. This article focuses specifically on the performance indicators that are significantly different between matches won and matches lost during the 2017/2018 World Rugby Sevens Series. The article is written accordingly to the guidelines of the European Journal of Sport Science (Appendix A). The referencing style is compiled through Mendeley and follows the guidelines as provided for the intended journal. Chapter Four contains Article Two: *Quantifying performance indicators of the breakdown and ruck and their effect on match outcomes in professional rugby sevens*. This article focusses specifically on the performance indicators in breakdowns and rucks that significantly differ between matches won and matches lost and possibly relate to a successful match outcome. This article is compiled under the guidelines of the International Journal of Performance Analysis in Sport (Appendix B). The referencing style is compiled through Mendeley and follows the guidelines as provided for the intended journal. In Chapter Five, a general discussion and conclusion of the aims and objectives of this investigation will be presented, as well as study limitations and recommendations for future research. Thereafter, the Appendices will follow. Refer to Appendices A and B for the author guidelines as provided by the respective journals, C for permission for the use of data as provided by SARU and D for

ethical clearance. The referencing format for this thesis follows the APA 6th Edition referencing style available by Mendeley for all the chapters.

CHAPTER ONE

INTRODUCTION

Today it is almost impossible to work in a professional sports environment without the use of data analysis to assist in performance assessment (Lovell, Sirotic, Impellizzeri, & Coutts, 2013). Due to the complex interaction of invasion team sports, the question remains if it is possible to extract relevant metrics in a similar way to striking sports, which have historically shown to be effective in sports such as baseball (Lewis, 2004). Allocating relevant performance parameters may be used as objective measures by coaches to enhance the chance of a team's success (Gerrard, 2007).

Rugby sevens (Sevens) has seen enormous growth in popularity and since its inclusion in the Summer Olympics in Brazil in 2016 (Engebretsen & Steffen, 2010), more data are collected with reference to the sport than ever before. This increase in data collection in the sport has provided some teams with the benefit of improving their tactical and technical approach to matches. Teams are now able to scrutinise the opponent's playing patterns in an attempt to neutralize their attacks and find weaknesses in their defensive systems (Ross, Gill, Cronin, & Malcata, 2016). With the use of modern video analysing software (Wright, Atkins, & Jones, 2012), more data than ever are accumulated on players and matches which are used to exploit the opponent's strengths and weaknesses (Wheeler, Askew, & Sayers, 2010). It is now possible to perform a much more in-depth analysis, providing more ways to assess various events that occur during a rugby sevens match (Higham, Hopkins, Pyne, & Anson, 2014a).

During match analysis, various actions of the team or players are noted that are of interest to coaches. The events that are characterised to be of interest to the performance of the team are usually referred to as performance indicators (PIs) (James, Mellalieu, & Jones, 2005). PIs that are found to significantly relate to successful match outcome (winning a match) are termed “success factors” (SFs) (Ross, Gill, & Cronin, 2014a).

To date, most studies on PIs were done in rugby union (Watson, Durbach, Hendricks, & Stewart, 2017). As rugby sevens and rugby union have the same objectives and are played under the same laws and field dimensions, with minor variations, an overlap of several PIs might be visible. It has been mentioned that there are limitations when transferring PIs findings from rugby union to rugby sevens (Ross, 2015).

PIs have been used in the aim to objectively classify aspects of play. James et al. (2005) studied different position-specific PIs in rugby union to determine position-specific performance profiling. Finding relevant PIs can thus be used not only for performance enhancement, but also for the recruitment of players. It is also valuable when used in specific positional skills development (Van den Berg, 2013). An extensive study on the 2011 Rugby World Cup fifteens provided insight on the use of PIs by other authors, but failed to provide clear indications for specific PIs that were relevant for a successful match outcome (Hughes, Evans, & Wells, 2001). The same conclusion was reached by Vaz, Mouchet, Carreras, and Morente, (2011) who considered the difference in PIs between winners and losers in games where the outcomes of the matches were close. Although

most of these studies were done on rugby union, it was mentioned that the different playing styles of the teams might obscure the definite outcome of the role PIs play in a team's performance.

Due to the vast majority of PIs, some literature refers to the term "key performance indicators" (KPI) as a collection of PIs that are most likely to have an effect on match outcome (Watson et al., 2017). Only a handful of studies have been published on sevens, but recent interest in PIs relevant to success have shown to be of value to coaches and trainers (Suarez-Arrones, Portillo, González-Ravé, Muoz, & Sanchez, 2012). Most studies on rugby sevens are currently confined to the physical and physiological demands of a rugby sevens match, focusing more exclusively on physical and physiological performance data (Williams, West, Howells, Kemp, & Flatt, 2018). Knowing the exact match load on rugby sevens players still provides valuable guidance to trainers for optimal player conditioning (Suarez-Arrones, Nunez, Portillo, & Mendez-Villanueva, 2012).

The optimal preparation of players on and off the field have become a priority for teams as the sport has become more professional (Hogarth, Burkett, & McKean, 2016). Coaches rely upon acquiring match insights to gain an edge over the opponent. In this regard, coaches have turned to more in-depth match analysis in the search for various PIs that could assist with knowledge of match demands but also to observe the tactical approach of the opposition's playing styles and structures (Schuster et al., 2018). Comparing the relationship between physical characteristics and match activities associated with success factors (SFs) provides valuable information (Ross, 2015).

With the abundance of events during a rugby sevens match, a wide variety of PIs are displayed. It is therefore extremely difficult for literature to cover all possible PIs. In one of the most extensive studies to date on PIs in rugby sevens, ranging over four years and including a spectrum of 23 PIs, the authors concluded that teams with successful match outcome gained and maintained more ball possession by dominating the ruck and retaining line-out possession (Higham et al., 2014a).

PIs are useful to indicate factors influencing the scoring of points during matches and why a match was won or lost. A study by Higham et al. (2014a) on rugby sevens showed that teams that score more points tend to control ball possession and display a patient and evasive playing style. It was also found that more rucks, mauls and passes will have a negative effect on point-scoring. Similar studies on PIs have also shown that aspects of successful match play can be extrapolated to enhance playing strategies. Van Rooyen, Lombard and Noakes (2008), concluded that rugby sevens teams need to have ball possession for 30-60s at a time and need to convert 30% of this possession into scoring opportunities to be successful.

The knowledge of PIs is essential for coaches and players when it comes to defensive and attacking play. The success of a team's defensive and attacking structures may be dependent on the extent of knowledge of the opposition's strengths and weakness. Disrupting the opponent's defensive line provides attacking opportunities that could lead to line breaks. It has been shown that successful teams are better at creating line breaks

while also capable of successfully limiting line breaks created by the opponents (Ross et al., 2016). Line breaks are usually a result of various events and therefore could be explained by assessing the PIs that contributed to the creation of the line break. In the same study by Ross et al. (2016), it was evident that the breakdown also played a significant role in the match outcome.

The breakdown is probably the most contested event in rugby union and rugby sevens, containing pushing and pulling while in the contest for the ball or to protect the ball (Suarez-Arrones, Portillo, González-Ravé, Muoz, & Sanchez, 2012). With the breakdown being such a unique event to rugby, it has received remarkably little attention in the literature. In rugby union, it was shown that fewer rucks are formed by winning teams during attacking play. The top teams also maintained more positive ruck outcomes and conceded fewer turnovers when rucks were formed in rugby fifteens (Kraak & Welman, 2014). Rucks have been shown to be a good platform to launch an attack in rugby union. The viability of rucks in rugby sevens, however, is still relatively unclear (Ross, Gill, & Cronin, 2014b). Most studies only included the frequency of the rucks, showing winning teams to form fewer rucks and concede fewer turnovers (Hughes & Jones, 2005) during ruck contests than losing teams (Higham et al., 2014a). There have been a small number of studies published on other aspects of the ruck or how rucks are used in territorial play in successful situations in rugby sevens (Higham, Hopkins, Pyne, & Anson, 2014b). Reference has also been made to successful teams playing a more evasive and open style of rugby by avoiding direct contact and limiting the breakdown contest while on the

attack. This suggests that the breakdown contest is an integral part of match outcome (Vaz et al., 2011).

Barkell, O'Connor, and Cotton (2016) realized the impact PIs might have on matches and the way teams might use it during their match preparation. The authors conducted a study showing that there are differences in the way PIs can be used to enhance team preparation depending on either rugby sevens men's or women's tournaments due to slight variations of PIs that relate to matches won. This might allow for rugby sevens men's teams to focus on different PIs than the women's teams as it was shown that different PIs related to success during these tournaments. PIs, however, should be well understood and used with caution in different tournaments as levels of participation might vary (McLaren, Weston, Smith, Cramb, & Portas, 2016).

There has been some criticism regarding the use of PIs in sport. The abundance of data and PIs have been criticized, because the high number of PI's can be overwhelming and confusing (Wright et al., 2012). Coaches do not all agree on the effectiveness of PIs. Trainers also vary widely on which PIs should be regarded as KPIs. The approach to the use of PIs in a team environment may sometimes lead to a scattered or shotgun approach that does not focus on the relevant PIs and usually delivers little success (Hughes et al., 2012).

There is a definite need for a better understanding of the events in rugby sevens that relate to winning a match. To effectively isolate PIs relevant to matches won, the

successful identification of contributing SFs are warranted. Although measuring the PIs of winning teams and comparing it to the PIs of losing teams provides a baseline for PI parameters, monitoring of a single team's PIs correlated to the match outcome might be even more valuable. Considering the abundance of PIs included in various studies, there is still only a vague understanding of the PIs involved that directly relate to a team's success. It might be of value to observe the alteration in PIs during the performances of the same team during matches won and matches lost. Placing the focus on the areas of difference between winning and losing scenarios might provide relevant insight into the effect of measurable events on match outcome.

PROBLEM STATEMENT AND MOTIVATION FOR THE STUDY

Despite the recent increase in data collection, there is still a lack of literature on rugby sevens in comparison to other rugby sport codes (rugby union and rugby league). The growing interest in sevens, especially with the inclusion in the 2016 Olympic Games, has created the need for coaches and players to obtain a better understanding of the game. Although some studies have provided valuable information on certain aspects of the game, there is still not enough evidence-based knowledge on SFs relating to sevens. Although sevens is an emerging area in rugby, it has received less attention than its counterparts of rugby codes in the literature (Prim, Van Rooyen, & Lambert, 2006). It has also been identified that almost no study focuses directly on the contest area in a sevens match. Although intra-team variables of competitions have been considered by Higham, Hopkins, Pyne, and Anson, (2014c), these studies produced only the collective

characteristics leading to subtleties in individual team performances that became indistinguishable (Higham et al., 2014c). Due to the limited research in sevens, various other PIs and their effects are still unaccounted for. The isolation of PIs of the overall winning team of the series, to avoid cross-pollination of tactics and generalisation of trends, should provide a better understanding of the impact of PIs during matches won and matches lost. Valuable knowledge can be obtained by analysing the relationship of intra-team changes. By examining the PIs of the most successful team and by separation of the matches won and matches lost, valuable insight on what it takes to be the most successful team at the highest level of competition can be gained. This study can also provide more information on one of the factors that could directly influence the match outcome. The successful campaign of the South African rugby sevens team, the Blitzboks, during two consecutive years has asserted them as ideal candidates for a study of this nature.

AIMS, OBJECTIVES AND HYPOTHESES

RESEARCH AIM ONE

The first aim of the study was to investigate which PIs could be classified as SFs for the Blitzboks during the 2017/2018 World Rugby Seven Series during general play and set pieces.

The following objectives relating to research aim one were stated:

To determine, with the use of video analysis, the relationship between matches won and:

- 1) the amount of possession or territory obtained;
- 2) the attacking PIs (ball carries, line breaks, passes, offloads, kicks);
- 3) the defensive PIs (tackles made, tackles missed, tackle completion ratio);
- 4) infringements and turnovers;
- 5) set pieces (scrums, lineouts, restarts, restarts regained)

HYPOTHESIS ONE

It was hypothesised that, compared to matches lost, matches won would show no significant difference between the amount of possession or total percentage of territory; ball carries, line breaks, passes, offloads and kicks; turnovers; as well as set pieces won.

HYPOTHESIS TWO

It was hypothesised that, compared to matches lost, matches won would show no significant difference for the number of breakdowns or rucks formed, retained, the speed of the breakdowns and rucks or the number of players committed to the breakdown or ruck respectively.

RESEARCH AIM TWO

The second aim of the study was to investigate the relationship between the PIs involved in the breakdown and rucks and their classification as SF for the Blitzboks during the 2017/2018 World Rugby Seven Series.

The following objectives guided the research for aim two:

To determine, with the use of video analysis, the relationship between matches won and:

- 1) the total number of breakdowns and rucks;
- 2) the number of breakdown and rucks retained;
- 3) the number of passes per breakdown
- 4) the amount of possession per breakdown;
- 5) the speed of the breakdowns and rucks;
- 6) the number of players committing to the breakdowns and rucks from the
Blitsboks during attack and defence.
- 7) the zones on the field of play where the breakdowns are formed.

By addressing aim one and two it might be possible to isolate SFs in general play, set pieces and in the breakdowns and rucks that positively related to matches won during the 2017/2018 World Sevens Series for the Blitsboks. The SFs might have played a critical role in the performance of the Blitsboks in becoming overall winners of the series and the aims provided will thus guide this study to determine which PIs contributed significantly to the matches won.

CHAPTER TWO

THEORETICAL BACKGROUND

INTRODUCTION

The complexity of interacting events in rugby sevens has made it difficult to isolate specific factors that lead to winning a match (Henderson, Harris, Poulos, Fransen, & Coutts, 2018). With prestige events such as the World Rugby Sevens Series and the Olympic Games promoting the sport all over the world the need for teams to gain knowledge on how to obtain an edge over the opponent has become a priority (Schuster et al., 2018). Numerous studies have been published on different game demands whether it be physical (Ross, 2015), physiological (Suarez-Arrones et al., 2013) or technical and tactical (Ross et al., 2016). It is, however, impossible for coaches and trainers to be sure which factors during matches may possibly relate to winning a match without the use of the available data (Watson et al., 2017). Higham et al. (2014c) introduced a model which provides four possible areas during match play that need to be assessed. These areas are match development, scoring, set piece play and phase play, with each area containing its own set of PIs.

Analysing match development may provide valuable information on how ball possession and territory are controlled during a match. Most studies thus far have contributed a successful match outcome to superior ball possession (Van Rooyen et al., 2008), while

the percentage territory play in different areas of the field is not regularly mentioned in the literature. Recent literature has provided some insight into the factors involved in attacking play that related to successful match outcomes. The number of line breaks a team achieves as well as the number of entries in the opposition's 22m area could strongly be linked to the success of winning teams (Ross et al., 2016). On defence, previous literature has shown that teams need to ensure a high successful tackling rate in order to win (Higham et al., 2014b). As teams compete for ball possession during attacking and defensive play, good discipline becomes an increasingly challenging factor. Different playing styles of teams have provided contrasting findings on the risk-reward play as teams might sacrifice discipline to gain or avoid conceding turnovers (Higham et al., 2014a).

Although set pieces (lineouts and scrums) are not as highly contested in sevens as in fifteens (Higham et al., 2014a), lineout-turnovers have been reported to be highly related to match outcome while the number of scrums did not show any relation to a successful match outcome (Barkell et al., 2016). The restart kick is a set piece that can be contested depending on the choice of kick. Deep restart kicks have been reported to be preferred by winning teams more frequently (Barkell et al., 2016). The extensive array of PIs during matches creates confusion as the methodology in the literature differ in providing specific and consistent outcomes. It is therefore crucial that PIs are validated against matches won and matches to highlight the PIs that are significantly altered. This chapter will follow by introducing sevens through a brief history of the game, the format of the game and the player positions. The chapter will then provide information on the competition that forms

the basis of this study (World Rugby Sevens Series) and the match demands of rugby sevens. The following section provides information regarding the measurement of performance, the selection of PIs and the classification of SFs following an adapted model of the one presented by Higham et al. (2014).

RUGBY SEVENS

HISTORY OF RUGBY SEVENS

Rugby sevens is often referred to as a compact version of rugby union due to the similarity in the laws of the game and the playing field, but with fewer players and less match time. Sevens is played in numerous countries all over the world and with a rapid rise in popularity, the sport has been voted in 2009 to form part of the 2016 Rio Olympic Games (Engebretsen & Steffen, 2010; Ross et al., 2014a). This code of rugby comes from humble beginnings and was first played in 1883 in Melrose, Scotland as a passtime after it's inception as a fundraiser for a local club (Nauright & Parrish, 2012). It, however, did not generate much attention outside of Scotland until after the 1920`s. The first international tournament took place in 1973 and the first World Cup was in 1993 (Nauright & Parrish, 2012). Sevens has formed part of the Common Wealth games since 1998 (Schuster et al., 2018). In 1999, the International Rugby Board (IRB) introduced a world series circuit that would see the top sevens playing nations competing in a series of tournaments on a yearly basis, the IRB Sevens World Championship (Ross et al., 2014a). To take part in the series, teams need to qualify as only 16 to 24 teams are allowed to compete in the championship (Van Rooyen et al., 2008). The early years of the competition were

dominated by Fiji, but subsequently New Zealand and more recently South Africa also proclaimed dominance in the competition. A name change occurred for the competition when the IRB changed its name to World Rugby. The competition is currently known as the World Rugby Sevens Series and is seen as the prestige event for the top rugby sevens nations each year. Today sevens is played competitively by more than 93 countries around the world (Carreras, Kraak, Planas, Martin, & Vaz, 2013).

GAME STRUCTURE

Sevens is an invasion sport with the aim to run, pass, catch and kick the ball up the field in an attempt to ground the ball behind the opposition`s goal line (Henderson et al., 2018). If successful, the scoring team is awarded five points and is given the opportunity to attempt to drop- kick the ball, in line with where the try was scored, over the posts for an additional two points if successful (Henderson et al., 2018). With the game being played under mostly the same laws and pitch dimensions as fifteens, the major differences relate to the number of players on the field and the reduction in total match time. During a match, teams consist of seven players from each side with five substitutions (Nauright & Parrish, 2012). A substitution can be made at any time during a stoppage in play. The total match time is 14 minutes, seven minutes for each half with two minutes of rest between halves (Granatelli, Gabbett, Briotti, Padulo, Buglione, D`ottavio & Ruscello, 2014). During injury or time-outs, time is stopped and therefore no extra time is added. However, matches may run into overtime as play has to completely stop for a match to end. Studies on match time have revealed that although total match time has decreased from 1064.5 ± 152.8 s

to 1002.15 ± 136.23 s (due to fewer stoppages during match play), ball in-play time has increased from 430.8 ± 27 s (Rooyen et al., 2008) to 480.98 ± 78.15 s at the time of the study in 2013 (Carreras et al., 2013). This indicates an increase in match intensity over time as there were fewer recovery periods during matches. It was also found that pool stages had the shortest amount of stoppage time demonstrating a tendency towards an increase of stoppage time for more evenly matched teams (Carreras et al., 2013).

RUGBY SEVENS POSITIONS

Due to the decreased number of players on the field, a player's position in sevens is not as clearly defined as in fifteens due to the decreased number of players on the field. The handful of players are thus required to adapt to various different positional roles during a match. There are still basic positional functions players adhere to during a match, although various terms are used to describe sevens positions. The figure below demonstrates the most commonly used terms according to World Rugby.

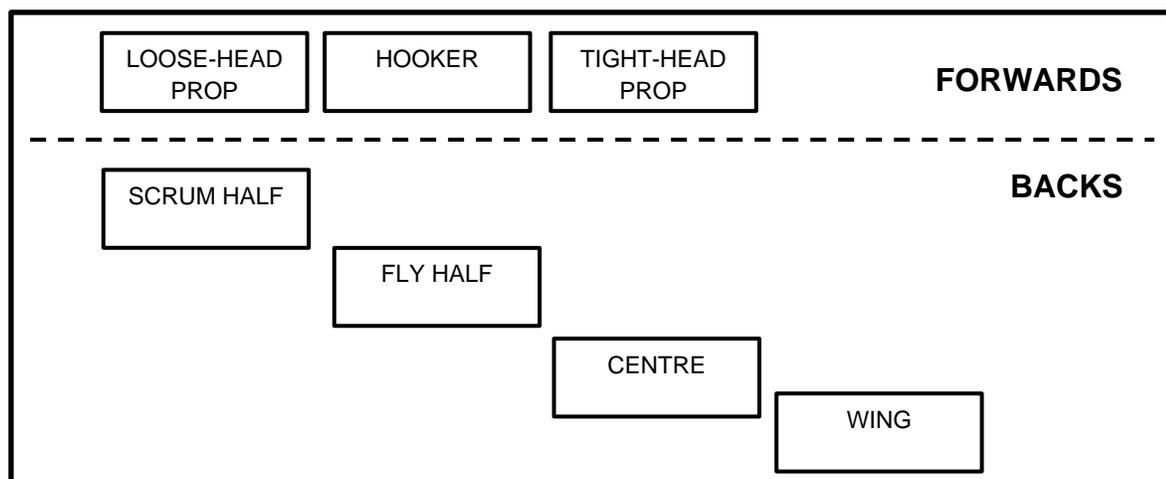


Figure 1: Sevens positions (World Rugby, 2019)

The difference in the anthropometric characteristics of sevens players compared to fifteens players as well as the difference between the forwards and backs are explained in further detail in the section for anthropometric characteristics. A short summary of each position is given below.

Props (Loose-head and Tight-head): The primary role of the props are to anchor the scrummage and provide lifting support to the jumper during the lineout (World Rugby, 2019).

Hooker: The hooker is a unique position as he is responsible for hooking the ball to win possession during a scrum as well as throwing the ball into the lineouts (World Rugby, 2019).

Scrum-half: The scrum-half provides the link between forwards and backs at the scrums and the lineouts. He is mostly responsible for either distributing the ball to the backs or maintaining play with the forwards (World Rugby, 2019).

Fly-half: The fly-half will usually have to consider the opposition's defence and decide whether to attack the opposition by running, play the ball to the backs or kick the ball to either gain territory or to get behind the opponent's defensive line (World Rugby, 2019).

Centre: The centre is usually agile and will attack the opposition line with speed and power. This position provides opportunities for the wing, but also assists in defending the wider channels (World Rugby, 2019).

Wing: This position is usually associated with players with fast running speeds and quick accelerations. The wing provides the team with velocity to chase kicks and outrun the opponents (World Rugby, 2019).

THE WORLD RUGBY SEVENS SERIES

The World Rugby Sevens Series is widely recognised as the most prestigious competition for the elite rugby sevens playing nations. Since the inception of the competition in 1999, the format of the competition has remained relatively similar over the years, but with the addition of more teams from various countries (Ross et al., 2014a). The current format (at the time of this study) includes 15 teams with five temporary invitational teams. The competition usually runs over a period of seven to eight months. Currently, two tournaments are played at the end of the year before the players take a few weeks to break from the tournament over the festive season. The series continues again in January and ends in May/July. The series consists of 10 tournaments each played in a different country. To minimize travelling the tournaments have been divided into five legs with two tournaments being played on back to back weekends in different but closely geographically related countries, before the travelling teams make the return journey home. The five legs of the competition are usually scheduled three to seven weeks apart (Henderson et al., 2018). A tournament is usually played over two to three consecutive days with each team playing five to six matches during this time. This cycle is repeated every three to four weeks which permits for little recovery time (Dennis, Dawson, Heasman, Rogalski, & Robey, 2016) as well as preparation time for the players between tournaments (Waterhouse, Reilly, Atkinson, & Edwards, 2007). The travelling schedule can be gruelling as teams may travel over up to 12 time zones with flights lasting more than 12 hours. Teams usually arrive in the same week as the tournament. Each year core teams qualify for the competition. A few temporary teams are included every

year, alternating during the season and playing only some of the tournaments in the series.

The tournament is played in a league style format with the first day usually consisting of pool stages. Each team plays three matches to determine the pool standings. The second or last day consists of knockout stages. For a team to be successful they need to make it through the quarter-final and semi-final before reaching the final of the knockout stages. These matches are usually only a few hours apart leaving the teams with very little recovery and preparation time between matches. Points are awarded to each team at the end of each tournament depending on where the team ends on the final tournament standings. The points awarded for each tournament are accumulated and determine the overall series winner at the end of the season (Higham et al., 2014a). Teams therefore need to be consistent in tournament placing to be successful in the series and obtain a higher rank on the final points table.

RUGBY SEVENS DEMANDS

Anthropometric characteristics

As previously referred to under the format of rugby sevens, sevens is played on the same field dimensions as fifteens, but with only seven players on the field of play. This provides more available running space with fewer defenders to cover the full playing area. Players are therefore required to be mobile, but also physically strong to cope with contact situations. It is therefore logical that sevens players will have to adapt to fast-paced match

play with high running intensities as well as rapid accelerations. The anthropometrics of rugby sevens are unique to the sport, as explained in the section that follows.

The higher number of players on the field in fifteens contributes to the large differences in playing positions compared to sevens. Due to more available running space in sevens, players are expected to perform multiple different positional tasks as they are more widely spread out on the field of play. The large difference in match time between sevens and fifteens also contributes to the difference in anthropometric characteristics between players. Sevens players are usually considered to have less muscle mass and are leaner than fifteens players which suits their playing style better due to higher running intensities (Rienzi, Reilly, & Malkin, 1999). In a study on 30 male sevens players during an international rugby sevens tournament in Uruguay, it was found that forwards had more mass (whole-body, adipose tissue, muscle) than backs. Forwards in sevens are usually taller and heavier than backs (Rienzi et al., 1999). Reported body composition for sevens players indicated an estimated total body fat of ~11-12% and a sum of skinfolds mean of 52.2–61.6 mm (Ross et al., 2014a). This can be compared to fifteens players who have been shown to have a body fat percentage of 15.5 ± 5 and 13.5 ± 4.8 for forwards and backs respectively as reported in a study on 30 French international fifteens players (Lacome, Piscione, Hager & Bourdin, 2014) and 105.3 ± 35.4 mm for the sum of skinfolds as reported in a different study on 15 under 21 male academy rugby fifteens players (Darrall-Jones, Jones & Till, 2015).

In a review study it has been noted that rugby sevens players are lean and have reduced excess body fat in order to obtain a better weight to power ratio allowing for an increase in work output (Meir, 2012). In another review study, Ross et al. (2014) showed that sevens players are lighter compared to fifteens players if not grouped by position. Sevens players are more similar in mass and stature to the outside backs in fifteens. When grouped by position, sevens forwards are similar in body mass to fifteens loose forwards (mean ~98 kg and 102 kg, respectively) and sevens backs are similar to the outside backs (mean ~87 kg and 89 kg, respectively) (Ross et al., 2014a).

Although anthropometric characteristics of sevens players and fifteens players have been introduced into the literature, a lack of recent measurements for current international competitions and international teams can be appreciated. Recent events have seen sevens players included into fifteens squads in the same season. It is therefore necessary to constantly monitor players and competitors to allow players the ability to adapt more effectively to changes in anthropometric characteristics in their respective rugby codes.

Physical demands

With only a limited number of players on the field, sevens players are uniquely challenged in terms of the physical demands. The intensity of sevens has been investigated in several studies by assessing the running demands of match play (Granatelli et al., 2014). This is usually done by the use of a Global Positioning System (GPS) device that can track the player's locomotive demands during a match (Cummins, Orr, O'Connor, & West, 2013).

A major component to sevens is the extensive amount of distance covered during matches. Studies have shown that international sevens players travel a mean distance of 1452 ± 243 m and 1420 ± 332 m respectively between forwards and backs during a single match (Ross, Gill, & Cronin, 2015). This is in keeping with other research that has shown the first and second half to be closely contested at 745.2 ± 105.5 m for the first half and 762.4 ± 111.5 m for the second for forwards and 895.9 ± 184.2 for the first half and 820.4 ± 135.4 m travelled over the second half for backs (Suarez-Arrones et al., 2014). A fifteens player could cover up to almost 7000m in a rugby union match over an 80min period (Coughlan, Green, Pook, Toolan, & O'Connor, 2011) although other studies have found it to be lower, but still well over the 6000m mark (Roberts, Trewartha, Higgitt, El-Abd, & Stokes, 2008).

Due to of the lower number of players on the field sevens players cover ~45% greater relative running volume and 135% greater high-velocity meters (Higham, Pyne, Anson, & Eddy, 2012). It was shown that sevens backs and forwards may cover ~51% and ~82% more distance when time periods are standardised to fifteens (Ross et al., 2014b). In soccer, it has been shown that players run between 10-12km during a 90min match (Di Salvo, Pigozzi, González-Haro, Laughlin, & De Witt, 2013) with Australian football still being one of the sports with the highest intensities at above 130m.min and 12-15km covered during a match (Hiscock, Dawson, Heasman, & Peeling, 2012).

Some studies have indicated that players cover less distance in the second half compared to the first half. The difference in distances covered could possibly be due to fatigue with the largest decrease in distance covered per minute in the final three minutes during the second half (Granatelli et al., 2014). The high intensity of sevens can be seen as relative distance covered ranges from 96m/min (Higham, Pyne, Anson, Hopkins, & Eddy, 2016) to 113m/min (Ross et al., 2014b; Suarez-Arrones et al., 2014). Some researchers have reported intensities as high as 120m/min (Higham et al., 2012). The running intensities of sevens have been shown to be higher than other forms such as rugby league (100-108m. min) (Gabbett, 2013; Sirotic, Coutts, Knowles, & Catterick, 2009) and fifteens (Venter, Opperman, & Opperman, 2011). Various studies on the running demands in other popular invasive sports have provided with the opportunity to place the above-mentioned findings into perspective.

Work to rest ratio was shown to be significantly higher in sevens (1:17.6) (Van den Berg, 2013) than in fifteens (1:6) (Austin et al., 2011). The work to rest ratio for sevens could be further divided into 5.4% workload with 58.5% non-active recovery and 36.24% active recovery (Van den Berg, 2013). Successful and less successful teams in provincial u/18 South African Rugby Sevens teams differed significantly in certain speed zones (Van den Berg, 2013). The level of intensity can be seen to increase as the level of competition increase. Higham et al. (2012) found players to cover more distance at higher speeds with greater accelerations and decelerations during international competitions compared to players in domestic competitions. A study on club level sevens players showed players spent more time standing, walking and jogging than at any other running speed during

both competition levels. Low-intensity activities represented 61% of total match time, which consisted of 34.8% of match time standing and walking and 26.2% jogging. Cruising, striding, high-intensity running, and sprinting represented 9.8%, 15.5%, 5%, and 8.7% of total time respectively (Suarez-Arrones, Nunez, Portillo, & Mendez-Villanueva, 2012).

Due to more available running space compared to other rugby codes, sevens players show different sprinting distances, speeds and number of collisions and impacts than their fifteens counterparts. It was shown by Suarez-Arrones et al. (2014) that maximum sprint speeds reached up to 27.5 ± 2.5 km/h, with maximum sprint distance reaching 37.2 ± 16.1 m. High speed running meters (>5 m.s⁻¹) accounted for almost 250m of a match per player (Higham et al., 2012). Velocities in sevens matches have also shown to increase as the tournament progress, 8.11 m.s in pool stages and 8.22 m.s in cup stages (Ross et al., 2014b). This is closely in line with fifteens players who have been shown to reach speeds of up to 30.8 km/h (Coughlan et al., 2011). Due to higher running speeds, the findings by Suarez-Arrones et al. (2014) showing high collisions and impacts in sevens could be explained. They found sevens players experience 45.1 ± 24.5 impacts above 7g during a match, with 2.5 ± 2.1 of the impacts shown to be higher than 10g. Although over a shorter period of match time compared to fifteens, sevens players are involved in up to ~40% more contacts if time were to be standardised to fifteens match time (Ross et al., 2014b).

The second half of sevens matches usually show less activity and a reduction in distance, speed and accelerations (Furlan et al., 2015; Granatelli et al., 2014). Notably, it has been shown that substitutes tend to display higher total distance and high-speed running (Murray & Varley, 2015). This can be explained by the speed duration relationship, proposing that substitutes are exposed to less playing time, consequently allowing them to perform at higher intensities due to the reduction in accumulated fatigue (Ferguson, Wilson, Birch, & Kemi, 2013). Speed tests for sevens players over 10m, 20m, 30m, and 40m have displayed respective times of 1.74, 2.92, 4.02, 5.11 with a maximum velocity of 9.2 ms⁻¹. Sevens players appear to be slower over 10m and 30m than tested fifteens players (Gabbett, 2005). It should, however, be taken into consideration that discrepancies may be due to testing inconsistency in protocols such as running surface and starting stands (Ross et al., 2014a). However, it seems players tend to run more when playing higher-ranked opponents as well as during close-scoring matches with running activity decreasing in the second half.

The mentioned high demands placed on the sevens players could be reflected in the severity of injuries sustained. Cruz-Ferreira, Cruz-Ferreira, Santiago, and Taborda Barata (2017) reported in their review that sevens players are subjected to mean severity of >34.1 days and an injury frequency of 101.5 to 119.8 per 1000 player-match-hours. The injuries most frequently experienced by elite players were lower limb and articular or ligamentous injuries. The authors concluded that sevens players have a higher injury rate that keeps players out of the game for longer periods of time, possibly due to the higher running and turning speeds sevens players are subjected to (Cruz-Ferreira et al., 2017).

This is in accordance with a recent study by Fuller (2018), who found the frequency of injuries to be in the same range but the severity to be lower as previously reported as their return to play time was quicker after an injury. It was also found that the number of injuries increased during the second half of the match. The most common injuries to occur include the knee ligament, ankle ligament and concussions (Fuller, Taylor, & Raftery, 2016). It was reported that the most common cause for the infliction of injury was due to tackles (impact) in 75% and 13% due to running (no impact) (Fuller, Taylor, & Raftery, 2017). Similar findings were made by (Fuller, Taylor, & Raftery, 2015) who reported 77% of injuries to be caused by contact and 22% due to running. When the injuries caused by tackles were assessed, it was found that 34% of injuries were due to being tackled and 18% due to being the tackler. Concussions obtained by sevens players were shown to be more severe than in fifteens play. Concussions occurred 8.3 times for every 1000 playing hours with a time of 19.3 days to return to play (Fuller et al., 2015).

Physiological responses

As mentioned, sevens is a high-paced sport that includes numerous accelerations, decelerations and impacts. To understand the impact that these stressors have on the body of a sevens player, it is necessary to address the physiological response of the players during a match. With the use of technology, it is now possible to monitor a player's heart rate (HR) during a match and training. Monitoring of the heart rate is the most widely used method to determine internal load (Elloumi et al., 2012). Heart rate response is accurately recorded with the help of HR straps and is commonly used in all sports to get

a broad but accurate sense of the physiological exertion players experience on the field and in training sessions (Lovell et al., 2013).

Heart rate recordings are usually divided into different zones to establish the time players spend at different intensities. HR is commonly used to prescribe and monitor intensity and can also be used as an indication of fatigue. HR is usually expressed as a percentage of maximal HR to determine effort (Karlsen et al., 2017). According to previous studies sevens players spend as much as 86% of the match above 90% of their maximum HR (Granatelli et al., 2014). It has also been shown that backs and forwards spend almost the same time in the different HR zones. There is however an increase in HR intensity above 91% of maximum HR in the second half (Suarez-Arrones et al., 2014). A breakdown of the HR zones show that players spend about 8% of match time above 95% of max HR, 24% between 91% and 95% max HR with the most time spent in zone 81-90% (~55%). Only about 4% of the total match time is spent at >70% of max heart rate (Suarez-Arrones et al., 2014).

With blood lactate concentration being sensitive to changes in exercise intensity and duration, it can be used to narrate the metabolic changes players experience in different exercises or match intensities (Halson, 2014). Blood lactate concentrations in sevens players were found to be higher at 11.2 mmol⁻¹, compared to fifteens (6.6mmol⁻¹), showing the immense focus trainers need to put on the glycolytic energy pathways during the training of sevens players. This is evidence that sevens training should differ from fifteens (Granatelli et al., 2014). This has led to sevens teams favouring high-intensity

interval training (HIIT) relating to short interval training or sprint intervals focussing on the adaption of the anaerobic glycolytic pathway and neuromuscular load (Buchheit & Laursen, 2013). The outcome benefit of this type of training includes maximum VO₂ improvements (Sloth, Sloth, Overgaard, & Dalgas, 2013).

Due to the format of the series that certain sevens tournaments are played in, it is very likely that back to back tournaments can occur in consecutive weeks. This could have serious consequences for the recovery of players. Neuromuscular function (NMF) was shown to be reduced between tournaments. In cases where play continued on consecutive weekends, full recovery before the next tournament could not be achieved. As expected, there was an increase in creatine kinase during the course of a tournament but levels returned to baseline before the next tournament was played (West et al., 2014). Studies in rugby union have shown an elevation in acute inflammatory markers and suppression in immune markers after rugby matches. It was found that host immune protection was compromised for up to 38 hours after the match. The immune system of a sevens player has been shown to be compromised to near equal levels to that of a marathon athlete when two matches were played consecutively (Takahashi et al., 2007). Cortisol/cortisone ratio has been shown to be a valid tool in the monitoring process in sevens and might be helpful in aid for further investigation (Bouaziz et al., 2016). However, further investigation on the exact effect sevens tournaments have on the immune system still needs to be conducted.

During the World Rugby Sevens Series, teams are required to travel to 10 different countries, exposing players to fatigue and jet lag (Lee & Galvez, 2012). Due to disruption in the circadian cycle when travelling over time zones, players can experience a decrease in mental and physical performance which could have an impact on the match results as well as on the players' injury frequency (Chennaoui, Arnal, Sauvet, & Léger, 2015a). A recent study showed that rugby players travelling across more than five time zones have a significantly higher risk of illness (Schwellnus et al., 2012). In a study on sevens, players travelling over multiple time zones did not show a higher injury frequency occurrence than teams travelling over 10 hours with no time zone crossings. Further investigation is needed into the exact effects of travelling on the performance of rugby sevens players.

MEASURING PERFORMANCE

Measuring the performance of teams and individuals is essential to acquire a complete perspective of all aspects pertaining to the match outcome. Match analysis is used in an attempt to obtain an objective and unbiased record of events related to individual or team performance (Higham et al., 2014a). Sport-specific factors can be marked, identified and analysed to obtain its relevancy in contribution to match outcome and performance. In teams, sports performance is generally based on the ability of scoring points or preventing the opponents from scoring relying on an efficient defensive and offensive performance. However, individual performance is difficult to measure due to the complex interaction during play and therefore no single metric could be used as a defining factor. Also, measuring performance may be subjective, objective or statistical which could be conflicting or unrelated, complicating influential metrics (Henderson et al., 2018).

Limitations on performance may occur due to inter-individual or inter-coach variation in perceived performance and may consciously or subconsciously influence performance.

Rugby sevens' performance theoretically have two overlapping areas that may influence performance. These areas consist of the individual influences and the uncontrollable situational influences which are opposed by the opposition. Within the overlapping areas, team performance consists of tactical, technical and physical performance, as shown in Figure 2.1.

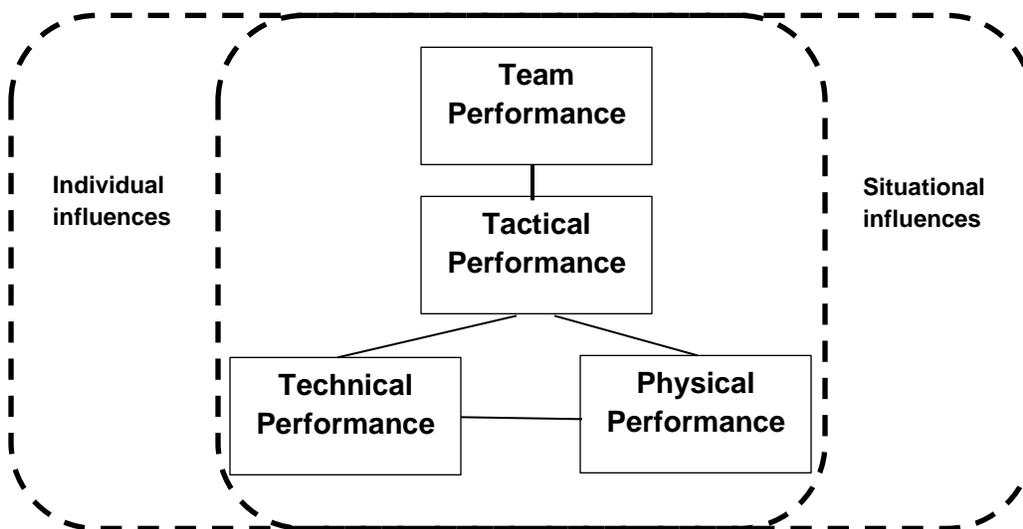


Figure 2.1: Theoretical model of rugby sevens performance (Henderson et al., 2018)

It has been mentioned that when it comes to accurately assessing successful individual performance, the only possible objective method is from match statistics. Relying only on match statistics could be limited in providing the full picture of performance as subjective input is not considered (Sullivan et al., 2014).

Background on performance indicators

Due to the complexity of rugby, PIs may not be obvious and may require analysis of big data sets to find events that make a small difference in performance. With the pressure on performance, coaches and athletes are constantly in search of methods that could provide them with an edge over their opponents (Vaz et al., 2011; Vaz, Van Rooyen, & Sampaio, 2010). A performance indicator can be defined as an event marker referring to as “a selection, or combination, of action variables that aims to define some or all aspects of a performance” (James et al., 2005). PIs should also be useful in its contribution to successful performance or match outcome (Hughes & Bartlett, 2002). PIs are usually normalised relative to a predetermined desired outcome to determine a level of success (Hughes & Bartlett, 2002).

In team sports PIs are used to contribute to the understanding of general tactical and technical demands (Kraak & Welman, 2014). PIs differ from sport to sport and could be expressed in counts, ratios percentages or any other numeric representation. In tennis, it could be the amount of forced vs unforced errors, in soccer, it could be the number of on-goal shots versus the number of goals scored and in basketball, it could be the number of turnovers (Hughes et al., 2012). PIs are thus not exclusive to any sport but may vary widely depending on the definition. PIs should, however, be presented with caution as isolating events could portray a distorted impression of the overall performance (Hughes et al., 2012).

PIs can be divided into four categories for performance analysis in sport i.e. matches classification, tactical, technical and biomechanical indicators (Gerrard, 2014). Match classification includes the frequency of key structural events that occur during matches. Some examples in sevens are shots on goal, lineouts and scrums (Hughes & Bartlett, 2002). The style of play by a team or individual, reflected by the decisions made during certain phases of play are considered to be tactical indicators. Tactical indicators may be represented as percentages or ratios of passes, kicks or runs (Hughes & Bartlett, 2002). The level of success at which a specific skill is performed is classified as technical indicators. Technical indicators are mostly normalised against the number of times the skill was performed successful or unsuccessful. Examples include percentage tackles made or percentage tackles missed (Hughes & Bartlett, 2002). Biomechanical indicators are usually quantitative in nature and could be used during the performance of certain skills to establish a certain range of correctness (Hughes & Bartlett, 2002).

PIs thus serve as a method for creating performance profiles. These performance profiles can be used to describe a team's pattern of play or technical and tactical abilities (Hughes et al., 2001). Higham et al. (2014a) claimed PIs in team invasion sports, such as rugby sevens, characterised a team's use of ball possession, field position, fitness and movement to execute patterns of play. However, the authors highlighted the fact that in order for the previous statement to be true, PIs need to be associated with success first (Higham et al., 2014a).

Success Factors

The need to identify PIs that could be associated with success in sevens was noted by Higham et al. (2014a). Although previous studies in sevens have tried to obtain PIs that could relate to SFs, the methodology varies as well as the statistical methods used (Henderson et al., 2018). Higham et al. (2014a) used a linear mixed model to quantify the increased effect of PIs on a logarithmically transformed series ranking of the teams where Vaz et al. (2011) opted to use results obtained with repeated measures ANOVA as a statistical test. Vaz et al. (2011) also differed in methodology from other authors, dividing matches into different groups depending on the difference of the final score between the two teams. Other literature in sevens has also used final team ranking as a measure of team success and not match outcome. This highlighting the different approaches taken in the literature to assess PIs that could have a positive effect on match outcome and be considered a SF (Higham et al., 2014b).

Although there is no standardised method in the literature as to what PIs constitute to SFs, Hughes and Bartlett (2002) stated that for PIs to be useful and meaningful it should relate to a successful performance outcome. To address the issue of when PIs are considered to be useful or meaningful, studies included results that showed the PIs that had a statistically significant difference between successful and unsuccessful teams. PIs that had a significant effect on match outcome was then considered SFs (Vaz et al., 2011). SFs should thus only include the PIs that had a significant effect on performance outcome.

Coding

Notation analysis of match play provides an objective examination of performance through analysis of frequency, duration, and characteristics of key tasks and events during a match (Ross et al., 2014b). Notational analysis provides individual player and team assessments that allow the tracking of data for players and teams across multiple competitions and seasons. Data from notational analysis can be used for an in-depth analysis of match demand (James et al., 2005). Advances in technology allow for notational analysis to be computerised and is now commonly known as coding. Coding involves electronically recording events for statistical purpose (Agnew, 2006).

Video analysis with the use of coding systems (Hughes et al., 2012) has become the preferred method to obtain PIs to describe an individual or team's performance (Vaz et al., 2010). Large databases of coded events provide coaches and players with the opportunity to analyse their own performance as well as the performance of their opponents well in advance. Although there is arguably no limit to the PIs assessed by means of coding a six-step process to create performance profiles have been suggested by Huges (2004). The six steps are:

- 1) Defining PIs,
- 2) Determine which are important,
- 3) Establish reliability in the data collected,
- 4) Ensure enough data have been collected to define stable performance profiles,
- 5) Compare sets of data,
- 6) Modelling performance, predicting outcomes.

The first two steps establish the PIs to be used with step three ensuring reliable data is collected. Step four ensures the stability of the data collected with step five ensuring the normalization of the data. Step six refers to the experimental manipulation of PIs to address the effect it might have on performance outcome (Agnew, 2006).

Rugby sevens performance indicators

Due to the limited research on PIs in sevens, the researcher has to rely on and report mainly on a few published studies as summarised in Table 1.1.

Table 1.1. Studies that included sevens rugby PIs since 2008.

Authors	Sample	Conclusion
Barkell et al., 2016	54 Men's and 30 Women's matches of the 2014 Sevens World Series	Winning women's teams gained more possession from handling turnovers, utilised more quick lineouts, had less ineffective set lineouts, threw more passes and made more ball-jolting-tackles. Winning men's teams utilised non-contested restarts more frequently, won a higher percentage of contested restarts, had more scrum feeds and made more effective tackles than losing men's teams.
Ross et al., 2016	16 Teams from 37 matches during an IRB Sevens World Series tournament plus 50 matches across a season	Line breaks had the strongest relationship with points scored and an increase in tackles resulted in fewer points conceded.
Ross et al., 2015	16 International sevens players and 68 provincial-level players match data collected	International players display superior ball handling and fewer bad passes. International players also display superior tackle ability with a greater number of effective tackles and fewer ineffective and missed tackles.
Higham et al., 2014a	12 Teams in the 2008/2009 to 2011/2012 IRB Sevens World Series	Team rankings were most influenced by tries scored and tries conceded. Factors that improved team ranking were based on increasing ball retention in line-outs and the breakdown, turning over possession more frequently in opposition rucks, and pressuring the opposition in their territory by kicking fewer short restarts.
Higham et al., 2014b	392 Matches of the 2011/2012 World Series	Successful teams maintain ball possession by reducing errors and turnovers, are efficient in converting possession into tries and have effective defensive structures resulting in a high rate of tackle completion.
Higham et al., 2014c	196 Matches of the IRB sevens world series	More points scored associated with a higher percentage of rucks and mauls retained. More rucks and mauls per minute negatively associated with the scoring of points. Winning teams adopted a more evasive style of play, whereas losing teams were more direct in their patterns of play.
Carreras et al., 2013	60 Matches of 3 tournaments in the 2011/2012 Sevens World Series	Play activities are longer in the pool matches when compared to play-off stages. Increasing trend of ball in play time. In quarterfinals and finals matches the length of the pause activities increase.
Van Rooyen et al., 2008	47 Matches of the top 8 teams in the 2005 Rugby World Cup Sevens tournament	Teams reaching the semi-finals and finals maintain possession for periods of between 30 and 60 seconds and convert over 30% of that possession into point-scoring movements.

An adapted model of the one provided by Higham et al. (2014c) in an attempt to create classification categories for PIs are shown in Figure 2.2. The following sections in the chapter will describe the categories presented in the model in more detail.

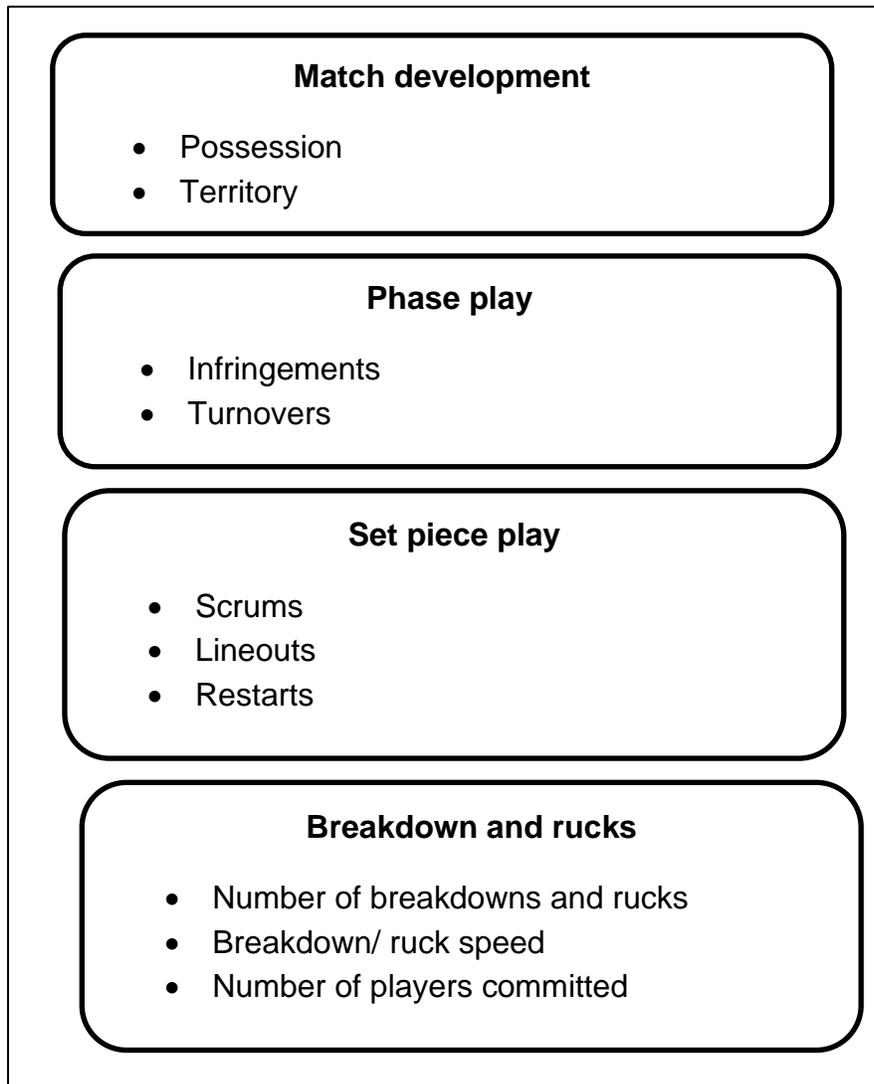


Figure 2.2. Adapted model for category identification of PIs

Match development

Possession and territory

Although the literature on PIs in sevens is less readily available than PIs on fifteens, some recently published studies did reveal interesting similarities and findings. A study by Van Rooyen et al. (2008) on the 2005 Rugby Sevens World Cup showed that when the winning team was compared to the lowest ranking team, the winning team showed a time of 40s between scoring events, while the least successful team took 90s between scoring in the 2014/2015 tournament. Successful teams used possession more effectively by keeping possession for 30-60seconds at a time and converted 30% of these possessions into point-scoring opportunities. Maintaining higher ball possession may lead to limited scoring opportunities for the opposition.

In a four-year retrospective longitudinal study of the IRB Sevens World Series which included 12 international sevens teams, Higham et al. (2014a) showed that successful teams maintain more ball retention by retaining lineout ball. Also, by turning over ball possession either in the set pieces or in the breakdown may lead to an enhanced ball possession time as well as attacking opportunities. Although this is similar to the conclusion by Henderson et al. (2018) who found in a review that successful teams had increased ball retention. It was mentioned that better-ranked teams are more effective in converting possession into points and not necessarily obtaining more possession (Higham et al., 2014a).

Evidence for the effective use of ball possession may be shown by how teams enter different areas of the field while in possession of the ball. It was shown by Higham et al. (2014b) that entries into the opposition 22m area had the largest relation to an increase in tournament ranking for a team, most likely due to better execution by the higher ranking teams. Maintaining more possession might be a way to increase chances of entering the opposition 22m area as supporting evidence showed that an increase in possession time relates to fewer points scored by the defensive team (Higham et al., 2014c). Although it might be logic that a team needs to be in possession of the ball to score points, effective use of possession in the attacking areas of the field might be of greater value than just the accumulation of ball possession.

Phase play

Although limited studies on skill demands in rugby sevens are available, some studies have provided us with some understanding of the technical requirements of professional sevens players. Match analysis of the 2001 IRB World Sevens Series revealed that successful teams (>70% matches won) missed 50% fewer tackles and broke the line of the defence 21% more times than unsuccessful teams (<70% matches won) (Hughes & Jones, 2005). This was in agreement with the finding of Ross et al. (2016) also showing that line breaks are the most influential factor to point scoring as well as a dominant tackle efficiency count (Ross et al., 2016). These findings were confirmed by Henderson et al. (2018) who concluded in a review study on match demands that successful teams have increased ball retention with fewer missed tackles. Fifteens also showed similar factors such as creating line breaks (Van Rooyen, Lambert, & Noakes, 2017), crossing the advantage line more often (Van den Berg & Malan, 2010) and entering the opponents

22m (Watson et al., 2017) to be some of the key factors to the success of successful teams.

As mentioned, an effective defensive effort seems to be crucial to a team's success. Barkell et al. (2016) reported rugby sevens winning teams to be more effective at tackling than losing teams. These findings are similar to previous research conducted, concluding winning teams to be capable of effective tackling and well-organised defensive structures (Higham et al., 2014b). These teams displayed a high successful tackle completion rate allowing them to limit the opposition's attacking opportunities.

Successful teams evading tackles more effectively. By evading tackles, teams create line breaks which lead to scoring opportunities (Ross et al., 2016). Ross et al. (2016) analysed 37 matches of the 2013 IRB Sevens World Series as well as 50 matches from a single team across the a full season of the same world series and found that an increase of ~2 line breaks per match equates to ~12 points per match. Similar findings were reported by Barkell et al. (2016) who also found line breaks to be associated with successful men and women's rugby sevens teams. Although line breaks are a mixture of technical and tactical factors which are also dependent on the effectiveness of the opposition's defensive structure, converting ball carries into line breaks can be a key factor to a team's success.

In sevens, the total number of passes showed a positive relation to points scored within team evaluation but when possession time was taken into consideration a reversal of results occurred (Higham et al., 2014). Due to the similar number of successful passes

between teams, authors speculated that combined with fewer rucks and mauls, a winning team`s tactical approach is to attack more with width and deception while avoiding contact during an attack. Previous literature reported that teams with a higher number of passes completed to the number of rucks formed, scored more points (Ross et al., 2016). These findings are in contrast to that of Higham et al. (2014b) who found that teams who completed more successful passes per try are associated with a worse tournament ranking. Due to the indirect comparison of passes to match outcome and the different methodologies used in the studies the results could differ. It is, however, possible that successful teams who avoid tackles and complete more passes may cause the defence to become fatigued allowing for an increased number of points to be scored.

Offloads score (successful offloads – unsuccessful offloads) could increase the chances of point-scoring (Ross, 2015). These findings are corroborated by the fact that successful teams vary their passes and offloads and find ways to create more opportunities by using looping or cut-out passes (Hughes & Jones, 2005). By incorporating offloads in the variety of types of passes during an attack, teams may produce more effective attacking opportunities. It should, however, be noted that handling errors have been shown to decrease point-scoring ability and therefore offloads should only be attempted when the possibility of a successful offload is high (Ross et al., 2016).

Other attacking strategies in rugby sevens, such as kicking the ball during matches, have been shown to be in contrast with tactical play in fifteens. In fifteens, successful teams gain more territory by kicking the ball while in possession (Vaz et al., 2011). In rugby

sevens, increased ball retention by kicking fewer times during the match is positively associated with scoring points (Henderson et al., 2018). PIs should be assessed individually for each sports code as PIs might not have the same impact for the different rugby codes on match outcome.

Infringements and turnovers

Although discipline is a crucial factor in any sport, the appreciation of the laws of the game to the extent where play borders infringement is always tested in sport. Successful teams in rugby sevens have been shown to concede more penalties than their less successful opponents (Hughes & Jones, 2005). This could be explained due to the circumstances of which successful teams would rather play through an advantage call by the referee where less successful teams would rather take the penalty (Hughes & Jones, 2005). This seems counter-intuitive and is in contrast with Higham et al. (2014c) who showed more discipline teams to be more successful. In a different study, Higham et al. (2014a) also indicated a negative relationship between penalties and free kicks conceded and points scored.

More than one study has highlighted the importance of gaining turnovers during set pieces and rucks in a match. In a study by Higham et al. (2014a) it was shown that successful teams are more effective on capitalizing turnovers. Another study by Higham et al. (2014b) also indicated that better-ranked teams concede fewer turnovers during competitions. These findings are supported by evidence showing conceding fewer turnovers is highly related to scoring more points (Higham et al., 2014c). When teams are

in a position to create turnovers, they create attacking opportunities while the opposition is still transitioning from attacking to defensive structures. This makes the defence vulnerable to attacks and creates scoring opportunities.

Set pieces

Set pieces are a crucial part of a team's defensive and attacking strategy in all codes of rugby. Although it is known that set pieces in sevens are mostly won by the feeder of the lineout or scrum and therefore not as heavily contested (Watson et al., 2017), it still should not be neglected. An increase in lineouts retained has been shown to be associated with more successful teams during a tournament with an ICC of 0.19 (Higham et al., 2014a). A lineout turnover results in an excellent attacking opportunity as the opposition needs to reorganise from attacking to defensive structures (Higham et al., 2014a).

Restart kicks are also a set piece as it is possible to practice the outcome of the restart kick during training. Better rankings were associated with kicking fewer contestable restart kicks in the IRB Sevens World Series (Higham et al., 2014a). It was found that more successful teams opted for longer and deeper restart kicks. This could be to gain a territorial advantage while relying on their defensive system to place the opponents under pressure deep in their own half. Deeper restart kicks also reduced the change of errors on the restart when an aerial contest for the ball occurs (Higham et al., 2014a). Another study by Higham et al. (2014b) on 392 matches of the 2011/2012 IRB World Series which included nine teams, could not provide evidence that restart kicks have a

positive influence on successful match outcome. The most plausible explanation would be that team tactics vary and while some teams would prefer a contestable restart, other teams would prefer a deep restart to gain territory. A team might also change tactics and use deep restarts more when they are leading in points as they would attempt to keep play as far away from their try line as possible. Further investigation on the effective use of restart kicks is warranted due to the limited current literature available.

Breakdowns and rucks

World Rugby defines a ruck as a phase of play where one or more players from each team, who are on their feet, in physical contact, close around the ball on the ground (World Rugby, 2018). On average a sevens team will perform 9.11 rucks per match and about 2.5 per minute of possession (Higham et al., 2014a). Players will be involved in the rucks 2.3 ± 3.9 times during pool play and this number will increase to 3.2 ± 3.5 during cup matches in the 2013 World Rugby Sevens Series. The increase in time could possibly be explained due to the increase in match time (Schuster et al., 2018). No differences were found for the frequency of rucks between forwards and back (Suarez-Arrones et al., 2014).

Fifteens showed rucks to be a valuable asset to the winning team's performance when used effectively, especially if ruck turnovers are achieved by the defending team (Kraak & Welman, 2014). According to Kraak and Welman (2014), ruck-play is a PI which has a direct influence on the amount of ball possession a team can obtain. The importance of

ruck play in rugby fifteens is obvious as it is considered an indication of performance quality (Hughes et al., 2012). During analysis, a field can be divided into four zones consisting of Zone D (own try-line to 22m), Zone C (22m to 50m), Zone B (50m to 22m) and Zone A (22m to opposition try-line). It was shown that in fifteens most rucks are formed in Zone B. Top-ranked teams formed fewer rucks on attack than bottom-ranked teams. This can be indicative of ruck play being a good platform to launch attacking play with most tries being scored from rucks in zone D. Top-ranked teams had 10% fewer rucks than unsuccessful teams indicating an evasive playing style (Kraak & Welman, 2014). It would, however, seem logical that rucks in rugby sevens would occur less frequent due to more running space available (Ross et al., 2014a).

As mentioned in sevens, 33% fewer rucks were shown to be associated with teams that won more than 70% of their matches in 2001 (Hughes & Jones, 2005). Playing styles of winning teams consist of fewer rucks and mauls. It seems that in contrast, losing teams had a more direct approach with a higher frequency of rucks and mauls. It was shown that a negative relationship exists between a higher number of rucks per minute and points scored. The higher ruck and maul frequency also had a negative impact on the likelihood of winning while percentage rucks and mauls retained showed to be highly related to a team's chances of being successful (Higham et al., 2014). Gaining 4.4% more possession from opposition ruck showed to have a 60% increase in the team's ranking during the tournament (Higham et al., 2014a). More rucks will negatively affect point-scoring and thus relate to a lower team ranking (Higham et al., 2014b). These findings were confirmed by Henderson et al. (2018) who reported that successful teams have

more ball retention with fewer rucks and mauls and fewer missed tackles than unsuccessful teams.

The effectiveness of rucks is dependent on the decision making of players. Appropriately adapting to changes in play from set pieces to general play is essential in rugby to optimise ruck outcomes (Kraak & Welman, 2014). It was advised by Ross (2015) to commit fewer players to attacking rucks and be more effective with players committed to rucks. This allows for more players in attack to win turnovers, increasing the chances of scoring points. More players committed to rucks were associated with scoring fewer points. However, studies have shown that decision-making skills are influenced by fatigue (Lorains, Ball, & MacMahon, 2013) which could have an effect on match outcome as rucks are considered a highly exhaustible event (Deutsch, Kearney, & Rehrer, 2007). A clear distinction should be made between breakdowns and rucks. Limited studies have mentioned the tactical approach of how teams engage in the breakdown and most studies only focus on the team's involvements in rucks. A possible reason for the lack of reference to the breakdown in literature could be attributed to the lack of clear definitions and terminology.

Summary

There has been a lack in development of standardised methodology and operational definitions on PIs, especially in rugby sevens. PIs should be used in an attempt to create performance profiles and remains an important investigation area. Although there is an

abundance of research on PIs there is little information on the variables contributing to PIs that will have a noticeable effect on successful match outcomes (Watson et al., 2017). To provide coaches with a better understanding and clear framework for decision making a greater understanding of situational and individual factors affecting performance is needed (Henderson et al., 2018). PIs can range over a broad spectrum of numerous events, which can be confusing and overwhelming. PIs can be used in different combinations to provide teams or individual feedback.

Grouping PIs that are most noted to enhance performance provides feedback that is relevant to the situation or area. These indicators relevant to performance improvement are sometimes referred to as key performance indicators (KPI). The term KPI has been used loosely in the literature and with no clear definition a more appropriate term might be SFs, however SFs should be linked to significant changes. This allows for more focussed feedback on certain areas of performance. Henderson et al. (2018) requested that further research is conducted on the impact of key contextual factors on rugby sevens physical performance to enhance optimal performance.

Also, no research has focussed on the physical and technical constructs of the match performance in rugby sevens. There is still a lack of research on the interaction of physical activity and skill association on performance as well as the factors affecting the physical and technical constructs of performance (Henderson et al., 2018). PIs might not necessarily relate directly to a team or an individual's performance but rather to various playing styles or game strategies (Vaz et al., 2010). Variations in finding on performance

indicators can be contributed to the tactical, technical and physical influences of the opposition team (Gabbett, 2013).

The need for the selection of PIs and its use in sevens is warranted as it is unclear which PIs should be monitored (Higham et al., 2014a). In order to gain the competitive edge over opposition teams, coaches, sport scientists and trainers need to adapt their current training programs to accommodate and take advantage of indicative performance markers (Kraak & Welman, 2014).

CHAPTER THREE

RESEARCH ARTICLE ONE

Performance indicators relating to successful match outcome in professional rugby sevens

This article will be submitted for publication in the European Journal of Sport Science. The article is included herewith in accordance with the guidelines for authors of this journal (Appendix A). The article has been edited to represent an actual published article as it would appear in this particular journal. This does not imply that the article has been accepted or will be accepted for publication. Consequently, the referencing style used in this chapter may differ from that used in the other chapters of this thesis.

Performance indicators relating to successful match outcome in professional rugby sevens

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Field of study: Sport Science (high performance)

Running title: Performance indicators and success factors of the South African men's rugby sevens team during the 2017/2018 World Rugby Sevens Series

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Performance indicators relating to successful match outcome in professional rugby sevens

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ABSTRACT

The World Rugby Sevens Series is the most prestigious platform for international rugby sevens teams to compete in each year. To assess match performance, performance indicators (PIs) can be used to objectively quantify specific match events. When a PI relates to successful match outcomes it can be classified as a success factor (SF). Current research has not yet assessed the success factors involved in matches won and lost for the winning team of a rugby sevens series. The methodology used in the assessment of previous PIs might have obscured individual team performance success factors. It was, therefore, the aim to determine success factors that could discriminate between matches won and lost for a series winner. A total of 59 of the South African rugby sevens team's matches for the 2017/2018 World Rugby Sevens Series were analysed to obtain specific PIs. One-way ANOVA was used to test for differences in measurements between matches won or lost. Results indicated that tackles made ($p=0.03$) and missed ($p=0.01$), as well as tackling completion rate ($p=0.01$), was the most critical success factors. Strong relations to successful match outcome could also be seen for fewer penalties conceded, 50m restarts regained and percentage territory. A superior defensive structure, therefore, would seem to have played a critical role in a team's success during the 2017/2018 World Rugby Sevens Series. Success factors could be used by teams to verify the occurrence of important match events leading to successful match outcomes.

Keywords: rugby sevens, performance indicators, success factors, performance analysis, World Rugby Sevens Series

Introduction

The use of objective statistical data to determine critical performance factors has become an important part of the modern-day sport for teams to be competitive and successful in a professional environment. A performance indicator (PI) is defined as an event marker referring to “a selection, or combination, of action variables that aim to define some or all aspects of a performance” (James *et al.*, 2005). PIs have been used in the aim to objectively classify aspects of play. When PIs are directly related to a successful match outcome (winning the match), it could be considered a success factor (SF). Rugby sevens has become even more popular after its inclusion in the 2016 Rio Olympics (Engebretsen and Steffen, 2010) and the World Rugby Sevens Series is still regarded as the most prestigious event for rugby sevens teams to compete in each year. The circuit-format World Series provides the platform for the world’s top national teams to compete in over 10 tournaments in 10 different countries. A rugby sevens match usually consists of seven players per team, competing in a 14-minute match under mostly the same laws and field dimensions as rugby union (Nauright & Parrish, 2012). Comparing the relationship between physical characteristics and match activities associated with success factors (SF) could provide valuable insights into aspects that could influence a match outcome (Ross, 2015). Within-team variability, different tactical approaches to the match (Vaz *et al.*, 2010) and the influence of the opposing team might lead to specific match characteristics that may alter and obscure the true reflection of certain PIs (Gabbett, 2013).

Researchers have attempted to determine the relevancy of PIs by contrasting the actions of successful teams to less successful teams. In rugby union winning teams during close matches (matches with a low final score points difference) have shown that kicking the ball away for territorial gain and making more tackles than the opponent were the most influential factors to

their success. Other important factors relating to success were winning of own lineouts and turnover of opposition lineouts, as well as keeping tackles missed to a minimum (Vaz *et al.*, 2010; Vaz *et al.*, 2011; Jones *et al.*, 2004). Although some similarities exist between rugby union and rugby sevens, PIs should not be assumed to be equally applicable to both codes (Higham *et al.*, 2014c).

Various PIs relating to a team's success in the IRB Sevens World Series have been identified. Attaining more possession seems to be heavily related to a team's success as more ball possession increases the opportunity to score points (Higham *et al.*, 2014a). Teams with a ball possession rate of 30-60s at a time and converting 30% of this possession into points were shown to be more successful (Van Rooyen *et al.*, 2008). It was also shown that successful teams tend to kick less to retain as much ball possession as possible which is in contrast with rugby union where territorial play is critical (Higham *et al.*, 2014b). Higham *et al.* (2014c) reported that successful teams maintain ball possession by retaining ruck and lineout possession.

During the 2001 IRB Sevens World Series, successful teams made 21% more clean line breaks than unsuccessful teams (Hughes and Jones, 2005). Line breaks were also shown to be highly related to the scoring of points during international matches (Ross *et al.*, 2016). Other attacking play such as the frequency of passes, entries into the opposition's 22m area as well as a higher total number of rucks per match accounted for a higher position on the final rankings of the 2011/2012 IRB Sevens World Series. An increase in the frequency of rucks and passes per try had a negative impact on the team's overall ranking in the series (Higham *et al.*, 2014b).

Superior defensive play has been shown to have a positive relation to successful match outcomes in rugby union. During the 2001 IRB Sevens World Series, successful teams missed 50% less

tackles than unsuccessful teams (Hughes and Jones, 2005). A higher tackle completion rate was also associated with a higher position on the final rankings of the 2011/2012 IRB Sevens World Series with a drop in rankings when more tackles were missed (Higham *et al.*, 2014b). Barkell *et al.* (2016) validated the finding of other authors by noting that a higher percentage of tackle efficiency was demonstrated by successful teams. Confirmation of these findings was further supplied in a study by Watson *et al.* (2017). Despite the fact that it was related to rugby union, this study confirmed the importance of a high tackle conversion rate. Watson *et al.* (2017) also highlighted the fact that successful teams are more efficient at the breakdown while maintaining superior ball retention (Watson *et al.*, 2017).

Successful international teams with a win rate of $\geq 70\%$ conceded more penalties per match than unsuccessful teams (Hughes and Jones, 2005). This is in conflict with results reported from a previous study by Higham *et al.* (2014a), which indicated that more penalties conceded during a match related to fewer points scored. In the 2011/2012 IRB Sevens Series 20% of tries originated from restarts. Successful teams, however, opted for longer restart kicks placing the opponent under pressure deep in their own half (Higham *et al.*, 2014c). More evidence for the importance of effective set plays and defence was shown in a study on the 2014 Rugby Sevens World Series, showing that successful teams utilise more deep restarts, but also regain more restarts when contestable (Barkell *et al.*, 2016). Gaining breakdown turnovers have also been shown to have a positive impact on the World Series rankings. Turning over ball possession at the breakdown allowed a team to attack while the opponents are scrambling in the transition from offence to defence. Higher ranked teams showcased a better defensive system that was able to more readily transform the opposition's breakdown into an attacking opportunity (Higham *et al.*, 2014c).

Research mostly focussed on comparing successful teams with unsuccessful teams. However, valuable insight would be gained if variation in different playing styles of different teams is eliminated. Only focusing on contrasting findings between winning and losing teams, might not always be the best method for determining specific strength and weaknesses of teams as individual variations could be obscured by different team tactics (Hughes *et al.*, 2012). Also, limited studies have assessed within-team variation (Ross *et al.*, 2016; Higham *et al.*, 2014a,c) to verify the change in PIs between winning and losing matches of a single team during a successful rugby sevens campaign. Although Ross *et al.* 2016 report on some PIs of a single team, the successfulness of the team during the series was not stated. Comparing the most successful rugby sevens team's matches won versus matches lost over the course of an entire successful series to determine intra-team variables contributing to success, is warranted.

This article reports on the differences in PIs between matches won and matches lost of the overall winning team during the 2017/2018 World Rugby Sevens series. The aim of the study is to determine if there is a significant difference between the PIs measured for matches won and matches lost that could be classified as SFs. Valuable knowledge can be gained by knowing the underlying success factors and how they relate to match outcome, which could lead to a better understanding of successful match play and provide coaches with specific focus areas for training.

Methods

An analytic study was conducted on data collected from the South African rugby sevens team (the Blitzboks) during the 2017/2018 World Rugby Sevens Series. The specific team was selected through purposeful sampling because they were the overall series winners. Ethical approval was granted by the ethics committee (project number 10813). A total of 59 matches were analysed during 10 tournaments. From the 59 matches analysed, 47 matches were won by the Blitzboks and

12 were lost. The matches included all the matches played by the Blitzboks over the season except for one match.

Broadcasted footage was used to code match activities using video analysing software (Stratus V3.6.6, Mobii, South Africa). Match codes for various events were coded by five professional rugby match analysts with more than 30 years of professional match analysing experience between them. Previous studies have shown time notion analyses to be accurate for the use of providing data for research purposes (Griffin, 2015). Inter-reliability and intra-reliability for matches coded were shown to be consistent with high correlations ($ICC = >0.98$) for events tested. All data were uploaded to the cloud for coaches, trainers and players to view and for further analysis. To ensure reliability and validity on the data, 10 matches were randomly selected for re-evaluation to eliminate any coding errors, while all activities were tracked with video-based linked evidence of the event. Matches were grouped into two distinctive categories: matches won and matches lost. This allowed for statistical analysis to be done on the various performance indicators (PI) included in the study. PI could be accessed from a database that was synchronised to match data and video footage of the events in question. PIs with comparable references to previous studies (Higham *et al.*, 2014c) were assessed (Table 1).

Table 2.1. General play and set piece PIs assessed

Category	Area	Performance Indicator
Match Development	Possession / Territory	Possession% Territory % Attack % Defence %
Defence	Tackles	Total tackles (Possession (%)/Total tackle) *100 Tackles made Tackles made percentage (%) Tackles missed

		Tackles missed percentage Ratio tackles made: missed (1)
Attack	Ball Carries	Carries
		Line breaks
		% Line breaks
	Passes	Total
		Completed
		In completed
	Offloads	Total
		Completed
		In completed
Infringements / Turnovers	Kicks Infringements Turnovers	G/P
		Penalties Conceded
		Conceded
Set-Pieces	Restarts	Gained
		50m
		Regained
	Scrum	Won
		Lost
	Lineouts	Won
		Lost

Statistical analysis

One-way ANOVA was used to test for differences in measurements between matches lost or won. Normal probability plots were inspected to check for normality and were in most cases found to be acceptable. In selected cases, the Mann-Whitney U-test gave the same results as the F-test of the one-way ANOVA. Levene's test was used to test for homogeneity of variance, and in only one case found to be significant. A Welch test gave the same result as the F-test.

Results

Results showed a typical match to consist, on average, of 22.93 ± 6 successful tackles of the total 29.34 ± 6.77 tackles made. A clear significance for tackles attempted during matches won versus matches lost is visible ($p=0.03$). Matches won showed a higher tackle completion rate (won:80.43

± 9.05 , lost: 69.26 ± 5.17 , $p < 0.01$) with fewer missed tackles (won: 5.85 ± 2.99 , lost: 8.58 ± 1.98 , $p < 0.01$) compared to matches lost. Results showed significantly more ($p < 0.01$) tackles were made during matches won than during matches lost.

Although not significant ($p = 0.07$), penalties conceded were higher in matches won than matches lost, data presented on restart kicks showed a statistically significant difference as restart kicks were significantly higher during matches won ($p < 0.01$). As restart kicks regained were of small data size, chi-square analysis was used to determine the value of the difference between matches won and lost. Restart kicks regained was significantly higher in matches won than in the matches lost ($p < 0.07$).

PIs over the entire series regarding possession (won: 45.68 ± 10.12 , lost: 45.67 ± 9.28) did not provide any clear relation to matches won. Mean territory for the matches won was slightly higher (won: 58.79 ± 13.5 , lost: 51.75 ± 12.67) with a possible trend towards the benefit of obtaining more territory during matches ($p = 0.11$). Mean difference between matches won and lost showed more time was spent on defence (won: 55.94 ± 11.94 , lost: 52.92 ± 10.99) than attack during matches won, although no significant difference was found ($p = 0.43$).

No significant differences between matches lost and won were found for line breaks ($p = 0.66$), general play kicks ($p = 0.42$), offloads ($p = 0.56$), and the total number of passes ($p = 0.5$). During attack, the team performed a mean of 24.66 ± 7.13 ball carries with slightly more ball carries in matches lost ($p = 0.3$). The percentage of line breaks in terms of ball carries were higher in the matches won compared to matches lost, but again, not significantly different ($p = 0.32$).

Scrums ($p = 0.71$) and lineouts ($p = 0.48$) won showed no difference between matches lost and won.

Table 2.2. PIs of matches lost compared to matches won represented as means \pm SD

Category	Area	Performance Indicator	Matches Lost (mean)	St dev	Matches Won (mean)	St dev	P
Match Development	Possession / Territory	Possession%	45.67	9.28	45.68	10.12	1
		Territory %	51.75	12.67	58.79	13.5	0.11
		Attack %	47.08	10.99	44.06	11.98	0.43
		Defense %	52.92	10.99	55.94	11.98	0.43
Phase play	Tackles	Total tackles	28.25	5.61	29.62	7.06	0.54
		(Possession %/total tackles) *100	12.58	2.1	12.99	2.16	0.56
		Tackles made	19.67	4.68	23.77	6.04	0.03*
		Tackles made percentage (%)	69.26	5.17	80.43	9.05	<0.01*
		Tackles missed	8.58	1.98	5.85	2.99	<0.01*
		Tackles missed percentage	30.74	5.17	19.57	9.05	<0.01*
		Ratio made: missed (1)	2.36	0.71	5.27	3.82	0.01*
	Ball Carries	Carries	26.58	6.37	24.17	7.29	0.3
		Line breaks	1.42	1.24	1.64	1.59	0.66
		% Line breaks	4.94	4.25	7.28	7.82	0.32
	Passes	Total	25.58	11.91	23.77	7.16	0.5
		Completed	25.08	11.79	23	6.9	0.43
		Incomplete	0.5	0.8	0.77	0.89	0.35
	Offloads	Total	2.58	1.38	2.91	1.85	0.56
Completed		2.33	1.44	2.51	1.63	0.73	
Incomplete		0.25	0.45	0.36	0.76	0.63	
Kicks	General play kicks	1.25	1.22	1.6	1.33	0.42	
	Penalties conceded	2.25	1.42	3.34	1.91	0.07	
Turnovers	Conceded	1.08	1.06	0.7	0.86	0.2	
	Gained	1.17	1.19	1.38	1.09	0.55	
Set-Pieces	Restarts	50m Regained	3.25	1.14	4.72	1.23	<0.01*
						0.07	
	Total scrums	Won	1.33	0.98	1.22	0.94	0.71
Total lineouts	Won	1.08	0.9	0.87	0.92	0.48	

Discussion

A number of PIs could have contributed to the success of the winning team of the 2017/2018 World Rugby Sevens Series including a total of 59 matches over a period of seven months. To the authors' knowledge, this is the first study in rugby sevens to exclusively focus on a series-winning team to determine possible contributing PIs to the matches won and matches lost. The aim of the study was to determine the existence of SF in matches won. Main findings in the study suggested a higher rate of successful tackles to be of significant value to match outcome. Also, restarts regained were also significantly higher during matches won.

Phase play

PIs that successfully translated to SFs were mostly found to be defence related as tackles made and missed showed clear significant differences between matches won or lost. Results indicated that more tackles made and fewer tackles missed were highly related to a successful match outcome. These results confirm the findings of similar studies that either considered the difference between successful and unsuccessful teams (Barkell *et al.*, 2016; Higham *et al.*, 2014b), team ranking (Higham *et al.*, 2014b), or the effect of PIs on scoring of points (Ross *et al.*, 2016). Effective tackling limits the opposition to gain line breaks and thus limits the opposition to score points. Missed tackles in return increase the change of the opposition for scoring, as well as giving the opponents the opportunity to gain territory (Ross *et al.*, 2016). It is therefore critical for successful teams to maintain a well-structured defence to limit the opponent's attacking opportunities (Higham *et al.*, 2014b).

Results from the current study are in accord with previous research (Hughes and Jones, 2005) suggesting that when the team exceeded a 75% successful tackle completion rate they had a

significantly higher chance of winning. This was complemented by the fact that during matches won, tackles missed were limited to six or less, providing similar evidence as to other authors on the importance of a highly successful tackling completion rate to better-performing teams (Higham *et al.*, 2014b). Similar to results presented in this study, more tackles made during matches with a successful match outcome could be explained by more time spent on defence during these matches (Higham *et al.*, 2014b). Interestingly fifteens has also shown similar findings suggesting that successful teams have significantly more total tackles, as well as successful tackles made during a match (Vaz *et al.*, 2011). Findings from the current study suggest that chances of winning increases if the ratio of successful tackles made to tackles missed is five or more.

PIs during attacking play did not show as many SFs as defensive PIs. Interesting to note, ball carries were lower in matches won than in matches lost. More carries provide the opportunity for more line breaks that could lead to the scoring of points (Ross *et al.*, 2016). A possible explanation for fewer ball carries during matches won could be due to more time spent on defence during matches won. Although line breaks were slightly higher during matches won it was less than expected as previous studies have indicated line breaks to be one of the key factors to success in high ranking teams (Hughes and Jones, 2005; Ross *et al.*, 2016). This could again be due to the focus on the defensive effort by the team during matches won limiting the opportunity for ball carries and thus limiting the chance for creating line breaks. Although offloads were higher over the series during matches won, incomplete offloads were also higher during these matches. The contribution of offloads to a successful match outcome thus remains unclear. Findings from the current study could support previous suggestions that if offloads are used, it should be used with caution and only when support is certain (Wheeler *et al.*, 2010).

Set pieces

Logically the match winners would have to score more points and therefore 50m restart kicks should reflect this. In the current study, restart kicks were significantly more during matches won when compared to matches lost. This significant result can be contributed to the higher rate of points scored compared to matches lost where restart kicks were lower. Due to the control retained over the restart kick, the restarting team can manipulate the restart kick to suit their playing style or use set-plays, developed in exercise routines. The restart kick in rugby sevens differs from the restart kick in rugby union. In rugby sevens the restart kick is taken by the team that scored last and by not giving the opponents possession of the ball limits their attacking opportunity. The previous statement might be visible in the clear trend shown during matches won for restarts regained. Previous authors have shown deep restarts to be associated with more successful teams rather than short contestable restarts (Higham *et al.*, 2014c). This does not indicate that all restarts regained were short restarts, but rather that restarts should be taken with the objective to regain possession and territory (Barkell *et al.*, 2016). Although deep restarts might provide the team kicking-off with a chance to gain territory, it might be that a kick that is well planned and well-executed could be a successful tool to implement to regain possession and the opportunity to attack in the opposition's half.

General

In general, it was worth noting that effectively using territory seemed to be a more relevant factor during matches won than the amount of possession kept. This is in contrast to previous studies reporting successful teams favoured more possession than unsuccessful teams (Hughes & Jones, 2005; Higham *et al.*, 2014b). However, with different methodologies used in other studies, the

unique attributes of the series winner could have been obscured. With territory being higher during matches won and possession almost equal for the same matches, success might be more dependent on converting possession into points more rapidly (Van Rooyen *et al.*, 2008), most probably by detaining play to the opposition's territory (Higham, 2013). Although it might seem counter-intuitive, penalties conceded were higher during matches won. These findings have been previously reported by other authors (Hughes and Jones, 2005) and could be explained by the fact that successful teams are better at utilising the advantage rule (Higham *et al.*, 2014a). Teams with a strong defensive system can quickly transition from offence to defence and could also be more attracted to play a higher risk-reward game plan.

Practical implications

Findings from the current study should provide valuable insight into the PIs of rugby sevens on a professional level. The factors contributing to the success of the campaign were highlighted and could be beneficial to coaches and players involved in rugby sevens. Coaches involved in rugby sevens can use these findings in order to concentrate on certain aspects of play during training in preparation for matches. The application of the knowledge obtained by analysis of the SF involved in gaining an advantage over the opponent can be replicated for a wide variety of sports. The use of effortlessly obtainable PIs allows for easy implementation of findings during training and matches.

Conclusion

Contrary to popular belief possession might not be as influential to the success of a team in rugby sevens (Watson *et al.*, 2017). Although retaining possession is important, maintaining possession in the opponent's territory is a crucial key to success. Territorial play showed to be more valuable to the team's success than possession.

A robust defensive system has a significant impact. An effective defensive system that maintains a high tackling rate, while limiting missed tackles, was shown to have a critical impact on success during the series. Although attacking play strategies should not be neglected, focussing exclusively on attack does not necessarily improve a team's chances of winning. However, a successful match outcome might be positively influenced by the percentage line breaks created.

Due to the complexity of rugby sevens, it is acknowledged that these findings could not be the sole cause of a team's success. The frequency of events that significantly contributed to the success of the 2017/2018 World Rugby Sevens Series champions (Hughes *et al.*, 2012) could add valuable information to the current body of knowledge.

Future research

This study only focused on the PIs that are easily measurable, however, due to the dynamic environment of sevens, the effect on match outcome of a vast number of PIs are still unknown and requires further investigation. Future research should focus not only on the relevance of PIs in isolation to match outcome, but rather on the effect PIs exerts on each with a direct or indirect effect on match outcome.

Limitations

Multiple factors involved in a dynamic team sport such as rugby sevens introduces a complexity of interacting variables, making it impossible to account for all factors involved in match outcome. The PIs measured are representative of technical and tactical factors but there are various other elements that influence a team's performance such as fitness, skills or technical proficiency, to name a few, which did not form part of this study. It should also be noted that this study was limited to one team that was assessed during only one season.

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CHAPTER FOUR

RESEARCH ARTICLE TWO

Quantifying performance indicators of the breakdown and ruck and the effect on match outcomes in professional rugby sevens.

This article will be submitted for publication in the International Journal of Performance Analysis in Sport. The article is included herewith in accordance with the guidelines for authors of this journal (Appendix B). The article has been edited to represent an actual published article as it would appear in this particular journal. This does not imply that the article has been accepted or will be accepted for publication. Consequently, the referencing style used in this chapter may differ from that used in the other chapters of this thesis.

Quantifying performance indicators of the breakdown and ruck and the effect on match outcomes in professional rugby sevens

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Field of study: Sport Science (high performance)

Running title: Performance indicators and success factors of the South African men's rugby sevens team during the 2017/2018 World Rugby Sevens Series

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Quantifying performance indicators of the breakdown and ruck and the effect on match outcomes in professional rugby sevens.

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ABSTRACT

The breakdown is an integral component of rugby sevens. Almost no other event in rugby sevens creates a more frequent contestable opportunity. Knowledge of how the breakdown is used by teams either in attack or defence in rugby sevens has received little attention with studies mostly focusing on how the breakdown and ruck is used by successful versus unsuccessful teams. The aim of the study is to analyse the breakdown of matches won versus matches lost of the same team to determine SF in the breakdown. Fifty-nine matches of the South African national men's rugby team (Blitsboks) for the 2017/2018 World Rugby Sevens Series were divided between matches won and lost. One-way ANOVA was used to test for differences in breakdown and ruck performance indicators (PIs) between matches won and lost. PIs such as breakdowns formed in Zone D and B, breakdown turnovers made, total defending breakdowns and committing one player to the breakdown were shown to be of significance and related to winning of matches. The novelty of this study lies in the identification of success factors surrounding the breakdown and ruck that can be effectively used to influence match outcomes.

Keywords: match analysis; performance analysis; performance indicators; rugby sevens; breakdown

Introduction

During phase play in rugby sevens, the occurrence of breakdowns are inevitable and could thus be used during tactical and technical play in order to disrupt the opponent's defence (Higham, *et al.*, 2014). Rugby sevens has seen a rapid gain in popularity, particularly since its re-introduction in the 2016 Summer Olympic Games. Rugby sevens is characterised by the fast pace and high intensity of the gameplay, with seven players from each team including five substitutes per team, competing in a 14-minute match (Elloumi *et al.*, 2016). The playing field dimensions are similar to rugby union thus providing passages of play with openings in the defensive system appearing more often than other rugby codes due to the availability of more running space. The World Rugby Sevens Series is considered the prestige competition among rugby sevens playing nations. The world series consists of 10 tournaments in various countries comprising of five to six matches per team per tournament. The tournaments have been dominated by teams such as Fiji, New Zealand and South Africa who appear to be superior to other teams over the course of the series (Nauright and Parrish, 2012). Match performance can be measured by the identification of contributing factors to match events. These factors are usually referred to as performance indicators (PIs) and are defined as event markers of actions that describe aspects of performance (Higham *et al.*, 2014). Once a PI has been shown to have a significant impact on a successful match outcome (winning the match), the indicator could then be classified as a success factor (SF) (James *et al.*, 2005). The effective execution of the breakdown is a contestable event that provides the attacking team with the ability to perform structured attacks from predetermined areas on the field of play. Even if breakdowns occur at random, it still provides the attacking team with the opportunity to recycle players and perform a structured attack from the breakdown point (Kraak & Welman, 2014).

The analysis of key events, known as PIs, during a match is usually used as focus points during match analysis. The capability of some teams to successfully disrupt the opponent's defensive system is usually accompanied by various PIs serving as markers for technical analysis (Higham *et al.*, 2014a). A number of skills such as ball retention and the breaking of tackles could contribute to a team's ability to place an opponent's defensive system under pressure (Van Rooyen *et al.*, 2008). Defensive systems, however, are built around breakdown events during match play as this provides an opportunity for role clarification between players in the defensive system. Without role clarification the defensive attempt is in disarray, usually referred to as scrambled defence (Kraak & Welman, 2014).

The uniqueness of rugby and especially rugby sevens can be contributed to the recycling of phases of play from breakdown to breakdown where the attacking team is able to restructure their attack as the opposition rearranges defence to re-compose for the attack, creating a vast range of complex interactions (Vaz *et al.*, 2011). Rugby sevens players will be involved in rucks 2.3 ± 3.9 times during pool play and this number could increase to 3.2 ± 3.5 during cup matches (Schuster *et al.*, 2018). An interesting observation was made by Higham *et al.* (2014b) showing successful sevens teams to adopt a more evasive playing style than the direct approach of their less successful counterparts (Higham *et al.*, 2014a). This is believed to be achieved by more successful teams avoiding the breakdown during the attack, as fewer breakdowns are formed by these teams (Carreras *et al.*, 2013). A 2005-study found that successful teams (winning percentage >70) formed 33% fewer rucks than unsuccessful teams (winning percentage <70) (Hughes and Jones, 2005).

In rugby union breakdowns and rucks have been acknowledged to be a vital part of tactical as well as technical play (Cunniffe *et al.*, 2009). Rucks are interesting as they do not only include physical strength and skills capabilities of players involved in rucks, but also cognitive decision-making

abilities on approaching the breakdown situation (Lorains *et al.*, 2013). When the playing field is divided into four zones with zone D being the team's own 22m area and zone A is the opponent's 22m area, it was shown in rugby union that most rucks are formed in zone B while most successful rucks were formed in zone D (Figure 1). Attacking teams were most successful in retaining ball possession when they had one or more players involved in the breakdown (Kraak and Welman, 2014). An increase in the number of players committed to attacking rucks was however associated with a decrease in point scoring (Ross *et al.*, 2015). Rugby union has shown that teams retaining ball possession during contact (McKenzie *et al.*, 1989), as well as teams that slow down the opposition's ruck (Bremner *et al.*, 2013; Watson *et al.*, 2017), are more successful. These findings on the importance of the breakdown have also been evident in studies in rugby sevens. Two findings that seem to be consistent in various studies are that successful teams tend to be involved in fewer breakdowns (Henderson *et al.*, 2018) and concede fewer turnovers in the ruck (Higham *et al.*, 2014a).

Although the breakdown has received some consideration in rugby union (Kraak & Welman, 2014) the PIs surrounding the breakdown in rugby sevens have received limited attention. Studies regarding the significance of the breakdown in the success of teams in rugby sevens usually only include the frequency of occurrence and the percentage of own rucks retained or conceded. No study in rugby sevens has investigated ruck speeds or players involved, although the effect has been shown to be influential in a team's success in rugby union. The breakdown forms a vital part of rugby sevens and investigation into the way it is utilised by successful teams should be regarded as a meaningful aspect of performance analysis. Knowledge of PIs that may lead to winning matches and assist trainers in practical guidelines for tactical and technical development (Higham *et al.*, 2014). The need for a more qualitative analysis of skill sets contributing to success has been

recommended (Hughes *et al.*, 2012). Contrasting successful and unsuccessful teams is vital for a better understanding of the contributing SFs, however, different playing styles might have an effect on the results (Vaz *et al.*, 2011). It could, therefore, be advantageous to focus on a single team and compare the breakdown PIs between matches won and lost.

Methods

Sample

In the 2017/2018 season the South African national rugby sevens men's team (Blitsboks) played 59 matches which were analysed to compare the PIs associated with the breakdown of the matches won to the matches lost. The field of play was divided into four territorial divisions which were combined to create an attacking half and a defensive half (Fig.1). To determine the location of the breakdown, ball tracing techniques were used. Video footage was used to determine the position on the field where the event occurred. A marker was digitally placed on the field linking the position of the event to a location on the field while the event remains linked to the video event footage. This provided a visual time-stamped event linked to a location that could be digitally assessed and reported on.

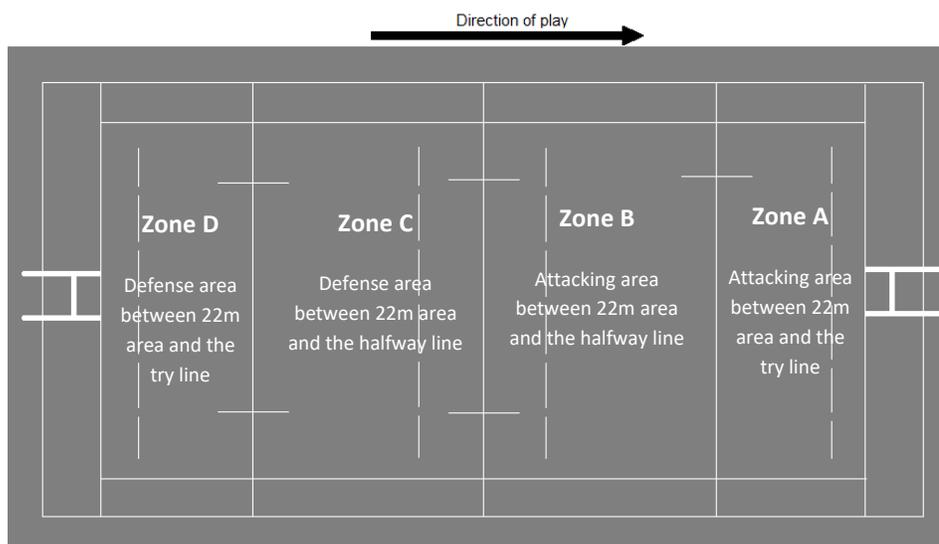


Figure 3. Breakdown and ruck location zones on the field of play (Kraak and Welman, 2014).

Video recordings of the publicly broadcasted match footage were used to analyse match activities. Video footage was loaded into rugby analysing software (Stratus V3.6.6, Mobii, South Africa) for the tagging of events. The software was used to mark key events for the study in order for playback, sorting and reporting of the events to be made possible while still linked to the video footage. This method of notion analysis has been shown to be accurate in previous studies (Griffin, 2015). All matches were analysed by five professional rugby analysts who perform match analysis for professional rugby teams, including the Blitzboks. These analysts are professionals with more than 30 years of experience between them. Inter-reliability and intra-reliability were shown to be consistent with high correlations ($ICC = >0.98$) for events tested. All analysed data was uploaded to a cloud-based server for teams to download. Activities coded are displayed in Table 1. Data included was collected with strict reference to agreed definitions for consistency. A ruck is considered to be formed if two or more players from opposing teams are in contact over or in close proximity of the ball (World Rugby, 2018).

To obtain true averages for mean behaviour in rugby, it was recommended that the sample size should include between three to seven samples (Hughes *et al.*, 2001). Analysing all matches over the season allowed us to account for volatile match conditions and eliminate bias to a single tournament. By committing to the data of the overall winning team for the specific series analysed, differentiation in playing styles could be eliminated. Ethical approval was granted by the ethics committee (project number 10813).

Data of the following PIs were coded:

Table 3.1. Breakdown PIs coded

Category	Area	Performance Indicator	
Breakdown and rucks	Match Development	% Breakdown retained	
		Turnover	
		Total rucks	
		% Rucks formed	
		Breakdown per possession	
		Total passes between Breakdowns	
		Breakdown Location	(Zone D)
			(Zone C)
			(Zone B)
			(Zone A)
	Ball Retained	Defensive area (0-50m)	
		Attacking area (50-100m)	
		Attacking-defensive area	
	Speed of Breakdown / Ruck	Breakdown retained ball out	
		Rucks retained ball out	
	Attack vs Defence Breakdowns	0-3s	
		3-5s	
(Total defensive breakdown - Total attacking breakdown)			
Total attacking breakdown			
Player arrival in attacking Breakdown	Total defensive breakdown		
	0		
	1		
	2		
		0	

Player arrival in defensive Breakdown	1
Breakdown Retained Infringement	2 Breakdown retained infringement Rucks retained infringement
Breakdown Lost infringement	Breakdown lost infringement Rucks lost infringement

The playing field was divided into two halves i.e. defense half and attacking half. Each half was divided into two zones.

Statistical analysis

One-way ANOVA was used to test for differences in measurements between matches lost or won. Normal probability plots were inspected to check for normality and were in most cases found to be acceptable. In selected cases, the Mann-Whitney U-test was also calculated and found to give the same results as the F-test of the one-way ANOVA. Levene's test was used to test for homogeneity of variance, and in only one case found to be significant. A Welch test was performed and found to give the same result as the F-test.

Results

In general, over the 2017/2018 season, a total of 645 breakdowns were assessed with a total of 343 resulting in rucks. PIs that showed to be significant between matches won and matches lost were breakdown turnovers won, number of breakdowns formed in zone D and B, rucks retained by infringement, difference between total attacking and defensive breakdowns, total defensive breakdowns as well as the players committed to the breakdown.

Match development

Although results showed that the total number of breakdowns for the Blitzboks were lower during matches won (won:10.47 \pm 4.72, lost:12.83 \pm 5.01, $p=0.13$), rucks formed during matches lost were higher (won:5.51 \pm 3.12, lost: 7 \pm 2.86, $p=0.14$). No significant difference, however, could be found for the percentage of rucks formed from breakdowns between matches won and matches lost ($p=0.71$). The number of breakdowns retained were lower during matches won (won:9.45 \pm 4.52, lost:11.25 \pm 5.03, $p=0.23$). Turnovers won in the breakdown by the Blitzboks were statistically significant. Results also showed fewer turnovers conceded to be strongly related to a successful match outcome ($p=0.08$).

A significant effect was shown when breakdowns were presented in terms of possession ($p=0.03$). However, when data were adjusted for outliers the significance faded ($p=0.07$). The relevance of the finding still points to fewer breakdowns formed in matches won than matches lost every time possession was obtained. No significant difference ($p=0.79$) was found for the number of passes (won:7.21 \pm 5.28, lost:7 \pm 3.25) between breakdowns when the team won versus lost, with a mean of approximately seven passes between breakdowns.

Although fewer breakdowns were seen during matches won, a significant difference was shown for the number of breakdowns during the defense. Defensive breakdowns were shown to be significantly higher during matches won (won:17.68 \pm 5.74, lost:12.75 \pm 4.52, $p<0.01$). When attacking breakdowns were subtracted from the total amount of defensive breakdowns to compensate for the attacking and defensive opportunities per match, a clear significant difference could again be seen ($p<0.01$) confirming that the number of defensive breakdowns was much higher during matches won.

Breakdown location

Locations of where the breakdowns occurred in the field provided a clear indication of how strategic play was set up to use the breakdown as an attacking platform. No significant difference could be found for breakdowns formed in the attacking half or in the defensive half between matches won and lost. Results representing the difference between breakdowns formed in the opponent's half and their own half showed almost no difference ($p=0.8$). However, when the playing field was further divided into more specific areas, a significant difference could be found between matches won and lost as significantly fewer breakdowns were formed on attack in Zone D ($p=0.04$) as well as between the 50m and 22m of the opponent (Zone B) ($p=0.05$). The only results indicating more breakdowns formed during matches won to matches lost on attack were in Zone A (won: 3.51 ± 2.34 , lost: 3.17 ± 3.16 , $p=0.67$).

Breakdown speeds

No significant differences were found between matches won and lost for breakdown speed 0-3s ($p=0.42$) and 3-5s ($p=0.35$) or for ruck speeds 0-3s ($p=0.82$) and 3-5s ($p=0.3$). Breakdowns ($p=0.06$) and rucks ($p=0.04$) that were retained by the measure of infringement by the opposition showed to have a significant effect on match outcomes.

Player arrival in breakdown

Knowing how many players to sacrifice in the breakdown is not always easy. More matches won contained no players entering the breakdown on attack ($p=0.19$). Matches lost were higher when one ($p=0.13$) or two ($p=0.11$) players entered the breakdown on attack. However, the opposite was true for defensive breakdowns which showed that although more matches were won when no players entered the breakdown, a significant difference was displayed for matches won if one

player ($p=0.02$) entered the breakdown as well as a strong trend for two players committing to the breakdown ($p=0.07$).

Table 3.2. Results table for breakdowns and rucks PIs between matches won and lost.

Performance Indicator	Matches Lost		Matches Won		P
	Mean	SD	mean	SD	
Breakdowns retained	11.25	5.03	9.45	4.52	0.23
Breakdowns % retained	86.1	10.88	89.49	10.33	0.32
Breakdown turnovers conceded	1.58	1.24	1	0.93	0.08
Breakdown turnovers won	1.67	1.44	2.62	1.44	0.05*
Total rucks formed	7	2.86	5.51	3.12	0.14
% Rucks formed	66.3	19.85	62.84	29.88	0.71
Breakdown per possession	0.78	0.23	0.63	0.25	0.07
Total passes between breakdown	7	3.25	7.21	5.28	0.89
Breakdown location (0-22)	1.5	1.68	0.62	1.19	0.04*
Breakdown location (22-50)	2.92	1.83	2.68	1.89	0.7
Breakdown location (50-78)	5.58	3.26	3.66	2.88	0.05*
Breakdown location (78-100)	3.17	3.16	3.51	2.34	0.67
Breakdown location own half	4.42	2.43	3.3	2.54	0.18
Breakdown location opposition half	8.75	5.93	7.17	4.07	0.28
A-D Zones - (Opposition half - Own half)	4.33	7.55	3.87	4.92	0.8
Breakdown retained ball out	10.17	4.93	8.87	4.44	0.38
Rucks retained ball out	4.83	2.52	4.38	2.75	0.61
Breakdown speed (0-3)	7.75	4.33	6.81	3.4	0.42
Breakdown speed (3-5)	1.08	1	0.81	0.88	0.35
Ruck speed (0-3)	3.17	1.53	3.32	2.17	0.82
Ruck speed (3-5)	0.83	1.11	0.53	0.83	0.3
Breakdown retained by infringement	1.08	0.9	0.57	0.8	0.06
Rucks retained by infringement	0.92	0.9	0.43	0.68	0.04*
Breakdown lost due to infringement	0.53	0.75	0.67	0.78	0.58
Rucks lost due to infringement	0.58	0.79	0.38	0.61	0.34
Difference defence vs attack breakdowns (D-A)	0	7.7	7.23	8.27	<0.01*
Total attacking breakdowns	12.75	5.01	10.45	4.72	0.14
Attack amount of players arrival in BD (0)	0.75	0.75	1.53	1.99	0.19
Attack amount of players arrival in BD (1)	9.92	5	7.77	4.2	0.13
Attack amount of players arrival in BD (2)	1.58	1.44	1.02	0.97	0.11
Total breakdowns defence	12.75	4.52	17.68	5.74	<0.01*
Possession / breakdown (on defence)	4.35	2.68	3.11	1.97	0.08
Defence amount of players arrival in BD (0)	5.08	2.19	6.26	2.91	0.2

Defence amount of players arrival in BD (1)	6.92	3.37	9.96	3.98	0.02*
Defence amount of players arrival in BD (2)	0.67	0.89	1.4	1.33	0.07

Discussion

The aim of the study was determined if SFs exists between matches won and lost in the breakdown area. Our results indicated that SFs did appear in the breakdown turn overs won, the forming of breakdowns in zone D and B, the number of rucks retained by infringement of the opposition, the total number of breakdowns formed as well as sacrificing only one player to a defensive breakdown.

Match development

Maintaining a structured and impenetrable defensive system have been argued to be a critical factor to the success of a team (Higham *et al.*, 2014c). This might be true as no significance was shown for total attacking breakdowns between matches won or lost. However, a large significance difference can be seen between matches won and matches lost for total defensive breakdowns. It should be noted that a defensive breakdown refers to the team on defense entering the ruck and an attacking breakdown refers to the team that is on attack entering the breakdown. We only assessed the Blitzboks and therefore our perspective of the attacking or defensive breakdown will only be pertained to their actions. There is a significant increase in the total number of defensive breakdowns by the Blitzboks during matches won compared to matches lost. Although it still might be true that a lower amount of breakdowns could be associated with an increase in point scoring (Higham *et al.*, 2014), being able to successfully defend against the attacks from the opposition might result into a higher amount of defensive breakdowns. It might thus be argued that matches won contain less attacking breakdowns, but more defensive breakdowns showing the balance of attacking with an evasive playing style (Higham *et al.*, 2014) while still being able to successfully

defend for longer periods (Van Rooyen *et al.*, 2008). This argument is strengthened by a strong relationship being shown for a decrease in breakdowns per possession during matches won. Fewer breakdowns per possession during matches won could be expected as a stronger defence is presented by teams during matches lost which requires more phases and breakdowns to disrupt the defensive line. Also, when attacking breakdowns were subtracted from defensive breakdowns, defensive breakdowns increased significantly to attacking breakdowns per match during matches won, indicating a higher defensive breakdown ratio during matches won. Successfully bringing the opposition to the ground during defence provides an opportunity for the defending team to compete for the ball in the breakdown or ruck. This creates an opportunity for the defending team to regain the ball as well as re-structure their defence.

Obtaining a turnover in the breakdown creates an attacking opportunity where the opponents must switch from an attacking to a defensive structure. The team gaining the turnover receives the opportunity to attack while the opponents are still in scramble defence. Obtaining turnovers in the breakdown were shown to be significantly more during matches won than during matches lost for the Blitzboks. Similar to other authors, a strong relationship during matches won were found when fewer turnovers were conceded as compared to during matches lost (Higham *et al.*, 2014a). Turnovers can be useful in teams that are able to rapidly switch from defence to attack. The same findings have been confirmed in rugby union (Ortega *et al.*, 2009) as well as in rugby sevens (Higham *et al.* 2014a). Although there might be a risk-and-reward tradeoff for between gaining a turnover and conceding penalties (Higham *et al.*, 2014a), it seems that the reward of successfully turning over opposition ball might outweigh the risks involved of conceding a penalty. This might also be true for retaining the breakdowns by means of the opposition infringing.

Breakdowns and rucks retained by infringements on attack were shown to be significantly lower during matches won. This finding, although appearing counterintuitive, was also reported by other authors for successful teams compared to unsuccessful teams (Hughes and Jones, 2005). The opposite was shown for rucks lost due to infringements on an attack which showed fewer rucks were lost due to infringements in matches won. A possible reason given for the gaining less breakdown possession through infringements on attack could be the exploitation of the advantage rule where the non-infringing team gains advantage by not taking the penalty and continuing play. Although less rucks were lost by infringement during matches won, an explanation for more breakdowns lost by infringement on attack during matches won could again be due to the risk and reward tradeoff where players try to push the boundaries of the laws in an attempt to maintain possession even if it may lead to infringements (Higham *et al.*, 2014a). However, obtaining possessions in the opposition's half might relate to an even larger relation to winning of matches.

Breakdown Location

Location-based analysis of breakdowns provided some of the most valuable insight into how certain areas of the field is utilized for the matches won. As in rugby union, the highest amount of breakdowns occurred in Zone B (Kraak & Welman, 2014). Breakdowns during matches won were significantly less in Zone B and Zone D. This is evidence of more successful teams being able to play in the “right” areas of the field. Our findings show that during matches won, play is kept to a minimum in Zone D. Exiting the “danger area” (Zone D) as quickly as possible seems to occur much more efficiently during matches won. This argument is strengthened by the fact that Zone A was the only zone where mean breakdowns were higher during matches won rather than during matches lost. Successful teams have been shown to adopt a territorial playing style, infiltrating the opposition's 22m area (Zone A) more often (Higham *et al.*, 2014b). This endorses the fact that

during matches won, successful teams spend less energy on breakdowns in their own 22m area (Zone D) and more in the opponent's 22m area (Zone A) relative to when matches are lost. The significantly higher number of breakdowns formed in Zone B during matches lost might be explained by the defensive efforts of the opponent, keeping the attacking team out of their 22m area, decreasing their chances for a successful match outcome. This might be achieved by committing the correct number of players to the breakdown in the correct areas of the field.

Players entering breakdown

Differences in the number of players entering attacking and defensive breakdowns provided unexpected findings. During an attacking breakdown the attacking team would usually commit at least one player to the breakdown, and more if necessary, to ensure possession is maintained (Kraak & Welman, 2014). We, however, found that attacking breakdowns benefitted during matches won when fewer players entered the breakdown. Benefits of committing fewer players to an attacking breakdown include more players available for attack and a readily available defensive side and easily accessible in case of a turnover. It is usually true for defensive breakdowns to commit as few as possible players to the breakdown to ensure a full defensive structure. A significant difference was found between matches won versus matches lost where only one player was committed to the defensive breakdown. This is similar to findings by Ross *et al.* (2016) who reported that more points are likely to be conceded when two or more players are committed to the defensive breakdown. Committing two players to the breakdown still showed a strong correlation to match outcome. These findings on defensive ruck commitment also concur with findings in rugby union (Kraak & Welman, 2014). This could be an effective strategy weighing risk and reward by sacrificing one player in the defence to the breakdown in order to attempt to obtain a turnover or to slow down the ball for defensive structures to have time to re-group.

Breakdown and ruck speed

Ruck speeds did not show any significant differences, but it is possible that during matches won the trade-off between catching the opposition's defence off guard with the use of quick breakdowns and rucks or waiting for the assisting support to get into attacking positions around the breakdown is a decision that could have a correlation to the outcome of the match. Results from the current research suggested that during matches won structuring the attack with enough attacking players was more effective than increasing the breakdown speed.

Practical application

As mentioned in this article the breakdown can be used to provide a platform for attack. Knowing where attacks could be launched to exploit the weakness of the opposition or obtaining knowledge on how the opposition structures their play could be beneficial to coaches and players. This could be used to develop attacking or defensive structures. Exploiting the breakdown and its various components could be used to place the opposition under pressure as the team in control of the breakdown can either decide to recycle quickly or slow down play for team mates to fill their positional roles.

Conclusion

Considering the faint margins between winning and losing in professional rugby sevens, the contestability of the breakdown could provide a unique platform to advance on the opponent as this study has shown. Critical SFs have been shown for teams playing at an elite level with a strong focus on defensive systems. An evasive attacking style of play (Higham *et al.*, 2014), limiting direct approaches that could lead to excessive breakdown build-ups on attack, seems to be counterproductive to a successful match outcome. However, being able to withstand multiple

attacking breakdowns on defence was shown to have a statistically significant impact on a matches won. Territorial breakdown play was shown to be beneficial for breakdowns occurring in certain areas of the field to optimise territorial play while in possession.

Players, on the other hand, should be able to make strategic decisions when faced with a breakdown scenario. This requires players to only engage in the event if it is required, depending on attacking or defending breakdowns, to eliminate chances of over- or under-committing players who could have been more effective on their feet (Kraak & Welman, 2014). This could also include sometimes slowing down the breakdown speed if supporting attacking players are not sufficient in numbers to decrease chances of not having playable options. This should assist with the overall game plan of being patient and evasive (Higham *et al.*, 2014).

In conclusion, breakdowns can be used as an effective attacking strategy if limited when in Zone D, but used to maximum exposure in Zone A & Zone B. Conceding less turnovers as well as keeping a strong defensive structure during defensive breakdowns and optimally using the number of players available to commit to the breakdown are vital factors that may lead to successful match outcomes.

This study can be used to further investigate measuring PIs at elite rugby sevens level as well as to serve as a platform for other sports in identifying SFs. Replicating this study at different competition levels could be applied to any sport. Understanding the dynamics of the breakdown can make an immense difference in how teams structure their play in order to become successful not only in rugby sevens, but can also be transgressed to other codes of rugby.

Future research

There is still a vast number of PIs in the breakdown with an unknown effect on match outcome and requires further investigation. Future research should focus not only on the relevance of PIs of the breakdown in isolation to match outcome, but rather on the effect PIs exert on each with a direct or indirect effect on match outcome. Future research should also investigate how successful teams use the laws of the game to their advantage during breakdown contests.

Limitations

The PIs measured are representative of technical and tactical factors, but there are various other elements that influence a team's performance such as fitness, skills or technical proficiency, to name a few, which did not form part of this study. Multiple factors involved in a dynamic team sport such as rugby sevens introduce a complexity of interacting variables, making it impossible to account for all factors involved in match outcome. It should also be noted that this study was limited to one team that was assessed during one season.

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CHAPTER FIVE

DISCUSSION

INTRODUCTION

The primary aim of the study was to determine if PIs significantly differ between matches won and matches lost during the World Rugby Sevens Series for the Blitzboks in general play and set pieces. The secondary aim of the study focused on the relationship of the PIs in the breakdown and ruck that relates to matches won. Due to significant differences found between PIs in matches won and matches lost, the null hypothesis can therefore be rejected and the alternative hypothesis can be accepted for both aims.

SUCCESS FACTORS IN RUGBY SEVENS

The current study focused on the impact of various PIs which could be classified as SFs during rugby sevens matches. By detecting significant differences in PIs between matches won and matches lost, it was possible to identify several SFs. Although not all PIs showed significant differences, SFs in all categories (match play, phase play, set pieces and breakdowns and rucks) could be observed. SFs in the categories could explain why the team was successful sometimes and less successful at other times, even

though most match variables did not change. It should be noted that, as previously mentioned (Figure 1), statistical analyses are limited to observable metrics and only account for small number of factors relating to an individual's and a team's performance. These factors include tackling (defence), ball carrying (attack) as well as set pieces (team cohesion). A discussion on contributing SFs takes into account that fitness and conditioning, skills and physiological factors also have a relation to performance and take these limitations into account. Adding strength to the current study, might be the fact that the performance of one successful team was analysed and therefore results are not contaminated by different playing styles of different teams.

MATCH DEVELOPMENT

Possession and territory

Territory and possession were assessed to determine if a significant difference could be found when matches were lost compared to when matches were won. Although no significant findings for the amount of possession or territory between matches could be reported, territory seemed to have a much larger trend on performance relating to matches won than the amount of possession a team partook in. Results in this study showed that during matches won and matches lost, possession was almost equal and did not seem to have any impact on match outcome. Results in this study are similar to the findings of Hughes and Jones (2005), who showed no significant difference between the possession of successful teams and less successful teams. The similarity in results

may be due to the fact that Hughes and Jones (2005) also distinguished between successful (winning rate of >70%) and unsuccessful teams. The highly successful teams in their study displayed similar characteristics during their successful matches for the amount of ball possession. Higham et al. (2014a), did however not found the same results and found successful teams to be more patient when in possession of the ball. Teams that were more patient had a longer possession time which enhanced their chances of scoring. Being more patient (not kicking the ball away and play through the phases keeping possession of the ball) probably allowed successful teams to create more scoring opportunities. The conflict in results could be pertained to the methodology and statistical methods used to determine the successfulness of the team and their ranking. Although it is crucial for a team to maintain possession in order to score, the combination of the factors involved during the time of possession might be even more critical to a successful match outcome. According to the results of this study, possession alone will not determine if a team will be successful.

Although territory also could not be classified as a SFs, it did show to have a stronger relation to match outcome than the amount of possession a team obtained.

This is similar to the strategic play seen in rugby union where successful teams would rather apply a territorial base approach by kicking the ball when in possession (Ortega, Villarejo, & Palao, 2009; Vaz et al., 2010). To increase point-scoring, due to the increase in available running space than in rugby union, it was proposed by Higham et al. (2014) that greater importance should be placed on ball possession and less significance on field position and set piece plays. Although it is crucial to have as much

ball possession as possible, it is even more important how possession is controlled. The researcher would argue that it is not the amount of possession per se that relates to success but rather how effectively possession is used. This argument might be in line with findings by Kraak and Welman (2014) who showed successful teams in rugby union to display a territorial approach to the game by entering the 22m area more often than unsuccessful teams. The effective use of possession rather than to only accumulate possession time was shown to be of importance during the 2005 Rugby World Cup Sevens Tournament where it was shown that successful teams maintained ball possession for between 30-60s and converting 30% of the possession into points. It was also shown that by kicking less short contestable restart kicks, successful teams were able to capitalise on gaining territory from the kickoff (Higham et al., 2014a).

Infringements

Surprisingly more penalties were conceded and fewer turnovers were won during matches won. Although this seems to be in direct contrast with Higham et al. (2014), who found the opposite, it must be reinforced that they based their results on the ability to score points and the likelihood of winning was unclear between teams and trivial within teams on penalties. Results from the current study are however in coherence with the results of Hughes and Jones (2005). They explained the counter-intuitive phenomena by firstly stating that successful teams are more likely to utilize the advantage rule to continue to play following an infringement by the opposition. Successful teams weaken the opponent's defence by maintaining momentum in the attack. In rugby sevens, teams would rather keep the ball in hand and take a chance to score a try than to kick for goal.

By not immediately taking the penalty after an infringement, successful teams maintain momentum by playing the advantage given by the referee. By using the advantage rule attacking pressure is maintained on the opponent's defence. This, however, gives the illusion that fewer penalties are conceded by the opposition. However, in fact, the penalty was conceded, but not counted to the overall penalties of the opponent, because the penalty was never officially taken. Secondly, the risk-reward strategy deployed by more successful teams might also be at play which increases penalty count for successful teams. The risk-reward trade-off is a strategy where successful teams will take risks that could possibly lead to infringement when the reward outweighs the risk factors. Although successful teams will not always be successful not to infringe, the benefits in the opportunities that are gained from the reward could be essential to a successful match outcome (Hughes & Jones, 2005).

Results from the current study showed fewer turnovers conceded during matches won. These results are similar to the results of Higham et al. (2014b,c) who found conceding fewer turnovers to be highly related to point-scoring. It was also noted that rugby union displays similar findings showing more turnovers won and less conceded to favour winning teams. Turnovers conceded gives the opposition attacking opportunities that could lead to point-scoring. By maintaining possession and not conceding turnovers successful teams are able to maintain momentum during the attack.

The current study would thus suggest that teams, similar to rugby union, should focus on playing in the right areas of the field even if it means that possession is sacrificed. The first objective of a team should be to obtain as much territory as possible. Gaining territory might be the best way to utilise and optimise ball possession. The effective use of territory could, therefore, be an important coaching application.

PHASE PLAY

Attack

For the assessment of PIs during attack, the focus for this study was placed on ball carries, line breaks, passes, offloads and kicking. None of the PIs assessed provided any SFs. Although, on average less time was spent on attack during matches won. During matches won ball carries were on average less than in matches lost. This might possibly be explained by the fact that less time was spent on the attack during matches won limiting the opportunity to create ball carries. Although ball carries were on average lower during matches won, line breaks were higher during matches won.

The higher number of line breaks during matches won shows the importance of being effective with ball possession during attack. Effective attacking play during matches won could be seen by the percentage of line breaks during matches won. The higher percentage of line breaks during matches won was displayed by the higher amount of line breaks even though there were fewer carries. Line breaks have been shown by other

authors to be highly related to points-scoring and to the success of a team (Ross et al., 2016). The line break ability of successful teams was also highly noted in rugby union (Watson et al., 2017).

Previous literature has reported that successful teams in rugby union yield fewer passes than unsuccessful teams (Vaz et al., 2010). The same results were shown in rugby sevens by Hughes and Jones (2005), showing successful teams to have a remarkably lower pass frequency per try during a match. Results from the current study concur with the finding that fewer passes were made during matches won, but no significant difference could be shown. Contrasting findings are observed as point-scoring was reported by Higham et al. (2014c) to be positively related to the absolute frequency of passing and kicking within a team. This conclusion is similar to other results by the same author, showing successful teams passed more during sevens rugby matches (Higham et al., 2014a). This, however, is in contradiction with the conclusion of Higham et al. (2014b) where a higher number of passes related to a lower tournament ranking.

The difference in the three studies conducted by Higham et al. (2014a, b, c) could be due to the sample size as all three studies did not span over the same amount of years. Also, the difference in possession time could have influenced the number of passes that could be made during a match. The latter statement was further supported as when the number of passes were standardised relative to possession time, the results were reversed and unclear (Higham et al., 2014c). Therefore, when possession time was considered, the higher number of passes and kicks did not provide any relevant relation to the success of

the team. The higher possession rate creates a longer attacking opportunity that relates to more passing as the attacking team will have more time in hand with the ball. It might, however, be true that the number of passes is directly proportional to the amount of possession time and as possession time has been shown not to be significant, the number of passes as a success factor can be discarded.

Hughes and Jones (2005) mentioned that successful teams perform fewer normal passes and more loop, cut-out and dummy passes. Higham et al. (2014c) included in his discussion that the number of passes between successful and unsuccessful teams might not necessarily provide any substantial contribution to matches won. However, the type of pass might play an important role in the team's success and requires further investigation. By effective distribution of the ball, a team is more likely to create opportunities for line breaks by concealing the direction, speed or timing of the pass and in such a way misleading the opposing team to be out of position in their defensive structure.

General play kicking is usually not encouraged in rugby sevens mostly due to the limited match time as there is less time to regain possession during a rugby sevens match than in rugby union. By kicking the ball away the opposition gain attacking opportunities and could maintain ball possession for long periods at a time, limiting scoring opportunities for the other team. In a study by Hughes and Jones (2005), it was shown that successful teams kick less frequent than unsuccessful teams. Although rugby union have shown general play kicking to be beneficial to successful teams (Vaz et al., 2010), most studies

in rugby sevens could not replicate the results (Higham et al., 2014b). In a recent review study, it was reported that the effect of general play kicking is still unclear (Henderson et al., 2018). Similarly, the results also presented no significant difference between the matches won and matches lost for the number of general play kicks. General play kicks were found to be higher on average which might be a strategy deployed to gain a territorial advantage, similar to strategic play in rugby union.

This result might provide evidence that general play kicks could benefit teams that have a strong defensive system. If possession is lost due to a kick turnover, immense pressure will be placed on the defending team. A strong defensive team will, however, be more successful in regaining possession after a kick or place the opposition under pressure in their own territory to force a turnover. Although more strategic kicking is not classified as a SF on its own, it is possible that effective strategic kicking coupled with a strong defensive system could be beneficial to a team's success. Therefore, it might be possible that teams with strong defence might benefit from strategic kicks which enable them to gain territory, lessen passes and reduce handling errors while placing pressure on the opponents. This theory might not be the right strategy for teams with a weaker defence as a strong defence was observed in the study during matches won.

Defence

Maintaining a strong defensive system is not always easy but could be the difference between winning and losing. It is, therefore, a critical component of rugby sevens and has

been showed to be an important factor to success (Higham et al., 2014b). The higher amount of time spent on defence during matches won shows that successful teams can maintain an effective defensive structure. This finding was previously reported by other authors (Vaz et al., 2011) and seems to be relevant in other rugby codes as well (Ortega et al., 2009; Vaz et al., 2010). Results, although without significance, indicated that during matches won more time on average is spent on attack. The defensive category displayed more SFs than any other category. A successful defensive system is a collection of multiple defensive components, but largely rely on the effectiveness of a team's tackling ability. The focus of the current study has thus remained on the tackling component during the defensive effort. Evidence for the contribution of defence to the match outcome is displayed in the SFs involved in the defence.

The total number of tackles showed to be a SFs as matches won contained significantly more tackles than matches lost. A high tackling rate prevents the opponents to gain momentum during an attack. This places pressure on the opponent and could disallow them territorial gain. The impact of a high tackling rate to the success of match outcome had previously been reported by other authors and seems to be consistent over multiple teams (Hughes & Jones, 2005). It should, however, be noted that a strong defensive tackling ability that can maintain a high defensive rate could be affected by a team's fitness or tactical and technical abilities. Technical tackling skills could also be an enormous contributor to a successful defensive system.

Results showed successful tackles to be a highly significant SF. The technical skills involved in generating successful tackles should be considered as the benefits of completing tackles were shown to be highly related to matches won. This is consistent with other authors who also found successful teams to rely on a successful tackle completion rate for successful match outcomes (Barkell et al., 2016). To strengthen the argument for the impact of effective defence on matches won, results from the current study also showed a low missed tackle count to be a success factor. Missed tackles could lead to line breaks by the opponents which could lead to try-scoring opportunities for the opponents. An effective defensive system should, therefore, be effective in limiting tackles missed while maintaining a high tackling success rate.

A high tackling rate fuelled by effective tackles seems to massively enhance the chances of matches won. These findings are in agreement with other authors that have also promoted an effective tackling rate (Ross et al., 2016). Interestingly, results from the current study showed that the tackle made-to-missed ratio significantly differs between matches won and matches lost. This, however, confirms the above statements that successful teams have a high successful tackling completion rate. Successful tackles made were 2.36 tackles for every tackle missed where matches won had 5.27 successful tackles for every missed tackle. It was shown that tackling ratio could also be seen as a SF. Limiting missed tackles while increasing tackling rate seems to be one of the most influential factors involved in contributing to a successful match outcome.

In summary, defence is arguably the most critical component to success in rugby sevens. Technical and tactical components of defence should not be neglected as the impact of a highly effective tackling rate has been shown. Matches won seem to be highly related to the limitation of missed tackles with an increased tackling rate.

SET PIECES

Results from the current study indicated no significant difference between scrums and lineouts won during matches won and matches lost. This could be due to scrums and lineouts not occurring often in contrast to rugby union where it has been shown to have a large impact on match results (Jones, Mellalieu, & James, 2004). Although lineouts and scrums are also usually won by the feeder, Higham et al. (2014a) indicated that successful teams have a slightly higher lineout retention rate than unsuccessful teams. Lineout and scrum turnovers could provide a great attacking opportunity as the defence would be scrambled. It seems however that lineouts and scrums do not occur enough to influence the match outcome on its own.

A clear significant difference could be seen between the total number of restarts which could be expected as the try-scoring team restarts the game. Although this finding might be perceived as a SF, it should be addressed with caution. In rugby sevens the try-scoring team restarts the match with a restart kick-off. This would mean that teams that scored the most points would have the highest amount of restart kicks, which explains that during matches won restart kicking count would most likely be higher for successful teams.

However, having a significantly higher restart kick-off rate would be evidence of the superior try-scoring ability of a team.

Although the significance of the high number of restarts during matches won might be deemed obvious and not a SF on its own, due to the winning team scoring more points. Therefore, attaining more restart kicks, the value of its influence on matches won might be indirect. With a strong trend displayed for restart kicks regained during matches won, it might be augmented that the opportunity to regain restart kicks is increased by the increase in restart kicks. By increasing the number of restarts kicks the number of restart kicks regained could be elevated which could attribute to winning the match.

Although restart kicks regained did not qualify, due to the parameters of this study, to be classified as a SF, it, however, did show a positive trend that may relate to matches won. This is in contrast with Higham et al. (2014b) who found restart kicks regained to have a minimal impact on a team's tournament ranking. Although Higham et al. (2014a) did mention a possible trend for the effect of restart regains and successful match outcome, it was dismissed as he concluded successful teams to rather opt for deeper restart kicks instead of short contestable restart kicks. The discrepancy between the studies and the value of restart kicks should not be confused as Higham et al. (2014a,b) did not test for the difference between matches won and restart kicks regained, but rather for the effect between short and long restart kicks of match outcome and tournament rankings. Also, Higham et al. (2014a) did not specify the definition of short restart kicks. Long restart kicks could also be contested especially if the restart is a high, hanging deep restart. Rugby

sevens players have shown to be fast enough contest restart kicks around the 22m area of the opposition. It might thus be possible for medium contestable restart kicks to be of optimal length for if the ball is not immediately regained, pressure could be applied to the opposition deep in their own territory. Restart kicks are thus an excellent way to gain territory while contesting for a turnover in the opposition's half.

In summary, the first aim was completed with the results that during matches won a strong effective defensive tackling ability was at heart, shown by more time spent on defence with a highly successful tackling rate. Although the territorial play could be more related to success than amount of possession, it is not achieved by more ball carries and passes but rather by more effective line breaks and strategic kicks. Using the advantage rule optimally as well as effectively risking penalties might be to a team's advantage. SFs were evident especially in defence on total tackles, percentage tackles successfully made and missed, on penalties conceded and on the total number of restarts.

BREAKDOWNS AND RUCKS

Introduction

The second aim of this study was to determine how breakdown PIs relate to the match outcome. Due to significant differences in certain breakdown PIs between matches won and lost the null hypothesis was rejected and the alternative hypothesis stating that there are significant differences between PIs involved in the breakdown that could effect the match outcome.

Match development

To be more specific in the analysis, the total number of breakdowns formed was divided between attacking breakdowns and defensive breakdowns in the current study. Total attacking breakdowns were found to be less during matches won, but defensive breakdowns were shown to be significantly more during matches won. Results showed defensive breakdowns to be highly related to matches won and could be classified as SFs as there was a significant difference between matches won and matches lost. On attacking breakdowns formed, results in the current study support findings by Hughes and Jones (2005), who showed attacking breakdowns to be formed 33% less by successful teams. Similar findings on attacking breakdowns were reported by Higham et al. (2014c) who strongly related more rucks and mauls per minute during attack to fewer scoring of points and worse team rankings (Higham et al., 2014b). A possible explanation for being more successful by limiting breakdowns on attack, could possibly be due to successful teams adopting an evasive, patient and less direct approach during play (Higham et al., 2014; Wheeler & Sayers, 2009; Griffin, McLellan, Presland, Woods, & Keogh, 2017).

As mentioned, the higher number of defensive breakdowns during successful matches compared to matches lost showed a clear significance. A possible explanation for the higher number of breakdowns during defence could be due to more time spent on defence which again illuminates the value of a strong defensive system. A strong defensive system would allow for more breakdowns to be formed by the opponents as they will be unable to penetrate the defensive lines. This could cause tiring of the attacking team

and allow for handling errors or turnovers due to the defensive pressure. It would, therefore, seem that if teams are able to keep their attacking rucks to a minimum while withstanding numerous defensive breakdowns, it could relate to successful match outcomes.

When attacking breakdowns were subtracted from defensive breakdowns, the difference was significantly more for successful matches when compared to the difference for the unsuccessful matches. These significant results again showed the increased amount of defensive breakdowns created during successful matches in comparison to attacking breakdowns.

Breakdown turnovers and infringements

Retaining breakdowns would be a crucial cornerstone for the attacking team to keep attacking momentum and to disallow the opposition from gaining turnovers and possession. Results showed a lower number of breakdowns retained during successful matches. This might seem unexpected as this is in contrast with other studies that have shown ruck retention to be highly related to point-scoring and winning (Higham et al., 2014c). Effectively, absolute breakdowns retained should not be considered as it was shown that successful matches might possibly contain fewer breakdowns which could relate to fewer breakdowns retained. Therefore, when retained breakdowns calculated to the total number of breakdowns, results are reversed and a higher number of breakdowns regained are displayed for successful matches. Higham et al. (2014a) confirmed the

method and findings in the current study by presenting the percentage of own rucks won to be highly related to success in rugby sevens.

Findings from the current study indicated that turning over opposition ball possession in the breakdown was a SF as breakdown turnovers won was shown to be significantly more during successful matches. This confirms a similar finding in other studies which have also displayed breakdown turnovers to have a massive effect on match outcome and the success of a team (Higham et al., 2014a). It is well known that turning over opposition ball in the breakdown creates attacking opportunities while the defending team is still in scrambled defence, transitioning from an attacking play structure to a defensive structure. Attacking from the breakdown while the opposition's defensive structure is vulnerable could be the perfect attacking opportunity. During successful matches, fewer turnovers were also conceded by the winning team. Numerous other studies have also reported on the positive effect not conceding turnovers in attacking breakdowns (Van Rooyen et al., 2008; Higham et al., 2014). Successful teams maintain attacking dominance by not conceding turnover in the breakdown. The effective breakdown and rucking technique of successful teams are evident in the fewer breakdown turnovers conceded. Maintaining attacking momentum by not conceding turnovers, while turning over opposition ball in the breakdown required technical skills which seems to give successful teams an advantage.

Breakdowns and rucks lost due to infringements did not show to have any effect on match outcome. However, a significant difference was clearly shown for rucks retained by opposition infringement as well as breakdowns retained due to opposition infringement.

In both cases, significantly fewer penalties were won by the attacking teams. Although this seems counter-intuitive, it has been previously reported by Higham et al. (2014a) who demonstrated the fact that successful teams are better at utilising the advantage rule as well as adopting a much greater risk-reward playing style that would allow them to often concede more penalties than unsuccessful teams. Similar corroborative findings were already reported by Hughes and Jones, (2005) during international matches played in 2001.

Breakdown speeds

To quickly recycle the ball in the breakdown is a strategy usually used in an attempt to catch the opposition defence off guard. Although the quick distribution of breakdown ball has been promoted in rugby union (Austin, Gabbett, & Jenkins, 2011), the current results showed an unclear effect for rucks and breakdowns of 0-3s and 3-5s breakdowns between matches won and matches lost. Unexpectedly, fast breakdowns and rucks were lower during matches won. A possible explanation could be the notion that, as seen with the number of players in attacking breakdowns being low, a more patient approach is taken to allow for more players to join the attacking line to provide more attacking options. This fits in with the theory that more successful teams adopt a patient playing strategy as it might be beneficial for the attacking team to have more players in the attacking line to outnumber the defence (Higham et al., 2014a; Schuster et al., 2018).

Committing players to the breakdown

Results did show SFs to be evident in the number of players committed to the breakdown. It was shown that during successful matches significantly more times only one player was committed to the attacking breakdown. Although there are limited studies on the number of players involved in the breakdown during successful matches in rugby sevens, rugby union has shown attacking teams to be successful in retaining possession if only one player was committed to the breakdown (Kraak & Welman, 2014). Although findings from the current study cannot compare findings directly with rugby union due to the higher number of players available to commit to the breakdown in rugby union, it is however interesting that a similar trend is visible in rugby sevens.

Results also indicated that during attacking play, having more players on their feet strongly relates to more successful matches. The impact of having one player in the breakdown during attack shows the opposite of having no players in the breakdown and even more so when a second player enters the breakdown. The negative impact of committing more players to the breakdown can probably be contributed to the fact that having fewer players in the attacking line limits attacking options. A previous study also reported that committing one player to the breakdown on defence is an effective strategy as this will force the attacking team to commit more players resulting in fewer players in the attacking structure (Ross et al., 2016). Results indicated that during successful matches, more breakdowns did not include any players committed to the breakdown compared to unsuccessful matches. Also, fewer times breakdowns during successful matches included one or two players committed to the breakdown. The strongest trend in

successful matches compared to unsuccessful matches, regarding player commitment to the attacking breakdown, could be seen when two players were committed to the breakdown fewer times. These findings confirm the notion that when more players are committed to the breakdown, fewer players are available to attack when the ball is recycled out of the breakdown.

In defensive breakdowns, it was shown that during successful matches one player was committed to the breakdown significantly more times than in unsuccessful matches. Committing no players to the defensive breakdown did not show to have any effect on match outcome. When committing two players more times to the defensive breakdown did display a positive trend towards success. This is interesting as teams would usually attempt to have the least number of players in the defensive breakdown, so that more players are available in the defence structure. However, the discrepancy could be explained by the fact that teams with an effective defensive structure might benefit from disrupting the opposition breakdown and slowing it down to limit the attacking options of the opposition from the breakdown. It may be argued that the significance of successful match outcome when committing one player to the breakdown could be because a sufficient number of players are still available in the defensive line but the opportunity to disrupt the breakdown and create turnovers is still exploited. It is, therefore, possible that during defence, teams should opt for a higher risk-reward playing style to gain momentum. This can be achieved by disrupting of the breakdown by one or two players, slowing down the attacking team's breakdown and attempting turnovers, as the latter has been shown to have a large effect on match outcome. During attack, successful teams

seem to commit as little as possible players to the breakdown. Committing too many players to the breakdown will leave players indisposed, weakening the attacking options for the back line.

Breakdown location

The location on the field of play where breakdowns are performed is valuable information to trainers. This could indirectly translate the strategy used by successful teams to gain access to certain areas on the field of play to strategically launch attacks on the opposition. Similar to rugby union most breakdowns on attack were formed in zone B. When the areas where rucks were formed during successful matches were compared to unsuccessful matches, a significant difference in zone B and Zone D was found. Fewer rucks were formed during successful matches in Zone D, Zone C and Zone B but not in Zone A where a higher number of rucks were found during successful matches.

This could be evidence of effective strategic play as successful teams limit play in their own 22m area. If play occurs in this area an effective exit strategy will be deployed by the team to keep the opponents from getting close to the try line. An effective strategy will allow for the successful teams to gain access into the opposition's 22m area to obtain point-scoring opportunities. During successful matches entries into the oppositions' 22m area were significantly higher. This finding is supported by Higham et al. (2014b) who reported more entries into the opponent's 22m area to be associated with better team rankings.

Zone D displayed significantly fewer breakdowns during successful matches. This is possible as, during successful matches, play will be limited in zone D. If access into the 22m area is restricted, scoring opportunities will also be restricted. Due to the significant difference displayed during successful matches limiting play to zone D could be used as a SF. However, the significance of the SF indicating play to have commenced significantly less in zone B is unknown. It can only speculate that during unsuccessful matches more effective defence by the opponents attempted to limited attacks to zone A. Zone B was thus effectively used fewer times as a base from where zone A could easily be penetrated due to the fact that zone A was accessed more often during successful matches which probably lead to more try-scoring opportunities. This clearly shows that the utilisation of territory during matches won and lost is a key aspect of success.

Table 5.1 indicated if SFs were observed to be more (higher) or fewer (lower) during matches won compared to matches lost.

Table 4.1 Table representing SFs reported

SFs during matches won	Relation to matches won
Tackles made successfully	Higher
Tackles made successful percentage (%)	Higher
Tackles missed	Lower
Tackles missed percentage	Lower
Ratio made: missed (1)	Higher
Restart kicks	Higher
Breakdown turnovers won	Higher
Breakdown location (0-22)	Lower
Breakdown location (50-78)	Lower
Rucks retained by infringement	Lower
Difference defence vs attack breakdowns (D-A)	Higher
Total breakdowns on defence	Higher
Defence number of players arrival in breakdown (1)	Higher

Table 4.2 indicate PIs with strong relation to be considered as a SFs were observed to be more (higher) or fewer (lower) during matches won compared to matches lost.

Table 4.2 PIs with a strong trend towards being a SF

SFs during matches won	Relation to matches won
Breakdown turnovers conceded	Lower
Breakdown per possession	Lower
Breakdown retained by infringement	Lower
Possession / breakdown (on defence)	Lower
Defence number of players arrival in breakdown (2)	Higher
Territory %	Higher
Penalties conceded	Higher
Restarts regained	Higher

CONCLUSION

This study confirms that PIs in rugby sevens can be used to allocate events that could possibly relate to successful match outcomes. Visible changes in PIs satisfied the alternative hypothesis. The first hypothesis addressed changes in PIs during match play in successful and unsuccessful matches. The second hypothesis focussed on PIs in the breakdown and the third hypothesis on the frequency of occurring breakdowns in the different areas of the field during attacking play. Overall it is evident that success could be mainly contributed to a strong effective defensive system. For defensive team analysis, the successful tackles to missed tackles ratio is a good indication of how effective a team's defensive efforts were.

It can thus be concluded that that SFs are a valuable tool for teams to monitor why certain matches had a successful match outcome and other matches did not.

LIMITATIONS

Rugby sevens is a dynamic team sport with multiple factors involved. Due to the complexity of the sport, it is impossible to factor in all interacting variables. The PIs measured are representative of technical and tactical factors, but there are various other elements that influence a team's performance. such as fitness, skills or technical proficiency to name a few. Also, to the multitude of components and strategies deployed by coaches in rugby sevens, PIs examined may only be partially representative of the factors related to the successful match outcome. It should also be noted that this study was limited to one team's performance during one season.

SUGGESTIONS FOR FUTURE RESEARCH

Due to the vast number of PIs, the effect of most PIs and the contribution to a successful match outcome is still relatively unknown. Future research should focus on investigating the possible effect of PIs exert on each other. Some PIs might prove to have an effect on other PIs and therefore either indirectly contribute to the success or enhance other PIs to become SFs. It will be interesting to observe the cause and effect that PIs have on each other as well as the effect various match outcomes may have on the PIs. It is also possible

that the strategy opponents use during matches could have an effect on PIs and could alter the outcome of SFs.

With constant changes in laws of the game, fluctuations in PIs are inevitable. Future research on PIs will allow teams to keep up with changing variables as the game changes. It will also be valuable to observe the impact different ranked teams have on PIs of a team and how PIs are restricted or amplified during matches against higher and lower-ranked teams.

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APPENDIX A: INTERNATIONAL JOURNAL OF PERFORMANCE ANALYSIS IN SPORT AUTHOR GUIDELINES

International Journal of Performance Analysis in Sport



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APPENDIX B: EUROPEAN JOURNAL OF SPORT SCIENCE AUTHOR GUIDELINES



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APPENDIX C: PERMISSION FOR THE USE OF DATA



To whom it may concern

30 January 2017

We hereby grant Eben Opperman (8511145072086) permission for the use of Stratus Video Analytics Software. We also allow for full access to match data from the software as data are also available in public domain.

Willie Maree
Technical manager

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APPENDIX D: ETHICAL APPROVAL

NOTICE OF APPROVAL

REC: Social, Behavioural and Education Research (SBER) - Initial Application Form

14 October 2019

Project number: 10813

Project Title: Performance indicators and success factors of the South African men's rugby sevens team during the 2017/2018 HSBC World Rugby Sevens Series

Dear Mr Eben Opperman

Your REC: Social, Behavioural and Education Research (SBER) - Initial Application Form submitted on 21 August 2019 was reviewed and approved by the REC: Humanities.

Please note the following for your approved submission:

Ethics approval period:

Protocol approval date (Humanities)	Protocol expiration date (Humanities)
14 October 2019	13 October 2022

GENERAL COMMENTS:

Please take note of the General Investigator Responsibilities attached to this letter. You may commence with your research after complying fully with these guidelines.

If the researcher deviates in any way from the proposal approved by the REC: Humanities, the researcher must notify the REC of these changes.

Please use your SU project number (10813) on any documents or correspondence with the REC concerning your project.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

FOR CONTINUATION OF PROJECTS AFTER REC APPROVAL PERIOD

Please note that a progress report should be submitted to the Research Ethics Committee: Humanities before the approval period has expired if a continuation of ethics approval is required. The Committee will then consider the continuation of the project for a further year (if necessary)

Included Documents:

Document Type	File Name	Date	Version
Budget	Budget	28/06/2019	V1
Default	SARU permission	28/06/2019	v1
Research Protocol/Proposal	Protocol Eben Opperman FINAL answerd	20/08/2019	V2

If you have any questions or need further help, please contact the REC office at cgraham@sun.ac.za.

Sincerely,

Clarissa Graham

REC Coordinator: Research Ethics Committee: Human Research (Humanities)

*National Health Research Ethics Committee (NHREC) registration number: REC-050411-032.**The Research Ethics Committee: Humanities complies with the SA National Health Act No.61 2003 as it pertains to health research. In addition, this committee abides by the ethical norms and principles for research established by the Declaration of Helsinki (2013) and the Department of Health Guidelines for Ethical Research: Principles Structures and Processes (2nd Ed.) 2015. Annually a number of projects may be selected randomly for an external audit.*

Investigator Responsibilities

Protection of Human Research Participants

Some of the general responsibilities investigators have when conducting research involving human participants are listed below:

1. Conducting the Research. You are responsible for making sure that the research is conducted according to the REC approved research protocol. You are also responsible for the actions of all your co-investigators and research staff involved with this research. You must also ensure that the research is conducted within the standards of your field of research.

2. Participant Enrollment. You may not recruit or enroll participants prior to the REC approval date or after the expiration date of REC approval. All recruitment materials for any form of media must be approved by the REC prior to their use.

3. Informed Consent. You are responsible for obtaining and documenting effective informed consent using **only** the REC-approved consent documents/process, and for ensuring that no human participants are involved in research prior to obtaining their informed consent. Please give all participants copies of the signed informed consent documents. Keep the originals in your secured research files for at least five (5) years.

4. Continuing Review. The REC must review and approve all REC-approved research proposals at intervals appropriate to the degree of risk but not less than once per year. There is **no grace period**. Prior to the date on which the REC approval of the research expires, **it is your responsibility to submit the progress report in a timely fashion to ensure a lapse in REC approval does not occur**. If REC approval of your research lapses, you must stop new participant enrollment, and contact the REC office immediately.

5. Amendments and Changes. If you wish to amend or change any aspect of your research (such as research design, interventions or procedures, participant population, informed consent document, instruments, surveys or recruiting material), you must submit the amendment to the REC for review using the current Amendment Form. You **may not initiate** any amendments or changes to your research without first obtaining written REC review and approval. The **only exception** is when it is necessary to eliminate apparent immediate hazards to participants and the REC should be immediately informed of this necessity.

6. Adverse or Unanticipated Events. Any serious adverse events, participant complaints, and all unanticipated problems that involve risks to participants or others, as well as any research related injuries, occurring at this institution or at other performance sites must be reported to Malene Fouche within **five (5) days** of discovery of the incident. You must also report any instances of serious or continuing problems, or non-compliance with the REC's requirements for protecting human research participants. The only exception to this policy is that the death of a research participant must be reported in accordance with the Stellenbosch University Research Ethics Committee Standard Operating Procedures. All reportable events should be submitted to the REC using the Serious Adverse Event Report Form.

7. Research Record Keeping. You must keep the following research related records, at a minimum, in a secure location for a minimum of five years: the REC approved research proposal and all amendments; all informed consent documents; recruiting materials; continuing review reports; adverse or unanticipated events; and all correspondence from the REC

8. Provision of Counselling or emergency support. When a dedicated counsellor or psychologist provides support to a participant without prior REC review and approval, to the extent permitted by law, such activities will not be recognised as research nor the data used in support of research. Such cases should be indicated in the progress report or final report.

9. Final reports. When you have completed (no further participant enrollment, interactions or interventions) or stopped work on your research, you must submit a Final Report to the REC.

10. On-Site Evaluations, Inspections, or Audits. If you are notified that your research will be reviewed or audited by the sponsor or any other external agency or any internal group, you must inform the REC immediately of the impending audit/evaluation.