The impact of law changes on match loads in university rugby union players during the FNB Varsity Cup

A dissertation presented to the

Faculty of Health Sciences, University of Johannesburg, as fulfilment for the M.Phil. degree in Sport Sciences by

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Declaration

I declare that this thesis is my own, unaided work. It is being submitted for the Degree of Master of Philosophy in Sport Science at the University of Johannesburg, Johannesburg. It has not been submitted before for any degree or examination in any other University.

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Abstract

Rugby union is played at a high intensity making it an appealing sport for spectators to watch. Law changes have been implemented to make the sport more competitive, to create continuity in the sport and to improve the enjoyment factor for the players and spectators. First National Bank (FNB) Varsity Cup Rugby have strived to be innovative by introducing new law variations and strives to make a difference in sport. The aim of this study was to determine the effect that the law changes implemented and match situational variables in the FNB Varsity Cup Rugby during 2016 until 2018 had affected the players' external load during match play.

This study followed a longitudinal retrospective quantitative research design using secondary data from a university rugby union team. A total of 61 players' external match load was captured on the Catapult Optimeye X4 micro-technology devices. The data was analysed and compared to each season's data with reference to the law changes implemented during each season and match influencing factors such as match outcome, match location and quality of opponent. The tests done for the results of this research include independent t-tests, ANOVA, two-way ANOVA and Tukey HSD post-hoc analysis.

The players' total distances, high-speed running distances and PlayerLoad were more affected compared to other variables during the three seasons. The front row forwards covered the most distances in 2016 (4317±2017m) when compared to the other seasons, while the back-row forwards and inside backs had higher running distances in 2017 (4554±1787m; 5566±1852m). Whereas, the outside backs ran larger distances in the 2018 season (6337±737m).

The backline players ran larger total distances than the forwards did during match play. Additionally, when separating the players into position specific groups, they differed in which year they ran more. It is evident that the running metrics of the players varied between each season analysed. This may indicate there is a difference between the seasons because of law variations introduced or amended. The match location and the match outcome also increased the external load when these situational variables change to playing at home and winning matches, respectively.

Key words: rugby union; FNB Varsity Cup; law variations; match load

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ABBREVIATIONS

FNB: First National Bank

GPS: Global Positioning System

RPE: Session rating of perceived exertion

RHIE: Repeated high-intensity effort

FRF: Front-row forward

BRF: Back-row forward

IB: Inside back

OB: Outside back

ANOVA: One-way analysis of variance

ES: Effect size

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

The worldwide popularity of rugby union is growing exponentially (Eaves, Lamb, & Hughs, 2008). Law changes have been introduced to improve the excitement and enjoyment of matches for both players and spectators (Eaves *et al.,* 2008; Kraak, 2015). As a result, teams have introduced new match strategies and tactics, which may result in changes in the demands on players (Kraak, 2015). Coaches need to ensure that their players are in optimal condition for competitions, and developing a deep understanding of the loads and physical demands that their players experience may guide coaches in prescribing relevant training regimes, as well as improving their effectiveness (Flanagan, O'Doherty, Piscione, & Lacome, 2017).

Rugby union is widely known for being intense and physically demanding in comparison to other team contact sports (Lacome, Carling, Hager, Dine, & Piscione, 2018). It is considered a high-intensity intermittent sport, involving periods of intense static exertions and collisions, with bouts of high intensity followed by incomplete recovery throughout a match (Cahill, Lamb, Worsfold, Headey, & Murray, 2013; Duthie, Pyne, & Hooper, 2003; Roberts, Trewartha, Higgitt, El-Abd, & Stokes, 2008). The sport's physical nature creates the need for consistent monitoring of players, as well as sport-specific conditioning for their well-being, health and performance (Kraak, 2015; Quarrie & Hopkins, 2007; van Rooyen, Rock, Prim, & Lambert, 2008).

In South Africa, the First National Bank (FNB) Varsity Cup rugby union competition occurs annually. It involves nine university rugby union teams from around the country. This competition has become an innovative and stimulating league in terms of ideas and match play in the sport. Eleven new laws have been introduced since 2015 in an attempt to promote attacking rugby and to speed up the game, creating excitement for both players and spectators (FNB Varsity Cup, 2018). After each season, the coaches, referees, the South Africa Rugby Union (SARU) and others involved in the competition work together to determine which law variations did or did not achieve expectations in terms of improving the flow of the game. These decisions lead to new ideas for improving the competition or to the discontinuation of some laws deemed ineffective (SA Rugby Referees Department, 2018).

Since rugby union became professional, research has aimed at improving the sport and maximising the performance of players (Quarrie, Hopkins, Anthony, & Gill, 2013; Schoeman & Schall, 2019; Vaz, Mouchet, Carreras, & Morente, 2011). Additions and changes to the rules of the sport have been shown to increase the external load of high-intensity activities and sprinting frequency (Austin, Gabbett, & Jenkins, 2011). Additionally, playing against a stronger opposition results in larger external loads, and the match location and outcome have been shown to affect the manner in which teams perform (Jones, Mellalieu, & James, 2004; Lago, Casais, Dominguez, & Sampaio, 2010; Vaz, Carreras, & Kraak, 2012). A match's influencing factors have resulted in coaches developing training regimes and monitoring systems for effective and practical preparation of their players (Austin *et al*., 2011).

Laws in rugby are constantly updated to allow the game to grow and develop into a more exciting and enjoyable experience for both players and spectators, as well as improving the safety of players while increasing the competitive nature (Austin *et al*., 2011; Kraak, Welman, Carreras, & Vaz, 2017). In order to develop the sport to achieve its full potential, implementing law variations may improve how it is portrayed and perceived across the world (Arias, Argudo, & Alonso, 2011). Law changes affect how the game is played and therefore affect the physical demands experienced by players (Vahed, Kraak, & Venter, 2014).

1.2 Problem Statement

Rugby union is one of the most popular sports in South Africa (Odhav, 2014). Since the inception of the Rugby FNB Varsity Cup in 2008, several law changes have been introduced to make the game more entertaining and enjoyable (FNB Varsity Cup, 2018). Despite these implementations and amendments, no study has examined the impact of law variations on the external load experienced by university rugby union players in the FNB Varsity Cup competition over several seasons. In addition, there is limited information on the influence of situational variables (e.g., match outcome, strength of the opponents and the match location) on a team's external match load in the FNB Varsity Cup competition.

1.3 Significance of Study

Analysis of the effect of law changes on match running performance among rugby union players may give coaches and trainers valuable information. These findings can assist in understanding how law changes affect the outcomes of the sport. The findings of this study may also help coaches to prioritise the time that players spend on the different performance indicators in their training programmes. Coaches can utilise this research to assist in preparing a programme depending on the importance of these performance indicators for competitive match play. This may improve evaluation of players and teams according to the increased physical demands of the modern game (Kraak, 2015). Monitoring and managing of external loads are vital for coaches and technical teams to ensure that players are fully prepared and well-conditioned for matches, particularly when new laws have been implemented.

1.4 Research Questions

The study conducted an external load analysis on a university team in the rugby union FNB Varsity Cup from 2016 to 2018. This presented the following research questions:

- What are the overall physical demands experienced by rugby union players during matches in the FNB Varsity Cup?

- Do law variations influence the external loads on the entire team in the FNB Varsity Cup?
- Do law variations influence the external loads on players in specific positions in the FNB Varsity Cup?
- What are the effects of the external loads according to influencing factors such as match outcome, match location and the quality of opponents?

1.5 Purpose of Study

The purpose of this study was to enhance understanding and examine the effects of the change of external load experienced by players due to law changes and other match influencing factors during the FNB Varsity Cup between 2016 and 2018.

1.6 Aims and Objectives

The aim of this study was to analyse how new law changes implemented in the FNB Varsity Cup from 2016 to 2018 affected the external loads on players during match play. A secondary aim was to examine how other match influencing factors affect the external loads on players.

The objectives of the study were:

- To analyse the overall match running performance of rugby union players during the Varsity Cup competitions (2016–2018).
- To examine how the law variations have influenced the match running performance of rugby union players in Varsity Cup matches from 2016 to 2018.
- To determine the extent to which the law variations had an impact on the match running performance of rugby union players based on specific positional play during the Varsity Cup competition.
- To assess the influence of match location, match outcome and quality of opposition on match running performance of rugby union players during the Varsity Cup competitions.

1.7 Outline of the Dissertation

The purpose of this research was to examine the external loads on rugby union players in the university competition (FNB Varsity Cup) from 2016 to 2018. With this data, trends were analysed with regards to how match factors such as law variations, match outcome, match location and quality of opponents affected the external loads on players. In Chapter 2, rugby union and training loads are reviewed, with further investigation of the demands of rugby union and the FNB Varsity Cup, and match influencing factors that may affect the external loads on players.

Chapter 3 explains the methodology. It defines the research design, sample size, how the data was collected, the ethical considerations considered and the manner of the data analysis. In Chapter 4, the results are defined and shown in tables. This data shows the external loads on players related to each of the research objectives. Chapter 5 discusses each of the research objectives in order to find trends that may explain the consequences of the match influencing factors. In Chapter 6, I conclude the findings of the study with possible reasons for the outcomes achieved in this research, along with recommendations for future research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews the history of rugby union and underline important facts, which could be valuable to this research. The research context focuses on rugby union and training loads.

2.2 Overview of Rugby Union

Rugby union is one of the most popular sports in the world (Macqueen & Dexter, 2010), played in more than 120 countries, with an estimated 9.6 million players (World Rugby, 2017). The nature of rugby union ranges from low to very high intensities, with high degrees of physical contact (Pollard, Turner, Eager, Cunningham, Cook, Hogben & Kilduff, 2018). It is a game of repeated activities of short duration and high intensity, requiring players to be well conditioned with respect to endurance, speed, agility, power, flexibility and game-specific skills (Flanagan *et al.*, 2017; Thomas & Wilson, 2015). The game also requires aerobic and anaerobic endurance as well as muscular strength (Macqueen & Dexter, 2010).

The history of rugby union cannot be ignored when considering the developments of the sport. Although the sport of rugby union was named and set out in Great Britain in the 1800s, many variations of the sport were played throughout the history of humankind. Different forms of kicking and running games were played over 2000 years ago. Many cultures and countries, such as the Chinese, Greeks and Romans, played sports that showed various characteristics of the modern sport of rugby union. For example, *harpastum*, played by the Romans, involved a game of two teams who had to keep possession of a ball and attempt to carry it forward to a specified goal. In 12th-century France, a game called *la soule* was very popular. It involved a leather ball that teams had to drive towards their opponent's goal using their hands, feet and sticks, showing some characteristics of the modern game of rugby (van der Merwe, 2012).

In Italy during the 15th to 17th centuries, *calcio* was a popular sport played mainly by soldiers, heroes and nobles. The game had two teams of 27 players, all in defined positions with different purposes. Each team had to carry, kick, hit or throw a ball over the opponent's goal line to score. In Great Britain and Ireland, games such as hurling and camp ball had some similar rules to modern-day rugby. The rules of camp ball included forward passes not being permitted, and scrums, line-outs and mauls also featured (van der Merwe, 2012).

In 1835, at Rugby School, the first rules for rugby were formulated and written down. These rules included the dimensions for the posts as well as the manner in which a team achieved victory. If the ball left the pitch, then the larger players, the forwards, would form a line-out to put the ball back into play. The forwards would also run and scrum with the ball, while the smaller players, the backs, would defend the area in front of their goal and kick the ball to their forwards if the ball landed in front of them (van der Merwe, 2012). Rugby union has since become increasingly popular around the world, growing into a well-supported and highly competitive sport (Eaves *et al*., 2008; Green *et al*., 2017).

There are an estimated 9.6 million people around the world playing rugby, in 123 countries. World Rugby, formerly known as the International Rugby Board (IRB), is the sport's governing and law-making body, consisting of 105 member unions and 16 associate unions (World Rugby, 2018). The responsibilities of World Rugby include delivering safe, enjoyable and pleasurable events as well as improving and updating laws as required (Murray, Murray, & Robson, 2012).

There has been an increased level of competition among teams from around the world. There have also been recent expansions of high-level competitions, with the European Cup being redeveloped in 2015, and an expansion of the Super Rugby competition, from 15 to 16 teams, in 2016. These changes demonstrate the progress of the sport, including more teams from different countries, such as Japan and Argentina, in Super Rugby. These developments aim at creating a larger and more diverse audience for the sport through media coverage around the world. In addition, there has also been increased financial investment (Kraak, 2015).

Since rugby union became professional in 1995 (Quarrie *et al.*, 2016), it has evolved into a faster, more dynamic and physically demanding sport (Quarrie & Hopkins, 2007; van Rooyen *et al.*, 2008). If a player lacks sport-specific conditioning, the probability of injury increases due to the high external loads during a competitive match (Kraak, 2015). Since the sport became professional, there has been an increase in physical contact and the demands made of players during matches, and the establishment of complex tactics has had visible effects on the manner in which players must perform (Kraak, 2015; Quarrie *et al*., 2016). In rugby union, each team begins play with 15 players on the field, as shown in Figure 1. They are divided into eight forwards and seven backline players. The positions can be further divided into front-row forwards (hooker, props and locks), back-row forwards (flankers and number 8), inside backs (scrum half, fly half and centers) and outside backs (wings and full back). Each game comprises two halves of 40 minutes each, separated by a half-time interval of 10 minutes (Kraak, 2015).

Figure 1: Positions in Rugby Union (Cros, 2013, p. 3)

2.3 Overview of Training Load

In an elite sporting environment, there is an eagerness for players to acquire an optimal condition for competition (Kiely, 2016). Accordingly, top sports teams have introduced specific daily practices and procedures (Akenhead & Nassis, 2016). These procedures aim to maximise training programmes whilst minimising the risk of injuries, illness and non-functional overreaching (Kiely, 2016; Williams *et al.*, 2017). Training causes stress to the body with the intention of improving physical conditioning (Kiely, 2016). These stresses create a stimulus which disrupts the homeostasis in an athlete's body, causing adaptation to the stimulus by recovering after the training session (Borresen & Lambert, 2009; Soligard, Schwellnus, Alonso, Bahr, Clarsen, Dijkstra, Gabbett, Gleeson, Hägglund, Hutchinson, Janse van Rensburg, Khan, Meeusen, Orchard, Pluim, Raftery, Budgett, & Engebretsen, 2016). The stresses of several training sessions will improve the efficiency of the central nervous system and help the body to acclimatise. This can be achieved by ensuring that training load and recovery are balanced so that players can be physiologically stimulated and experience the correct recovery to fully adapt to the stimuli (Borresen & Lambert, 2009).

The term 'load' is broad and has various meanings, including external stressors and internal stressors, which is the work done by the player and the association and physiological response of the player, respectively (Akenhead & Nassis, 2016). Monitoring of the training load allows coaches to determine ways to improve players' optimal performance while reducing injury risk. The training load can be measured and categorised into a broad spectrum of internal and external loads (Bourdon, Cardinale, Murray, Gastin, Kellmann, Varley, Gabbett, Coutts, Burgess, Gregson & Cable, 2017). External loads, which are the most commonly used variables for monitoring match and training loads, are objective measures of the work performed by a player during training and competition (Bourdon *et al.*, 2017). These metrics can be physically monitored and evaluated by the coach in real time using Global Positioning System (GPS) micro-technology devices. GPS devices use satellites to track a player during exercise to determine when the player is in optimal physical condition (McLellan, Coad, Marsh, & Lieschke, 2013). External loads that can be monitored include training frequency, distance, power output, speed, accelerations, decelerations, high-speed running, energy expenditure and metabolic power.

Internal loads, which are not as extensively assessed, are physiological and psychological stressors that have been imposed on an athlete during training, competition and in their personal lives (Bourdon *et al.*, 2017). Several methods exist to assess the internal loads on an athlete. These include measuring the session rating of perceived exertion (RPE), heart rate, the training impulse (TRIMP), physiological and sleep assessments, and questionnaires to determine mood states, recovery scales and daily analysis of the athlete's life demands (Halson, 2014). Sport science practitioners and coaches view training, performance, fitness, and monitoring of injuries as forming a critical relationship that should be taken into account (Gabbett, 2016). In Figure 2, the hypothetical relationships between team fitness, performance and injuries and the training load experienced are shown. Inadequate or excessive training may lead to increased injuries, reduced fitness and overall poor team performance (Orchard, 2012).

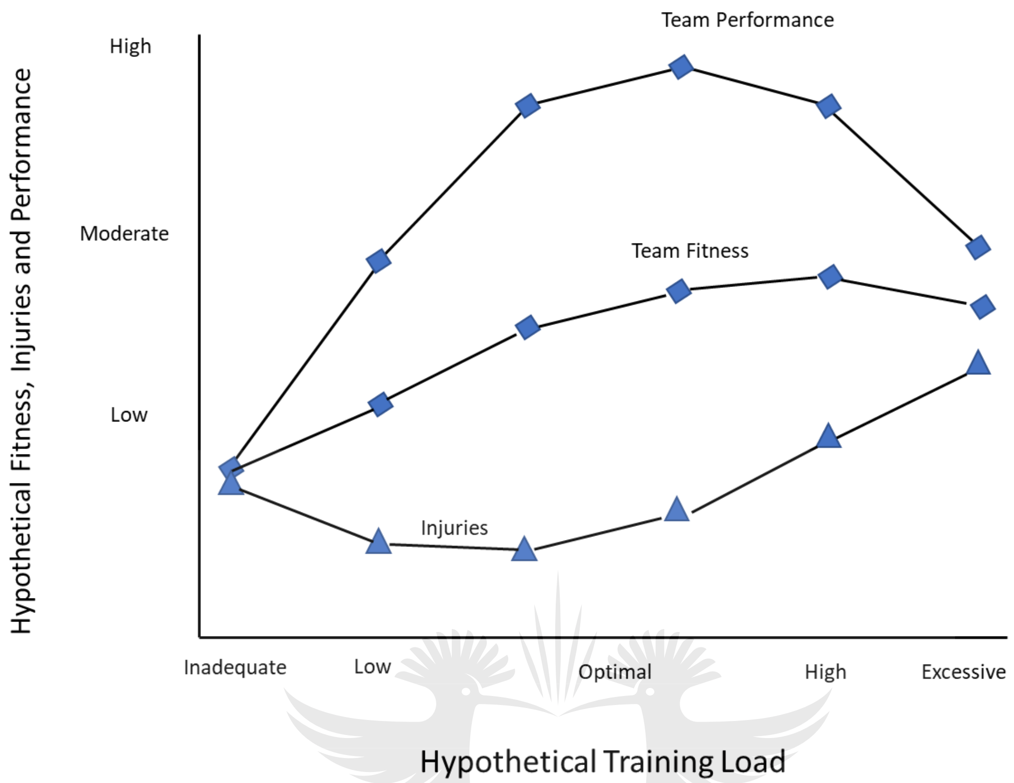

Figure 2: Hypothetical relationship between training loads, fitness, injuries and performance (Gabbett, 2016, p. 2).

In 2003, Impellizzeri presented at a session of the Eighth Annual Congress of the European College of Sport Science in Salzburg, Austria (Impellizzeri, 2003). This presentation focused on looking at the taxonomy of training stimuli, including the terms and concepts of external and internal loads related to team sports (Impellizzeri, 2003; Impellizzeri, Marcora, & Coutts, 2019). Several models and ideals have been formulated to track and further understand players' workloads (Impellizzeri *et al.*, 2019; Murray, Gabbett, Townshend, Hulin, & McLellan, 2016). One method is to utilise rolling averages to assess training and match loads with the acute:chronic workload ratio (ACWR). This extension of a training load model has expanded on Banister's model (Banister, Calvert, Savage, & Bach, 1975), which concentrates on the fitness–fatigue relationship (Coyne, Haff, Coutts, Newton, & Nimphius, 2018).

The ACWR has limitations in how the training load is calculated for external load metrics. There is no correct length of the acute or chronic periods, ultimately showing different results when using different periods (Coyne *et al.*, 2018). Additionally, this method overlooks certain aspects of training, which will affect the results as well as the goal of implementing the optimal training load prescription for players (Menaspà, 2016). The latest proposed application uses 'exponentially weighted moving averages (EWMA)', which account for the decaying nature of fitness and fatigue effects that will occur over time (Williams *et al.*, 2017). However, even with this addition of decaying fitness and fatigue in the EWMA model, there is still debate over what the length of the acute and chronic periods should be (Coyne *et al.*, 2018; Fanchini, Rampinini, Riggio, Coutts, Pecci, & McCall, 2018; Impellizzeri *et al*., 2019; Williams *et al.*, 2017). Different period time periods result in varied relationships with injury risk of players. This may guide training load periods to differ between different sports depending on the competition periods or time required to return from injury (Carey, Blanch, Ong, Crossley, Crow, & Morris, 2016). When considering the training load, the ACWR can be utilised to improve performance while also reducing injury risk (Blanch & Gabbett, 2015). The amount of days or weeks in the acute and chronic periods must be decided upon to monitor the ACWR (Coyne *et al.*, 2018). Figure 3 suggests that if a player's ACWR is above or below the recommended 0.8:1.3, then there is an increased risk of injury (Gabbett, 2016). This recommendation is a guide for managing and monitoring the external load, rather than using this ratio to try to predict possible injury, and therefore it must not be the only monitoring practice in place (Fanchini *et al.*, 2018). Although the model proposed by Williams *et al.* (2017) takes more factors into account when monitoring training load, it can be argued that there are many other stressors placed upon an athlete which must be taken into consideration, such as internal loads (Bourdon *et al.*, 2017; Soligard *et al.*, 2016).

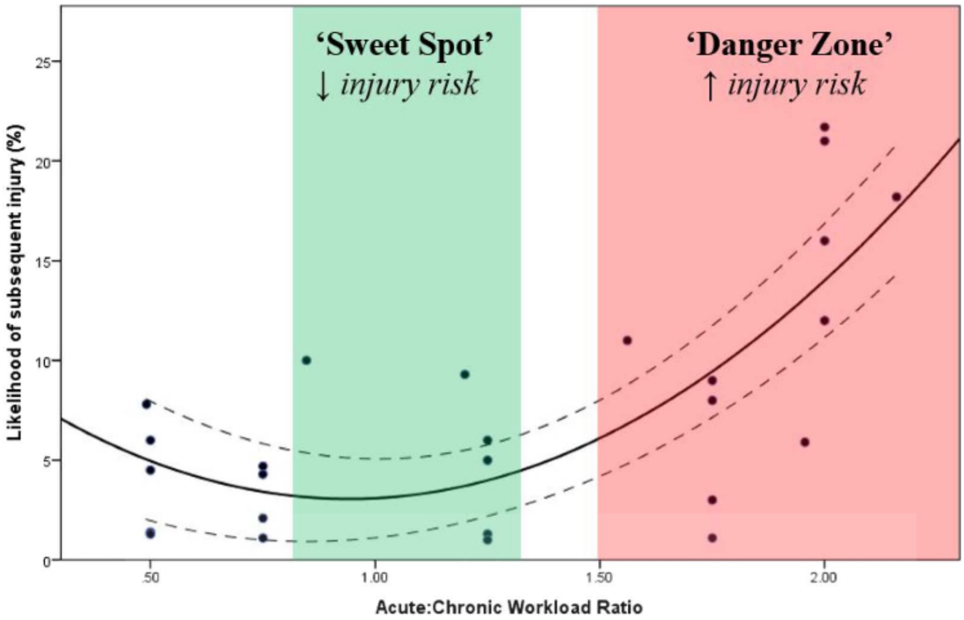

Figure 3: Guide to interpreting and applying acute:chronic workload ratio data (Gabbett, 2016, p. 6).

It is essential for ruby union players to manage the external demands required by match play. Using scientific aids, coaches can optimise the condition of the players (Vahed *et al*., 2014). Coaches are investigating innovative ways to create a competitive edge for their teams by adapting their training programmes into more specific training regimes that meet physical demands of match play (Vahed *et al*., 2014; Kraak, 2015; Eaves *et al*., 2008). Players with high training loads improve their fitness levels, as described in Figure 4. Low training loads may lead to poor fitness, resulting in poor performance and potential injury risk. Adequate training loads decrease the risk of injury to a player's soft tissues. In addition to injury prevention, the player's resultant fitness will be greater than that from a lower training load, thus improving performance. High training loads can lead to an increased risk of soft tissue injuries or fatigue, ultimately leading to players performing poorly or not playing at all (Gabbett, 2016).

Improvements will result in increased physical output and resilience during match play, as well as maximising the selection of players available (Gabbett, 2016). The coach can use this research to assist in preparing conditioning programmes and training. Preparations can further develop understanding of how to utilise individualisation techniques specific to each player and their playing position. Recovery is another critical aspect of training and can be tailored to specific positions. With knowledge of external loads experienced by forwards during match play, the coaches can ensure that forwards have a greater recovery period (Owen, Venter, du Toit, & Kraak, 2015).

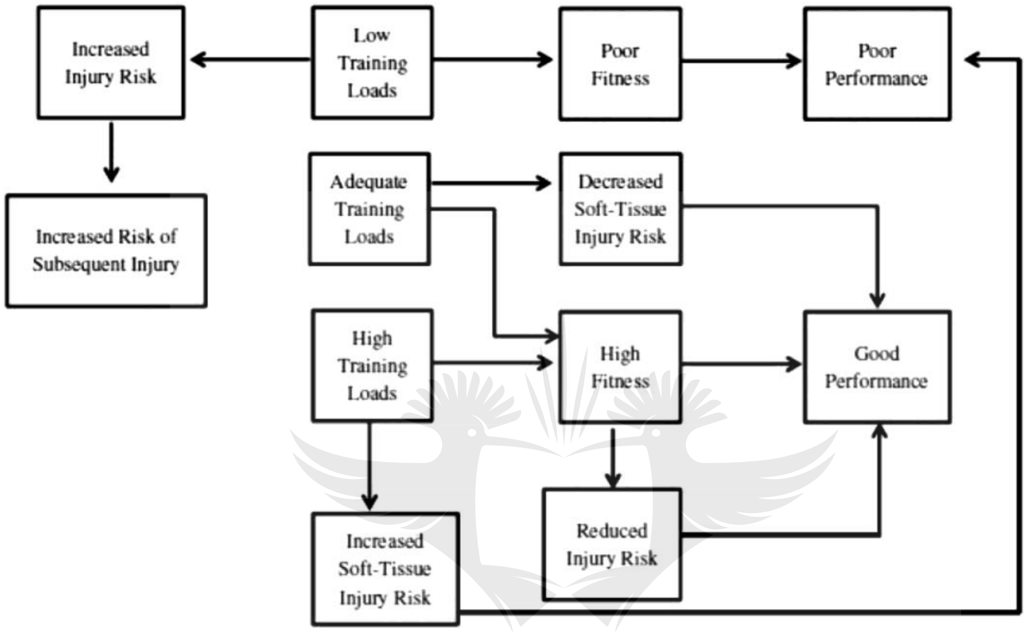

Figure 4: Relationship between physical qualities, training load, and injury risk in team-sport athletes (Gabbett, 2016, p. 7).

2.4 Physical Demands in Rugby Union

In order to accurately determine the training requirements for rugby players to be fully prepared for the high-intensity demands in a game, analysis of the actual physical requirements of players is necessary (Roberts *et al.*, 2008). The physical demands of the sport, such as total distance, high-speed running and accelerations, have increased since the sport became professional (Owen *et al.*, 2015). Thus, the link between external loads on players and the training programmes prescribed by coaches may assist in creating a physical and tactical stimulus, which can be successfully transferred into the match environment (Pollard *et al.*, 2018). Teams in professional as well as non-professional rugby union have assessed match demands. These assessments have shown differences in the teams' external loads

(Austin *et al*., 2011; Flanagan *et al.*, 2017; Lacome *et al.*, 2013; Roberts *et al*., 2008).

When reviewing the physical demands of professional Super 14 rugby during 2008 and 2009, Austin *et al.* (2011) observed that total distances covered by front-row forwards, back-row forwards, inside backs and outside backs were 4,662±659 m, 5,262±131 m, 6,095±213 m and 4,774±1017 m, respectively. This data indicates that the front-row forwards and outside backs covered less total distance than the inside backs. The average total sprinting distance was 501±163 m for the front-row forwards, 547±55 m for the back-row forwards, 918±253 m for the inside backs and 558±282 m for the outside backs. A significant difference was observed between the front-row forwards and the inside backs (Austin *et al*., 2011). Roberts *et al*. (2008) also found that the distances covered by elite English rugby union players from 2002 to 2004 were 5,408 m for front-row forwards, 5,812 m for back-row forwards, 6,055 m for inside backs and 6,190 m for outside backs. These differences may suggest that each position in rugby union has different requirements and roles, resulting in differing demands between the positions (Roberts *et al*., 2008).

When playing rugby union at an international level, it was found that backs (7,227 m) covered greater total distances than forwards (6,680 m) (Cunniffe, Proctor, Baker, & Davies, 2009). However, these results were higher than those reported by McLellan *et al*. (2013), who observed distances of 4,709m and 6,005m for forwards and backs, respectively. Backs were also found to have a higher number of sprints and covered greater distances during high-intensity running (309 m) compared to forwards (93 m) (McLellan *et al.*, 2013). Backs generally had a larger number of accelerations and decelerations at higher speeds than forwards (Owen *et al.*, 2015).

In addition, the total distances of 7944 m and 7006 m covered by French international backs and forwards, respectively, show a difference of nearly 1 km between the two subgroups (Lacome, Piscione, Hager, & Bourdin, 2013). Front-row players covered the least distance, while inside backs and outside backs covered the most, with similar distances between the two. Back-row forwards (7,215 m) covered more distance than front-row forwards (6,935 m), but not as much as inside backs (8,079 m) or outside backs (7,764 m) (Lacome *et al.*, 2013).

Furthermore, in under-18 elite rugby union, it was found that the total running distances for forwards and backs (4,747 m and 5,201 m, respectively) were not vastly different (Roe, Halkier, Beggs, Till, & Jones, 2016). When monitoring rugby union players at university level in England, similar results were obtained to those for players playing at a professional level (Read, Jones, Phibbs, Roe, Darrall-Jones, Weakley & Till, 2017). Forwards had a total distance of 4,683 m and a sprinting distance of 64 m, while backs had a total distance of 5,889 m and a sprinting distance of 353 m (Read *et al.*, 2017). The current study also monitored under-18s, with backs (4,489 m) having a slightly greater total distance than forwards (4,232 m); however, the sprinting distance was significantly greater for backs (319 m) compared to forwards (94 m) (Read *et al.*, 2017).

Another study by Read *et al.* (2017) found that relative distance and high-speed running among under-20s and under-18s were both greater for backs compared to forwards. However, backs completed less low-speed running compared to forwards during match play for the under-18s, while the difference was unclear in the under-20s. This is likely due to the different roles of the two positions (Reardon, Tobin, & Delahunt, 2015). Furthermore, back-row forwards were found to be more similar to backs than to front-row forwards in terms of their running activity throughout a match (Flanagan *et al.*, 2017). When reviewing and comparing specific positions in junior international rugby union, props and hookers had very similar total distances of 3,944±847 m and 3,984±683 m, respectively. These were the lowest totals compared to the other positions, with locks running a distance of 4,712±1022 m. The distance covered by back-row forwards (5,224±1041 m) was more similar to that covered by backs than that of their forward counterparts. Outside backs ran the furthest (6,209±715 m), and centres (5,791±874 m) ran more than the scrum half (5,422±685 m) and fly half (5,250±747 m) (Flanagan *et al.*, 2017).

Furthermore, the high-speed running during match play was higher for outside backs (514±153 m) and centres (363±120 m) than for the fly halves (123±29 m) and scrum halves (191±80 m) (Flanagan *et al.*, 2017). Back-row forwards (153±65 m) again ran distances closer to that of backs than forwards. However, hookers ran larger distances (88±88 m) at high speed compared to props (44±42 m) and the second row (55±66 m). The number of accelerations was significantly higher among backs compared to forwards. Fly halves, scrum halves, centres and outside backs had similar numbers of accelerations to one another, while props, hookers and the second row had the least numbers. Back-row forwards were found to make the greatest number of accelerations compared to all other positions (Flanagan *et al.*, 2017).

2.5 Overview of the FNB Varsity Cup

The First National Bank (FNB) Varsity Cup, is an annual South African university rugby tournament, involving the top nine rugby union universities from across the country (FNB Varsity Cup, 2018). This competition began in 2008 when eight universities worked together and formed the FNB Varsity Cup for rugby union. In 2011, the competition grew larger and a second division was added to allow more universities to participate (News24, 2012). The team that finishes at the bottom of the first-tier table is automatically relegated to the second-tier competition, named the FNB Varsity Shield. The FNB Varsity Cup has become a leading rugby competition in South Africa, with matches watched by crowds in excess of 18,000 spectators (FNB Varsity Cup, 2018).

The FNB Varsity Cup and Shield competitions emphasise the development of South African rugby by introducing a transformation policy, which improves diversity and creates opportunities for players of colour[1] (Sport 24, 2019), while also improving the quality of rugby and the match day spectacle for the spectators. In 2008 additional competitions were added for the under-20 teams (from nine universities), as well as a competition between regional university residences (Koshuis). This occurred during the first year of the FNB Varsity Cup. In the

[1] Refers to black, coloured and Indian people.

Koshuis competition, the teams that qualify top in their local residence leagues qualify for playoffs and finals between universities from across the country (FNB Varsity Cup, 2018).

The Varsity Cup is known for its innovation, creating additional competitions for rugby union in South Africa as well as introducing new law variations to increase the popularity and quality of the sport. The competition also aims to give exposure to the young rugby talent in South Africa, as well as focusing on important social issues faced by universities, the local community and the wider South African population (FNB Varsity Cup, 2018),. These include a pledge to fight against abuse of women and children by supporting causes and donating money to shelters (Varsity Cup, 2017). In addition, the FNB Varsity Cup collaborates with the South African National Blood Association to bring in more blood donations at universities (Rekord East, 2018).

Within the FNB Varsity Cup competition, there have been significant developments in terms of adding new laws aimed at improving the quality of rugby and creating a better atmosphere for the spectators in the stadium and at home. The Varsity Cup has been innovative by introducing new law variations and trying to make a difference to the game of rugby union across the globe. The law variation allowing an additional player for the match-day squad (23 players) has been a success, with World Rugby subsequently introducing it for all rugby union competitions across the world (FNB Varsity Cup, 2018). Some of the new laws and law variations have focused on creating more space and speeding up the game. Additionally, controlling the rucks as well as foul play and the transition to a maul from a lineout have become focal points for improvement (SA Rugby Referees Department, 2018). Since 2015, an additional 10 laws have been introduced aimed at developing the competition and sport (FNB Varsity Cup, 2018).

2.6 Law Variations

In an attempt to become more competitive and remain attractive to spectators, the sport has undergone a variety of law changes (Duthie *et al.*, 2003; Kraak, 2015).

These changes and amendments also aimed to promote game continuity, enhance player safety, improve player performance, enhance the appeal of the sport, increase the use of technology such as the Television Match Official (TMO), and maintain the game's integrity and ethics (Eaves *et al*., 2008; Kraak, 2015). Rule changes help to sustain the viability of contact sports, developing them to reach their full potential. This potential not only concerns players becoming better, faster and stronger in order to become the best players they can, but also involves how the sport is portrayed and how the spectators react (Kew, 1987; Vahed *et al*., 2014; van den Berg & Malan, 2012; Wright, 2014).

The continuity of match play has been improved due to various law changes (Kraak, Coetzee & Venter, 2017). The amount of time with the ball in play has increased, with passages of play becoming quicker and more frequent as a result of ball recycling (Eaves & Hughs, 2003; Williams, Hughes, & O'Donoghue, 2005). In addition, there has been an increase in the frequency of high-intensity activities, with an increase in sprinting during matches in subsequent seasons indicating constant increases in external loads (Austin *et al*., 2011). With these law changes occurring within the sport, coaches and trainers must adapt in terms of recognising the physical demands on their team, thus allowing them to improve performance and gain any competitive edge over their opponents wherever possible. An effective way to gain this competitive advantage is to analyse and understand the effects of the law changes (Eaves & Hughs, 2003).

The introduction of new laws or amendments may affect the external loads on players during match play. Different tactics and strategies resulting from law changes have led to players having improved strength, speed, and physical conditioning in order to adapt to increased external loads (Vahed *et al*., 2014). These expectancies and changes in external loads on the players during match play are rarely evaluated (Eaves *et al*., 2008). Without proper conditioning, fatigue or injuries may result (van den Berg & Malan, 2012).

As law variations are made effective in match play, the match profile is affected (Kraak, 2015). After the 2011 Rugby World Cup, new and varied laws were introduced to rugby union in all competitions (International Rugby Board, 2012). These include the referees consulting the Television Match Official (TMO), changes to the outcome of a knock-on or forward throw into touch, and different penalty and free kick options and requirements, which have all increased total match time (Vahed, Kraak, & Venter, 2016). Other law variations such as that addressing an unsuccessful end to a ruck reduced ruck and maul times, increased the tackle time, reduced individual phase activity due to the risk of a penalty, and committing more players to defence (Kraak *et al.*, 2017). The addition of a quick throw-in increased match stoppage time and reduced line-out time (International Rugby Board, 2012; Vahed *et al*., 2016). Vahed *et al.* (2016) found that the amount of time with ball in play decreased because of law variations introduced during different time periods, which affects the external loads placed on players during matches.

A comparison of the 2006 and 2008 Super Rugby seasons found that the number of scrums and line-outs decreased significantly, while tackles made, metres gained, and penalties conceded all increased significantly (van den Berg & Malan, 2012). These changes in the match profiles can be directly correlated with effective law variations introduced between these seasons for the competition. These laws restricted the opposition backline to a 5-metre offside line on defence, encouraging the attacking team not to kick the ball directly into touch and also encouraging quick and safer throw-ins instead of lineouts, thus restarting the game quicker (van den Berg & Malan, 2012). However, there may be other reasons for these changes, such as professional players having increased time in which to practise their skills training, which decreases the likelihood of handling errors and other unforced errors (Quarrie & Hopkins, 2007). The amount of time with ball in play also increased – by 33% from 1995 to 2011. This indicates the changes in how the sport is played and the expectations of players' preparations in order to be able to cope and excel in the modern game (International Rugby Board, 2011).

Whether a team is playing at a professional or recreational level, there is a constant need for a competitive edge by maximising individual and team performances (Kraak, 2015). World Rugby granted permission to the Varsity Cup to amend the mode of scoring in the competition to create a try-scoring culture and improve the competition for spectators (Kraak *et al.*, 2017). The match profile of university rugby in South Africa was examined from 2011 to 2012 by Kraak *et al*. (2017), who also investigated the effect of law changes on the performance of players (Kraak *et al.*, 2017). There were significant differences between the two seasons that were examined regarding scoring: in 2012, there were more tries and conversations compared to the 2011 season, as well as a decrease in penalties and drop goals (Kraak *et al.*, 2017).

When introducing new laws to a competition, the physical effects on players are rarely evaluated (van den Berg & Malan, 2012). The IRB introduced studies to assess players' experiences of these changes in order to decrease injuries and increase interest among spectators (van den Berg & Malan, 2012). These evaluations can assist in understanding the physical profile of rugby union. However, a larger variety of research has examined the technical and tactical changes as a result of law variations in rugby union (Vahed *et al*., 2014; Wright, Atkins, & Jones, 2012).

To understand how the law variations have affected external loads on players, the findings associated with the implemented variations must be examined and reviewed (Wright, 2014). In the 2016 season of the FNB Varsity Cup, the 'point of origin' law variation was implemented. According to this law, teams were awarded more than the usual 5 points for a try if they started running from their own half of the field. Teams scored 9 points if they ran from their own 22 m line and 7 points if they scored from between their own 22 m line and the opposition 22 m line. Subsequently, in 2017, the law was changed, with teams running from their own half and scoring a try receiving 7 points. This amendment was aimed at promoting attacking rugby and encouraging teams to hold onto possession instead of kicking it away. Although this law positively influenced teams to reconsider their attacking options and speed up the game, there was immense confusion for the players and spectators due to its complexity (FNB Varsity Cup, 2018; SA Rugby Referees Department, 2018). Despite this confusion, no changes to the law took place during the 2019 season.

Furthermore, in the 2018 season of the FNB Varsity Cup, two new laws were added: the ‘power play’ and the ‘strategy break’. The power play enables a team to choose two backline players from the opposition team to be removed from the game for 3 minutes of playing time. Each team can use a power play only once in a match, and if the below-strength team scores a try during this period, they will receive two additional points for that try. This law was added to create excitement and to create new talking points about the sport. A survey of spectators showed that the majority of the audience enjoyed the idea of this law, as they felt excited by the attacking opportunities that could be created in the game (FNB Varsity Cup, 2018). Increased attacking opportunities were anticipated as a result of the law change, but only 23 tries were scored after 77 power play periods (SA Rugby Referees Department, 2018). The strategy break enables coaches to re-evaluate their tactics during the halves, as well as allowing a water break for the players. These breaks occur between the 18th and 22nd minutes of each half, and each break lasts for a total of 2 minutes. Coaches, technical staff, medical personnel and players all support this law. Additionally, the atmosphere at the matches improves as activities and spectator interviews are conducted on the field during these breaks (FNB Varsity Cup, 2018). Law variations introduced in the FNB Varsity Cup from 2015–2018 are reviewed in Appendix A.

2.7 The influence of situational variables on match running performance

In rugby union, situational and contextual variables influence match-running performance of players during a match. This research discusses the following situational variables: match location, quality of the opposition, and match outcome. Due to the paucity of information on match running distance in rugby union, this section refers to other sports such as soccer and hockey.

2.7.1 Match location

Match location refers to a team playing at home or an away venue (Kubayi & Toriola, 2019). A previous study conducted by Aquino, Munhoz Martins, Palucci Vieira, and Menezes (2017) found that when considering a soccer team's external loads during a match, the players ran further distances at their home venue compared to when playing away. In rugby union, teams were found to have greater success when playing at their home ground compared to when playing away (Cunniffe, Morgan, Baker, Cardinale, & Davies, 2015; Kerr & van Schaik, 1995; Kraak et al., 2017). In addition, players' psychological state is better when playing at home (Terry, Walrond, & Carron, 1998; Vaz *et al*., 2012), and research has shown that home-field advantage results in different effects and outcomes (Carron, Loughhead, & Bray, 2005; Pollard, 2006; Vaz *et al*., 2012). In other sports such as hockey, crowd density at matches has a major influence on the home advantage (Cunniffe *et al.*, 2015; Pic & Castellano, 2017). Players may feel intimidated when playing away from home, which is demonstrated by their increased cortisol levels (Cunniffe *et al.*, 2015). Possible reasons underpinning 'home advantage' may include, but not are limited to, crowd effects, familiarity with the field, psychological factors, territoriality and specific tactics associated with playing at the home ground (Carling, Williams, & Reilly, 2005; Pollard, 2008; Pollard & Pollard, 2005).

2.7.2 Quality of the Opposition

Similar to previous research, the quality of the opposition was defined by the final league positions of each team in the current study (Abbott, Brownlee, Harper, Naughton, & Clifford, 2018; Varley, Gregson, McMillan, Bonanno, Stafford, Modonutti, & d Di Salvo, 2016). Therefore, a team was classified as stronger if it finished higher than the other team in the final log of that season, and classified as weaker if it finished lower (Abbott *et al.*, 2018; Varley *et al.*, 2016). Playing against a stronger opponent may influence the physical demands on the players (Lago *et al.*, 2010). The psychological state of teams playing against more evenly matched opponents is better than when playing against teams that are considered better (Vaz *et al.*, 2012). In contrast to the match outcome and location, the quality of the opposition had less of an effect on the psychological and physical well-being of the players (Abbott *et al.*, 2018). When playing against stronger opponents in football, players covered greater distances and performed more high-intensity activities compared to playing against weaker opposition. This could be attributed to the fact that the team may have to attempt to surprise the opposition and change their tactics to be successful against strong opposition (Aquino *et al.*, 2017; Rampinini, Coutts, Castagna, Sassi, & Impellizzeri, 2007).

2.7.3 Match Outcome

Factors influencing the match outcome (i.e., whether the team wins or loses) may enable coaches to find weaknesses or strengths within their teams when considering their team's performance during match play (Vaz *et al.*, 2011). There is a paucity of research that considers how the match outcome affects the physical demands on players. However, it has been shown that there are statistical and practical differences due to the result of the match (Aquino *et al.*, 2017; Ortega, Villarejo, & Palao, 2009). The match outcome in rugby union 7s was found to have no correlation with the external loads on the players (Blair, Body, & Croft, 2017). In elite soccer, when the match outcome is a win, attacking players have increased total distances, while defensive players run less (Andrzejewski, Konefał, Chmura, Kowalczuk, & Chmura, 2016). The sprinting distance of soccer players appears to increase when the team wins a match as compared to the distance when losing or drawing (Andrzejewski, Konefał, Chmura, Kowalczuk, & Chmura, 2017). Higher-intensity actions increase during wins compared to losses, but the total distance covered shows no significant difference between winning and losing (Bradley & Noakes, 2013).

2.8 Summary

This review has examined several topics, that may develop a greater understanding of this research. An extensive history and evaluation of the sport of rugby union was presented, as well as an understanding of training loads on athletes. The high physical demands during a rugby union match were outlined, as well as the history and ideals of the FNB Varsity Cup, a South African rugby union competition. The rules of the competition influence the manner in which a match is played, and we see teams performing differently when in different match situations, such as different match locations and against different quality opponents. Teams also perform differently when they have different match outcomes. The next chapter presents the manner in which the research was conducted, and the information used to determine the results of each objective of the study.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The research methodology is presented in this chapter. The design of the study is firstly described based on the questions and objectives of the research. Next, the size of the sample from which the data was collected is discussed. The considered performance indicators are also discussed, along with the instrument used to capture the data and, finally, the ethical considerations made during the study.

3.2 Research Design

This study used a longitudinal retrospective quantitative research design. This approach can be defined as research in which: (a) data are collected for each item or variable for two or more distinct periods; (b) the subjects or cases analysed are the same, or at least comparable, from one period to the next; and (c) the analysis involves some comparison of data between or among periods (Menard, 2002). The research conducted used data examining the relationship among variables, which may have a direct effect on one another. The independent variables in this research are the law variations, as well as situational variables (quality of opposition, match outcome and match location) that occur during each season of the competition. The external load on the players is the dependent variable, as this is the outcome that changes due to the law variations and match observations.

3.3 Sample Size

A sample refers to a group of people, objects or items which represent the population or a representative part of the population, chosen to ensure we can generalise the findings of the research (Mujere, 2016). The sample consisted of 61 male players from a university rugby union team that participated in the FNB Varsity Cup competitions from 2016 to 2018. The players were grouped according to general (i.e., backs, n = 28; forwards, n = 33) and specific (front-row forwards, n = 17; back-row forwards, n = 16; inside backs, n = 19; outside backs, n = 9) positions. The hookers were measured with the back-row forwards due to their wandering style of play (Duthie, Pyne, & Hooper, 2005).

3.4 Performance Indicators

The performance indicators consisted of three situational variables (i.e., match outcome, game location and quality of opposition) and dependent variables (i.e., match running performance). The dependent variables are various metrics related to external loads, which are shown in Table 3.1. Each metric has a specific use for a coach or trainer to monitor and work towards trying to get the most out of their players. One variable is the total distance covered by each player, and the coach can evaluate the distances covered by players when running within specific velocity bands. The coach can use this information to train players for specific elements and phases of a particular strategy, as well as managing loads in training and matches.

PlayerLoad is a modified vector magnitude, which calculates the magnitude of each acceleration derived from the vertical, medio-lateral and anterior-posterior planes of motion (Weaving, 2016). This metric expresses arbitrary units of the square root of the sum of the squared instantaneous rates of change in acceleration in each of the three planes of motion and further divided by 100 (Boyd, Ball & Aughey, 2011; Barrett, Midgley & Lovell, 2014; Weaving, 2016). Vector magnitude has been previously used in physical activity research as a proxy for energy expenditure (Levine, Baukol & Westerterp, 2001; Rowlands, Thomas, Eston & Topping, 2004; Fudge, Wilson, Easton, Irwin, Clark, Haddow, Kayser & Pitsiladis, 2007). This method is used to monitor a player's full energy expenditure during a session of exercise, and its measurement is critical. Some players will not play a full game, as they are substituted on or off, and therefore the relative distance covered is an indispensable metric for comparison when taking into consideration how long each player played during a match (Weaving, 2016).

Table 3.1: Summary of metrics

Metric	Unit of measurement
Total distance	Metres
Moderate-speed running (7–16 km/h)	Metres
High-speed running (16–20 km/h)	Metres
Very high-speed running (20–25 km/h)	Metres
Sprint distance (>25 km/h)	Metres
Relative distance	m.min²
PlayerLoad™	-
PlayerLoad™ (slow)	-
RHIE	Volume
Accelerations	Volume

3.5 Data Collection

The instrument used to collect the data during a match was the Catapult Optimeye X4 micro-technology device (Catapult Innovations, Melbourne, Australia), which was worn by each player and was positioned in between the scapulae in a tight vest (Creswell, 2009). Various metrics were obtained during each match. The data shows each player's metrics from each match they played in during the three seasons examined. This information was stored in a excel database by the sport scientist of the team who worked at the team throughout the duration of this research. In 2016, 177 matches played by the players were observed while 186 and 199 matches were analysed in 2017 and 2018 respectively. Furthermore, the data examined 98 matches (54 matches for front-row forwards and 44 matches for back-row forwards) for forwards in 2016, 107 matches (52 matches for front-row forwards and 55 matches for back-row forwards) in 2017 and 114 matches (63 matches for front-row forwards and 51 matches for back-row forwards) in 2018. When assessing the backs, they were found to play 79 matches (45 matches for inside backs and 34 matches for outside backs) in 2016, 79 matches (52 matches for inside backs and 27 matches for outside backs) in 2017 and 85 matches (58 matches for inside backs and 27 matches for outside backs) in 2019.

The Optimeye X4 has shown good levels of accuracy and reliability for distance and speed measures during intermittent exercise bouts involving high-intensity actions. The tri-axial accelerometer in the Optimeye X4 has also shown satisfactory levels of reliability and validity (Weaving, 2016). The GPS sampling rate within the Optimeye X4 is 10 Hz. This sampling rate has good co-efficient variations (CV) in the intra-unit (CV: <5%) and inter-unit (CV: 0.7–1.3%) during short sprints, total distance (CV = 1.9%), high-speed running (CV = 4.7%) and low-speed running, all of which are essential in team-sport environments (Castellano, Casamichana, Calleja-Gonzalez, San Román, & Ostojic, 2011; Johnston, Watsford, Kelly, Pine, & Spurrs, 2014).

This study analysed the retrospective data to examine how the external loads in match play changed from season to season (2016–2018) with regards to the law variations, determining if these variations had an effect on physical demands. The team as a whole was examined, as were players in various positions, with each position potentially experiencing different effects due to the law variations implemented.

3.6 Ethical Considerations

This study received ethical clearance from the Research Ethics Committee of the University of Johannesburg (Ethics no: REC-01-159-2018). Permission was also granted from the university rugby union team in order to use player data. When considering ethical elements in a study involving human subjects, a researcher should consider beneficence, justice and respect for human dignity (Houser, 2012; Schmidt & Brown, 2009; Polit & Beck, 2012).

3.6.1 Beneficence

The potential harms linked to a retrospective study are much less than those of experimental studies. This is due to the lack of a relationship between the investigator and the participants. The most likely potential harm in a retrospective study is a breach of confidentiality, and therefore the confidentiality of data was comprehensively ensured (National Ethics Advisory Committee, 2012). This data was secured on a password protected computer with only the researcher having access to the files. The results can be positive for the participants and for the sports team as a whole, as their training programme and the manner in which they prepare themselves may increase the readiness of the players for match play (Houser, 2012; Schmidt & Brown, 2009; Polit & Beck, 2012).

3.6.2 Respect for Human Dignity

Anonymity of the participants and confidentiality of their personal information are of utmost importance, as well as respect for their rights. The information collected was not shared with anyone, other than those directly involved in the study (National Ethics Advisory Committee, 2012; Houser, 2012; Schmidt & Brown, 2009; Polit & Beck, 2012). The name of the team and the names of players in the team were not revealed in this study, thus respecting the confidentiality of the subjects.

3.6.3 Justice

The study was conducted with great honesty, integrity and respect for all agreements made. None of the participants' data was judged or treated unequally in this study, and each person was treated fairly (Houser, 2012; Schmidt & Brown, 2009; Polit & Beck, 2012). No biased burden or discrimination was imposed on any particular group during this research, and therefore, no person or group benefitted more from this research (National Ethics Advisory Committee, 2012).

3.7 Statistical Analysis

Statistical analysis is a tool used to find patterns and to determine differences in the data, which are then linked to identify certain relationships between the variables (Lazar, Feng, & Hochheiser, 2017). Data were reported as means and standard deviations. An independent t-test was applied to examine significant differences in game location (i.e., home vs away games), quality of the opposition (stronger vs weaker teams) and general position (i.e., forwards vs backs). One-way analysis of variance (ANOVA) was undertaken to ascertain significant differences based on match outcome (i.e., teams that won, drew and lost) and law variations for particular years (i.e., 2016, 2017 and 2018). Two-way ANOVA was used to examine the interaction between the influence of law variations and playing position on match running performance of rugby union players. Tukey HSD post-hoc analysis was conducted where the F-ratio was significant ($p<0.05$). Effect size (ES) was also used to assess the magnitude of the differences in the mean scores of variables. ES values were interpreted as follows: trivial (<0.20); small (0.20–0.59); moderate (0.60–1.19); large (1.20–2.00); and very large (>2.00) (Hopkins, 2002). All analysis was conducted using IBM SPSS Version 25.

3.8 Summary

A detailed description of the research methodology was presented. The research design, sample size, performance indicators, data collection, ethical considerations and statistical analysis were described in this chapter. The research methodology provides information regarding how the researcher observed the data and how the data were examined to determine the objectives of the research.

These details give insights into how the research was conducted and how the results were obtained. The results of this research are discussed in the next chapter.

CHAPTER FOUR

PRESENTATION OF RESULTS

4.1 Introduction

This chapter presents the results on match running performance of university rugby union players in Varsity Cup competitions between 2016 and 2018. Running performance is presented in relation to match location (i.e., playing home or away), match outcome (i.e., won, lost or drew) and the quality of the opponents (i.e., stronger or weaker opposition). In addition, match-running performance of rugby players is analysed based on their specific playing positions. Data are reported using statistical methods such as frequencies, percentages, means, standard deviations, effect size (ES), one-way ANOVA and two-way ANOVA. The results of the current study are presented in association with the research objectives postulated in Chapter 1.

4.2 Match Observations

Table 4.1 shows the match observations of rugby players over three seasons. Most of the team's games were played in 2018 (35.4%), with 2016 (31.5%) having the fewest games. Furthermore, fewer games were played at home (47.7%) than away (52.3%). Regarding the quality of the opposition, it was found that there was a higher number of weaker opponents (72.4%) than stronger opponents (27.6%). Subsequently, the majority of match observations of players resulted in a win (61.7%), followed by losses (34.2%) and a draw (4.1%).

Table 4.1: Descriptive statistics for players' match observations

	Frequency	Percentage (%)
Year		
2016	177	31.5
2017	186	33.1
2018	199	35.4
Game location		
Home	268	47.7
Away	294	52.3
Quality of opposition		
Stronger opponents	155	27.6
Weaker opponents	407	72.4
Match outcome		
Win	347	61.7
Lose	192	34.2
Draw	23	4.1

Players' data was analysed and compared with each other in certain match situations to answer the objectives of this research. The aim is to determine how players' external loads changed over the three seasons as a result of different match locations, match outcomes, and the strength of the opponents. Each of the three seasons was compared to the others, with all players grouped together, to observe an overall difference between the seasons. Playing positions were compared to one another, as overall values for the three seasons, to determine the differences between players playing in these different positions. Furthermore, players were defined and sorted into four position-specific groups, (front-row forwards, back-row forwards, inside backs and outside backs) and compared to each other with overall values to perceive the variances in external loads. Each season saw laws introduced or amended, which may have had a direct effect on the match running performance of the players.

Research Objective 1: To analyse the overall match running performance of rugby union players during the Varsity Cup competitions

Table 4.2 shows the differences in metrics between forwards and backs. Backs had higher averages than forward players on the following variables: total distance (5,105 ± 2,150 m; *p* = 0.00; ES = 0.49, small effect), high-speed running (496 ± 258 m; *p* = 0.00; ES = 1.03, moderate effect), very high-speed running (260 ± 136 m; *p* = 0.00; ES = 1.50, large effect), sprinting distance (117 ± 99 m; *p* = 0.00; ES = 1.32, large effect), metres per minute (238 ± 94; *p* = 0.00; ES = 0.46, small effect), total PlayerLoad (488 ± 203; *p* = 0.00; ES = 0.31, small effect), RHIE (9 ± 8; *p* = 0.00; ES = 0.75, moderate effect) and number of accelerations (4 ± 5; *p* = 0.00; ES = 0.49, small effect).

Table 4.2: Match running performance between forwards and backs

Variable	Forwards M ± SD	Backs M ± SD	Sig.	ES
Total distance (m)	4,097 ± 1,971	5,105 ± 2,150	0.00*	0.49 (small)
Moderate-speed running (m)	1,821 ± 877	1,868 ± 828	0.52	0.06 (trivial)
High-speed running (m)	262 ± 189	496 ± 258	0.00*	1.03 (moderate)
Very high-speed running (m)	85 ± 93	260 ± 136	0.00*	1.50 (large)
Sprinting distance (m)	19 ± 34	117 ± 99	0.00*	1.32 (large)
Metres per minute (m)	197 ± 85	238 ± 94	0.00*	0.46 (small)
Total PlayerLoad	426 ± 201	488 ± 203	0.00*	0.31 (small)
PlayerLoad (slow)	186 ± 86	181 ± 75	0.52	0.06 (trivial)
RHIE	4 ± 5	9 ± 8	0.00*	0.75 (moderate)
Number of accelerations (n)	2 ± 3	4 ± 5	0.00*	0.49 (small)

Note: *Significant at p<0.05. RHIE = Repeated high-intensity effort. ES values were interpreted as follows: trivial (<0.20); small (0.20–0.59); moderate (0.60–1.19); large (1.20–2.00); and very large (>2.00).

It was found that outside backs (5,481 ± 1,749 m) covered a significantly greater total distance compared to inside backs (4,898 ± 2,322 m), back-row forwards (4,471 ± 1,931 m) and front-row forwards (3,742 ± 1,948 m) (*F* (3, 558) = 16.35; *p* = 0.00). Post-hoc comparisons using the Tukey HSD test showed that the mean value for outside backs was significantly different from those of back-row forwards and front-row forwards. The post-hoc test further showed that the outside backs were not significantly different from inside backs. The comparison between inside backs and outside backs on total distances showed a moderate effect size (ES= 0.94).

Outside and inside backs ran significantly (*p*=0.00) greater distances for high-speed running, very high-speed running and sprinting distances compared to back-row and front-row forwards. There were large effect sizes for high-speed running for both front-row forwards vs inside backs (ES = 1.54) and front-row forwards vs outside backs (ES = 1.87). There were large effect sizes of very high-speed running for both front-row forwards vs inside backs (ES = 1.90) and back-row forwards vs outside backs (ES = 1.41), and a very large effect size was observed for front-row forwards vs outside backs (ES = 2.74).

Additionally, outside backs covered more metres per minute than players in other positions (i.e., inside backs, back-row forwards and front-row forwards). The Tukey HSD Post-hoc test indicated that the mean score on metres per minute for outside backs (253 ± 78 m) was larger than those of the back-row forwards (213 ± 85 m; *p*=0.00; ES = 0.49) and front-row forwards (182 ± 83 m; *p*=0.00; ES = 0.88). Outside backs did not differ significantly from inside backs (230 ± 101 m). However, a moderate effect size was apparent for front-row forwards vs outside backs (ES = 0.88) (Table 4.3).

Table 4.3: Positional differences in match running performance

Variable	FRF M ± SD	BRF M ± SD	IB M ± SD	OB M ± SD	Sig.
Total distance (m)	3742 ± 1948	4471 ± 1931	4898 ± 2322	5481 ± 1749	0.00*
Moderate-speed running (m)	1800 ± 957	1843 ± 787	1873 ± 922	1859 ± 627	0.89
High-speed running (m)	178 ± 116	350 ± 210	523 ± 294	448 ± 168	0.00*
Very high-speed running (m)	42 ± 47	131 ± 107	243 ± 142	290 ± 119	0.00*
Sprinting distance (m)	8 ± 23	30 ± 39	83 ± 76	176 ± 107	0.00*
Metres per minute	182 ± 83	213 ± 85	230 ± 101	253 ± 78	0.00*
Total PlayerLoad	381 ± 191	473 ± 201	474 ± 222	514 ± 160	0.00*
PlayerLoad (slow)	167 ± 82	206 ± 86	172 ± 79	199 ± 63	0.00*
RHIE	2 ± 2	6 ± 7	8 ± 7	10 ± 10	0.00*
Number of accelerations (n)	2 ± 2	3 ± 4	4 ± 4	5 ± 5	0.00*

Note: *Significant at $p<0.05$. RHIE = Repeated high-intensity effort. FRF= Front-row forwards. BRF = Back-row forwards. IB = Inside backs. OB = Outside backs.

Outside backs also had higher averages for total PlayerLoad (514 ± 160), RHIE (10 ± 10) and number of accelerations (5 ± 5) than players in other positions. The comparison showed that there was a moderate effect size of total PlayerLoad for front-row forwards vs outside backs (ES = 0.75). With regard to RHIE, there was a moderate effect for front-row forwards vs outside backs (ES = 1.11). Moderate effect sizes of the number of accelerations were noted for both front-row forwards vs outside backs (ES = 0.79) and front-row forwards vs inside backs (ES = 0.63) (Table 4.4).

Table 4.4: Effect size values of match running performance in different positions

Variable	FRF vs BRF	FRF vs IB	FRF vs OB
Total distance (m)	0.38 (small)	0.54 (small)	0.94 (moderate)
Moderate-speed running (m)	0.05 (trivial)	0.08 (trivial)	0.07 (trivial)
High-speed running (m)	1.01 (moderate)	1.54 (large)	1.87 (large)
Very high-speed running (m)	1.08 (moderate)	1.90 (large)	2.74 (very large)
Sprinting distance (m)	0.69 (moderate)	1.34 (large)	2.17 (very large)
Metres per minute	0.37 (small)	0.52 (small)	0.88 (moderate)
Total PlayerLoad	0.47 (small)	0.45 (small)	0.75 (moderate)
PlayerLoad (slow)	0.46 (small)	0.06 (trivial)	0.44 (small)
RHIE	0.77 (moderate)	1.17 (large)	1.11 (moderate)
Number of accelerations (n)	0.32 (small)	0.63 (moderate)	0.79 (moderate)
	BRF vs IB	BRF vs OB	IB vs OB
Total distance (m)	0.20 (small)	0.55 (small)	0.28 (small)
Moderate-speed running (m)	0.03 (trivial)	0.02 (small)	0.02 (trivial)
High-speed running (m)	0.68 (moderate)	0.52 (small)	0.31 (small)
Very high-speed running (m)	0.89 (moderate)	1.41 (large)	0.36 (small)
Sprinting distance (m)	0.88 (moderate)	1.81 (large)	1.00 (moderate)
Metres per minute	0.18 (trivial)	0.49 (small)	0.25 (small)
Total PlayerLoad	0.00 (trivial)	0.23 (small)	0.21 (small)
PlayerLoad (slow)	0.41 (small)	0.09 (trivial)	0.38 (small)
RHIE	0.29 (small)	0.46 (small)	0.23 (small)
Number of accelerations (n)	0.25 (small)	0.44 (small)	0.25 (small)

RHIE = Repeated high-intensity effort. FRF= Front-row forwards. BRF = Back-row forwards. IB = Inside backs. OB = Outside backs. Effect size values were interpreted as follows: trivial (<0.20); small (0.20–0.59); moderate (0.60–1.19); large (1.20–2.00); and very large (>2.00).

Research Objective 2: To examine how the law variations have influenced the match running performance in the rugby union Varsity Cup competitions from 2016 to 2018

Table 4.5 indicates the ANOVA results for the match running performance from 2016 to 2018. The findings showed that there was a trivial reduction in total distance covered by players for the 2016 (4696 ± 2193m), 2017 (4629 ± 1960m) and 2018 (4304 ± 2157m) seasons. No significant difference (*p*>0.05) was observed for the total distance over the period of three years. Additionally, ES values of the total distances were trivial, thus demonstrating very little difference between these years.

It was also found that the metres covered per minute significantly decreased from 2016 (226 ± 101) to 2017 (218 ± 86) and to 2018 (203 ± 87). Despite the significant difference, there were trivial increases between 2016 vs 2017 (ES = 0.09) and 2017 vs 2018 (ES = 0.17). A small increase was observed for 2016 vs 2018 (ES = 0.24).

Players' RHIE significantly increased from 2016 (2 ± 3) to 2017 (4 ± 5) and to 2018 (11 ± 9) (F (2, 559) = 95.48; p = 0.00). Post-hoc comparisons using the Tukey HSD test showed that the mean value for 2016 was significantly different from those of 2017 and 2018. The magnitude of difference for RHIE was large between 2016 and 2018 (ES = 1.34). Similarly, the number of accelerations significantly increased from 2016 (1 ± 1) to 2017 (2 ± 3) and to 2018 (6 ± 5) (F (2, 559) = 107.90; p = 0.00), with a large effect between 2016 and 2018 (ES = 1.38) (Table 4.6).

Table 4.5: Means and standard deviations of match running performance from 2016 to 2018

	2016	2017	2018	
Variable	M ± SD	M ± SD	M ± SD	Sig.
Total distance (m)	4,696 ± 2,193	4,629 ± 1,960	4,304 ± 2,157	0.15
Moderate-speed running (m)	1,758 ± 862	1,960 ± 834	1,804 ± 862	0.06
High-speed running (m)	381 ± 261	367 ± 234	345 ± 255	0.36
Very high-speed running (m)	172 ± 145	160 ± 133	153 ± 150	0.42
Sprinting distance (m)	60 ± 81	60 ± 74	63 ± 97	0.91
Metres per minute	226 ± 101	218 ± 86	203 ± 87	0.00*
Total PlayerLoad	441 ± 200	474 ± 195	444 ± 215	0.23
PlayerLoad (slow)	187 ± 80	187 ± 77	178 ± 86	0.51
RHIE	2 ± 3	4 ± 5	11 ± 9	0.04*
Number of accelerations (n)	1 ± 1	2 ± 3	6 ± 5	0.00*

Note: *Significant at p<0.05. RHIE = Repeated high-intensity effort.

Table 4.6: Effect size values of match running performance from 2016 to 2018

Variable	2016 vs 2017	2016 vs 2018	2017 vs 2018
Total distance (m)	0.03 (trivial)	0.18 (trivial)	0.16 (trivial)
Moderate-speed running (m)	0.24 (small)	0.05 (trivial)	0.18 (trivial)
High-speed running (m)	0.06 (trivial)	0.14 (trivial)	0.09 (trivial)
Very high-speed running (m)	0.09 (trivial)	0.13 (trivial)	0.05 (trivial)
Sprinting distance (m)	0.00 (trivial)	0.03 (trivial)	0.03 (trivial)
Metres per minute	0.09 (trivial)	0.24 (small)	0.17 (trivial)
Total PlayerLoad	0.17 (trivial)	0.01 (trivial)	0.15 (trivial)
PlayerLoad (slow)	0.00 (trivial)	0.11 (trivial)	0.11 (trivial)
RHIE	0.49 (small)	1.34 (large)	0.96 (moderate)
Number of accelerations (n)	0.45 (small)	1.38 (large)	0.97 (moderate)

Note: *Significant at $p<0.05$. RHIE = Repeated high-intensity effort. Effect size values were interpreted as follows: trivial (<0.20); small (0.20–0.59); moderate (0.60–1.19); large (1.20–2.00); and very large (>2.00).

Research Objective 3: To determine the extent to which the law variations had an impact on the match running performance of rugby union based on specific-playing positions during the Varsity Cup competitions

Table 4.7 illustrates the match running performances of players (i.e., forwards and backs) during the 2016, 2017 and 2018 FNB Varsity Cup competitions. In 2016, forwards ran their highest total distance (4,370 ± 2,062 m) compared to 2017 (4,145 ± 1,902 m) and 2018 (3,821 ± 1,937 m). The backs, however, ran larger total distances in 2017 (5,284 ± 1,856 m) compared to 2016 (5,092 ± 2,293m) and 2018 (4,952 ± 2,275 m). The metres per minute accrued by the forwards was highest in 2016 (211 ± 94 m) compared to 2017 (197 ± 83 m) and 2018 (185 ± 78 m). The backs amassed the most metres run per minute in 2017 (246 ± 82 m) compared to 2016 (244 ± 105 m) and 2018 (226 ± 93 m), with trivial effect sizes. The PlayerLoad accumulated was largest for both forwards (445 ± 204) and backs (513 ± 175) in 2017. The forwards experienced a larger PlayerLoad in 2016 (419 ± 189) compared to 2018 (414 ± 209), while the backs had a larger PlayerLoad in 2018 (485 ± 219) compared to 2016 (467 ± 211).

In 2017, the forwards covered more distance in high-speed running (268 ± 176 m) and very high-speed running (87 ± 92m) compared to 2018 (237 ± 185 m; 70 ± 83 m), but 2016 had the largest distances (285 ± 205 m; 102 ± 102 m). The backs ran the least distance in high-speed running (489 ± 265 m) in 2018, and the largest distance with very high-speed running (264 ± 147 m) in the same year. The backs ran less high-speed running distances in 2016 (498 ± 274 m) as compared to 2017 (502 ± 236 m). Backs also ran slightly less very high-speed distances in 2016 (257 ± 144 m) compared to 2017 (258 ± 114 m), with a trivial effect (ES = 0.00). The forwards ran the most sprinting metres in 2017 (22 ± 42 m) compared to 2016 (18 ± 31 m) and 2018 (16 ± 27 m). In contrast, the backs ran greater sprinting distances in 2018 (127 ± 119 m) compared to 2017 (112 ± 78 m) and 2016 (110 ± 94 m).

Forwards and backs both engaged in more RHIE in 2018 (of 7 ± 7 and 16 ± 9, respectively) compared to the forwards in 2017 (2 ± 4) and 2016 (1 ± 2) and the backs in 2017 (6 ± 6) and 2016 (3 ± 3). Additionally, 2018 resulted in the largest number of accelerations among forwards (5 ± 4) and backs (8 ± 5). Furthermore, 2017 had the largest number of accelerations for both forwards (1 ± 3) and backs (3 ± 4) compared to 2016 (1 ± 1 and 1 ± 1, respectively).

Table 4.7: Means and standard deviations of match running performance for general positions in the FNB Varsity Cup from 2016 to 2018

Variable	Total		2016	
	Forwards	Backs	Forwards	Backs
	M ± SD	M ± SD	M ± SD	M ± SD
Total distance (m)	4,097 ± 1,971	5,105 ± 2,150	4,370 ± 2,062	5,092 ± 2,293
Moderate-speed running (m)	1,821 ± 877	1,868 ± 828	1,776 ± 872	1,737 ± 855
High-speed running (m)	262 ± 189	496 ± 258	285 ± 205	498 ± 274
Very high-speed running (m)	85 ± 93	260 ± 136	102 ± 102	257 ± 144
Sprinting distance (m)	19 ± 34	117 ± 99	18 ± 31	110 ± 94
Metres per minute	197 ± 85	238 ± 94	211 ± 94	244 ± 105
Total PlayerLoad	426 ± 201	488 ± 203	419 ± 189	467 ± 211
PlayerLoad (slow)	186 ± 86	181 ± 75	195 ± 82	178 ± 78
RHIE	4 ± 5	9 ± 8	1 ± 2	3 ± 3
Number of accelerations (n)	2 ± 3	4 ± 5	1 ± 1	1 ± 1
	2017		2018	
Variable	Forwards	Backs	Forwards	Backs
	M ± SD	M ± SD	M ± SD	M ± SD
Total distance (m)	4,145 ± 1,902	5,284 ± 1,856	3,821 ± 1,937	4,952 ± 2,275
Moderate-speed running (m)	1,911 ± 890	2,026 ± 752	1,774 ± 871	1,845 ± 854
High-speed running (m)	268 ± 176	502 ± 236	237 ± 185	489 ± 265
Very high-speed running (m)	87 ± 92	258 ± 114	70 ± 83	264 ± 147
Sprinting distance (m)	22 ± 42	112 ± 78	16 ± 27	127 ± 119
Metres per minute	197 ± 83	246 ± 82	185 ± 78	226 ± 93
Total PlayerLoad	445 ± 204	513 ± 175	414 ± 209	485 ± 219
PlayerLoad (slow)	186 ± 87	187 ± 63	178 ± 89	179 ± 82
RHIE	2 ± 4	6 ± 6	7 ± 7	16 ± 9
Number of accelerations (n)	1 ± 3	3 ± 4	5 ± 4	8 ± 5

Tables 4.8, 4.9 and 4.10 present an examination of the means and standard deviations of specific positions' external load metrics for the three seasons of 2016, 2017 and 2018. The front-row forwards were observed to run the most metres in 2016 (4,317 ± 2,017 m), while these players ran 3,711 ± 1,940 m in 2017 and 3,313 ± 1,811 m in 2018. Furthermore, there was a reduction of metres covered during

high-speed running, very high-speed running and sprinting distance from 2016 through to 2018 for these players. High-speed running in 2016 was calculated to be 230 ± 148 m, which was more than in 2017 (179 ± 85 m) and 2018 (137 ± 76 m). A moderate effect size (ES = 0.79) of high-speed running was observed between 2016 and 2018. Very high-speed running was also less in 2018 (23 ± 25 m) and 2017 (39 ± 39 m) compared to 2016 (70 ± 62 m). In 2016, the front-row forwards experienced the largest PlayerLoad for their positions (401 ± 174). The year with the next highest PlayerLoad was 2017 (395 ± 205), with front-row forwards experiencing the least PlayerLoad (354 ± 192) in 2018. Nevertheless, it was found that in 2018 these players engaged in more RHIE and accelerations than they did in 2017 and 2016.

The total distance for the back-row forwards was greatest in 2017 (4,554 ± 1,787m), with 2018 (4,426 ± 1,924m) and 2016 (4,423 ± 2,127m) being slightly less. The accumulation of high-speed running metres was greater in 2018 (357 ± 206 m) than in 2017 (352 ± 190 m) and 2016 (341 ± 239 m), but sprinting distance was greater in 2017 (37 ± 52 m) compared to 2018 (33 ± 31 m). The PlayerLoad of the back-row forwards was 491 ± 194 in 2017, which was greater than that in 2018 (485 ± 207) and 2016 (438 ± 203). In 2018, RHIE and accelerations were both largest for these players (12 ± 8; 6 ± 5) compared to these metrics in 2017 (4 ± 4; 2 ± 3) and 2016 (2 ± 2; 1 ± 1).

Furthermore, in 2017, the inside backs amassed the largest total distance of 5,566 ± 1,852 m, while 2016 (4,855 ± 2,474 m) also had a greater total distance than 2018 (4,342 ± 2,454 m) for these players. Additionally, the number of metres gained during high-speed running and very high-speed running was highest in 2017, followed by 2016 and then 2018. Even though the sprinting distance was greater in 2018 (71 ± 72 m) than in 2016 (69 ± 63 m), 2017 (110 ± 85 m) was the highest. The PlayerLoad of the inside backs was also found to be greatest in 2017 (540 ± 175) compared to 2016 (458 ± 235) and 2018 (428 ± 238). The totals of RHIEs and accelerations were 24 ± 7 and 6 ± 4, respectively, in 2018, which was greater than in both other years analysed.

Finally, the outside backs experienced the most intensive running season during 2018. The total distance covered by the outside backs was greatest in 2018 (6,337 ± 737 m), followed by 2016 (5,412 ± 2,015 m) and then 2017 (4,741 ± 1,772 m). In addition, high-speed running, very high-speed running, and sprinting distance were highest in 2018. High-speed running in 2018 reached a value of 532 ± 113 m, while in 2017 it was only391 ± 157 m. In 2017, the sprinting distance was 116 ± 62 m, which was substantially lower than in 2018 (254 ± 104 m). The results also show how PlayerLoad for the outside backs was largest in 2018 (613 ± 65), while 2016 (479 ± 176) and 2017 (462 ± 166) had values similar to one another. Similarly, the other positions examined, in 2018 the outside backs experienced the most RHIEs and accelerations compared to the 2016 and 2017 seasons.

Table 4.8: Means and standard deviations of position-specific match running performance in the FNB Varsity Cup 2016

Variable	2016			
	FRF	BRF	IB	OB
	M ± SD	M ± SD	M ± SD	M ± SD
Total distance (m)	4,317 ± 2,017	4,423 ± 2,127	4,855 ± 2,474	5,412 ± 2,015
Moderate-speed running (m)	1,840 ± 916	1,710 ± 829	1,764 ± 970	1,699 ± 680
High-speed running (m)	230 ± 148	341 ± 239	550 ± 315	429 ± 189
Very high-speed running (m)	70 ± 62	134 ± 123	239 ± 154	281 ± 129
Sprinting distance (m)	18 ± 35	19 ± 26	69 ± 63	165 ± 102
Metres per minute	206 ± 90	217 ± 99	233 ± 113	259 ± 94
Total PlayerLoad	401 ± 174	438 ± 203	458 ± 235	479 ± 176
PlayerLoad (slow)	188 ± 79	201 ± 85	167 ± 81	192 ± 71
RHIE	0 ± 1	2 ± 2	4 ± 3	3 ± 3
Number of accelerations (n)	0 ± 1	1 ± 1	1 ± 1	2 ± 2

Table 4.9: Means and standard deviations of position-specific match running performance in the FNB Varsity Cup 2017

Variable	2017			
	FRF	BRF	IB	OB
	M ± SD	M ± SD	M ± SD	M ± SD
Total distance (m)	3,711 ± 1,940	4,554 ± 1,787	5,566 ± 1,852	4,741 ± 1,772
Moderate-speed running (m)	1,883 ± 1,025	1,938 ± 749	2,192 ± 759	1,705 ± 635
High-speed running (m)	179 ± 103	352 ± 190	560 ± 251	391 ± 157
Very high-speed running (m)	39 ± 39	132 ± 105	270 ± 120	236 ± 101
Sprinting distance (m)	6 ± 17	37 ± 52	110 ± 85	116 ± 62
Metres per minute	176 ± 85	216 ± 77	258 ± 81	221 ± 79
Total PlayerLoad	395 ± 205	491 ± 194	540 ± 175	462 ± 166
PlayerLoad (slow)	163 ± 84	209 ± 84	190 ± 61	181 ± 69
RHIE	1 ± 3	4 ± 4	7 ± 6	6 ± 7
Number of accelerations (n)	1 ± 2	2 ± 3	3 ± 4	3 ± 4

Table 4.10: Means and standard deviations of position-specific match running performance in the FNB Varsity Cup 2018

Variable	2018			
	FRF	BRF	IB	OB
	M ± SD	M ± SD	M ± SD	M ± SD
Total distance (m)	3,313 ± 1,811	4,426 ± 1,924	4,342 ± 2,454	6,337 ± 737
Moderate-speed running (m)	1,698 ± 936	1,865 ± 786	1,677 ± 955	2,227 ± 347
High-speed running (m)	137 ± 76	357 ± 206	470 ± 309	532 ± 113
Very high-speed running (m)	23 ± 25	126 ± 93	223 ± 149	358 ± 87
Sprinting distance (m)	1 ± 8	33 ± 31	71 ± 72	254 ± 104
Metres per minute	167 ± 72	207 ± 80	204 ± 102	278 ± 26
Total PlayerLoad	354 ± 192	485 ± 207	428 ± 238	613 ± 65
PlayerLoad (slow)	153 ± 81	207 ± 91	159 ± 89	226 ± 30
RHIE	3 ± 2	12 ± 8	24 ± 7	11 ± 9
Number of accelerations (n)	3 ± 2	6 ± 5	6 ± 4	11 ± 4

Research Objective 4: To assess the influence of match location, match outcome and quality of opposition on match running performance of rugby union players during the Varsity Cup competitions

Table 4.11 shows the results of the independent *t*-test and ES on the match running performance when playing games home or away. Although no significant difference was observed (*p*=0.06), players covered greater total distance when playing at home (4,600 ± 2,068 m) compared to when playing away (4,476 ± 2,147 m), although the effect was trivial (ES = 0.06). A significant difference was only observed for sprinting distance when playing away games compared to home games (t [562] = −2.103; p = 0.04; ES = 0.17, trivial effect).

Table 4.11: Match running performance for home and away matches

	Home	Away		
Variable	M ± SD	M ± SD	Sig.	ES
Total distance (m)	4,600 ± 2,068	4,476 ± 2,147	0.49	0.06 (trivial)
Moderate-speed running (m)	1,861 ± 846	1,823 ± 866	0.60	0.04 (trivial)
High-speed running (m)	357 ± 245	370 ± 255	0.54	0.05 (trivial)
Very high-speed running (m)	155 ± 139	167 ± 146	0.29	0.08 (trivial)
Sprinting distance (m)	53 ± 73	68 ± 94	0.04*	0.17 (trivial)
Metres per minute (m)	220 ± 93	211 ± 90	0.26	0.10 (trivial)
Total PlayerLoad	453 ± 199	452 ± 209	0.94	0.00 (trivial)
PlayerLoad (slow)	187 ± 80	181 ± 83	0.42	0.07 (trivial)
RHIE	6 ± 7	6 ± 7	0.36	0.00 (trivial)
Number of accelerations (n)	3 ± 4	3 ± 4	0.15	0.00 (trivial)

Note: *Significant at p<0.05. RHIE = Repeated high-intensity effort. ES values were interpreted as follows: trivial (<0.20); small (0.20–0.59); moderate (0.60–1.19); large (1.20–2.00); and very large (>2.00).

Table 4.12 illustrates the differences in the metrics when playing against stronger or weaker opposition. The total distance was marginally larger when playing stronger opponents (4,575 ± 2,112 m) compared to weaker opponents (4,431 ± 2,106 m), with a trivial effect (ES = 0.07). Players also covered slightly greater distances when playing against stronger opponents with regards to metres per minute (219 ± 92 m) and PlayerLoad (454 ± 204) when compared to playing against weaker opponents. None of the metrics showed significant differences when comparing stronger and weaker opponents. In addition, effect sizes showed trivial differences, thus demonstrating minimal differences in the metrics.

Table 4.12: Match running performance against stronger and weaker opponents

Variable	Stronger M ± SD	Weaker M ± SD	Sig.	ES
Total distance (m)	4,575 ± 2,112	4,431 ± 2,106	0.47	0.07 (trivial)
Moderate-speed running (m)	1,843 ± 850	1,836 ± 873	0.92	0.00 (trivial)
High-speed running (m)	368 ± 255	353 ± 239	0.55	0.06 (trivial)
Very high-speed running (m)	164 ± 143	154 ± 142	0.43	0.07 (trivial)
Sprinting distance (m)	63 ± 87	56 ± 78	0.36	0.08 (trivial)
Metres per minute (m)	219 ± 92	205 ± 89	0.10	0.15 (trivial)
Total PlayerLoad	454 ± 204	450 ± 206	0.83	0.02 (trivial)
PlayerLoad (slow)	185 ± 83	181 ± 78	0.61	0.05 (trivial)
RHIE	6 ± 7	6 ± 7	0.90	0.00 (trivial)
Number of accelerations (n)	3 ± 4	3 ±4	0.81	0.00 (trivial)

Note: *Significant at p<0.05. RHIE = Repeated high-intensity effort. ES values were interpreted as follows: trivial (<0.20); small (0.20–0.59); moderate (0.60–1.19); large (1.20–2.00); and very large (>2.00).

Table 4.13 shows running performance based on the match outcome. Teams covered greater total distances when winning (4,645 ± 2,121 m) compared to when losing (4,394 ± 2,057 m) or drawing (4,048 ± 2,308 m). No significant difference (*p*>0.05) was observed for total distances. When comparing match outcomes, the effect sizes were trivial and small, suggesting that there were minimal differences for total distance. A significant difference was observed for metres per minute when teams were winning (223 ± 93 m) when compared to drawing (207 ± 91 m) or losing (201 ± 88 m) (F (2, 559) = 3.73; p = 0.03), although effect sizes were trivial and small.

Post-hoc comparisons using the Tukey HSD test indicated that the mean values for teams that won were significantly different from those of teams that lost or drew. Teams that drew had significantly higher RHIEs (9 ± 7) and number of accelerations (6 ± 4) than teams which won or lost their games. There were small effects for RHIE, and a moderate effect (ES = 0.75) was noted between teams which won or lost (Table 4.14).

Table 4.13: Match running performance for different match outcomes

Variable	Win M ± SD	Lose M ± SD	Draw M ± SD	Sig.
Total distance (m)	4,645 ± 2,121	4,394 ± 2,057	4,048 ± 2,308	0.22
Moderate-speed running (m)	1,857 ± 849	1,835 ± 863	1,662 ± 920	0.57
High-speed running (m)	372 ± 256	356 ± 242	314 ± 228	0.49
Very high-speed running (m)	168 ± 144	151 ± 141	137 ± 131	0.29
Sprinting distance (m)	66 ± 91	52 ± 71	69 ± 96	0.16
Metres per minute	223 ± 93	201 ± 88	207 ± 91	0.03*
Total PlayerLoad	458 ± 204	447 ± 202	418 ± 231	0.60
PlayerLoad (slow)	187 ± 82	180 ± 78	170 ± 95	0.44
RHIE	5 ± 7	7 ± 8	9 ± 7	0.00*
Number of accelerations (n)	3 ± 4	4 ± 4	6 ± 4	0.00*

Note: *Significant at *p*<0.05. RHIE = Repeated high-intensity effort

Table 4.14: ES values of match running performance for different match outcomes

Variable	Win vs Lose	Win vs Draw	Draw vs Lose
Total distance (m)	0.12 (trivial)	0.27 (small)	0.16 (trivial)
Moderate-speed running (m)	0.03 (trivial)	0.22 (small)	0.19 (trivial)
High-speed running (m)	0.06 (trivial)	0.24 (small)	0.18 (trivial)
0Very high-speed running (m)	0.12 (trivial)	0.23 (small)	0.10 (trivial)
Sprinting distance (m)	0.17 (trivial)	0.03 (trivial)	0.20 (small)
Metres per minute	0.24 (small)	0.17 (trivial)	0.07 (trivial)
Total PlayerLoad	0.05 (trivial)	0.18 (trivial)	0.13 (trivial)
PlayerLoad (slow)	0.09 (trivial)	0.19 (trivial)	0.12 (trivial)
RHIE	0.27 (small)	0.57 (small)	0.27 (small)
Number of accelerations (n)	0.25 (small)	0.75 (moderate)	0.50 (small)

Note: *Significant at p<0.05. RHIE = Repeated high-intensity effort. ES values were interpreted as follows: trivial (<0.20); small (0.20–0.59); moderate (0.60–1.19); large (1.20–2.00); and very large (>2.00).

4.3 Summary

This chapter presented the results found when examining the external loads on university rugby players during matches. The results were divided according to the objectives of this study and were described and illustrated in tables for each objective. The outcomes will be further discussed and analysed in Chapter 5 to achieve a greater understanding of the loads experienced by the players.

CHAPTER FIVE

DISCUSSION

5.1 Introduction

The objectives of the current study were to analyse the effect of law variations and match influences on the external match loads on rugby union players, as a collective team, over three FNB Varsity Cup seasons (2016–2018) to determine differences in each season. These objectives include investigating whether the change in laws that occurred over the three seasons affected the external loads experienced by the players, grouped in their specific positions. Additionally, the study aimed at exploring the changes of external loads for different circumstances – match location, match result and quality of the opposition – over three seasons.

Finally, the players were grouped into specific positions and compared to each other to explore the variances of the external loads between the positions. To the best of the author's knowledge, this is the first study to compare the external match loads on rugby union players based on aspects including law changes, match location, match outcome and quality of opponents, as well as expanding it to compare position-specific external loads between the variables.

The law variations and amendments introduced to the FNB Varsity Cup may have affected the players' external loads. The introduction of new laws such as the point of origin may have affected how much the front-row forwards ran. Additionally, the point of origin and power play laws may have affected the back-row forwards, as their external load changed from before the point of origin law was amended and after the power play was introduced. The inside backs ran the furthest distance after the point of origin law was amended, and therefore the decrease may be as of a result of this law variation. This trend continues for the inside backs when considering that their high-speed running metrics changed in the same manner. The outside backs ran larger distances during match play in 2016 before point of origin was introduced, as well as after the law was amended in 2017, as their external load was lowest in the 2017 season. In addition to this law, the strategy break may have influenced the increase of high-intensity efforts in 2018, as these breaks could assist the players' recovery, better preparing them for the next phase of play.

5.2 Research Objective 1: To analyse the overall match running performance of rugby union players during the Varsity Cup competitions

This objective was proposed to describe the differences of external loads during matches based on playing positions.[2] It was found that the backs generally covered more metres run for all relevant variables in this study, as well as the amount of PlayerLoad expended and the numbers of RHIEs and accelerations. The PlayerLoad (slow) for the backs was the only value that was less than that of the forwards, which is similar to results found when under-18 elite rugby union players were assessed (Roe *et al.,* 2016). This could indicate that when the players are running slowly during the match, the forwards are working more than the backs. However, when the match is at high intensity, it can be presumed that the backs are increasing their external loads more significantly. The relative distance experienced by the backs was greater than that of the forwards, a finding that is consistent with those of previous studies of young rugby union players (Cunningham *et al.*, 2016; Read *et al.*, 2017). Although the running demands of total distance and relative distance are similar to previous research (Cahill *et al.*, 2013; Cunniffe *et al.*, 2009; Deutsch, Maw, Jenkins, & Reaburn, 1998; Duthie *et al.,* 2005; Roberts *et al.*, 2008), in this study, the players ran less. This may indicate the difference with more elite teams as well as different approaches to how the sport is played in different countries. Therefore, the level of competitiveness may differ between teams of elite and less elite players, as well as between teams playing in different countries.

Match demands showed that the backs ran significantly longer total distances than the forwards during matches. Likewise, backs covered much greater higher-speed running distances than the forwards. This finding shows the different requirements for the two general positions. In professional rugby union competitions, similar

[2] Refer to Table 4.2

results were observed, with backs covering larger total distances (Austin *et al*., 2011; McLellan *et al.*, 2013; Roberts *el al.*, 2008). The number of accelerations and RHIEs were found to be slightly different to the other studies examined. Nevertheless, it may be argued that the difference is due to the rules or the amateur level of the players. This variance includes the manner in which professional teams play compared to non-professional teams (Austin *et al*., 2011; Deutsch *et al.*, 2007; Roberts *el al.,* 2008).

Exploring the external match loads of the players' specific positions[3] created a formative outline of the different demands that the players experienced. The outside backs were found to have covered the greatest total distance over the three seasons, while the inside backs also ran further distances than the back-row and front-row forwards. This is in agreement with the findings of Austin *et al*. (2011) and Lacome *et al.* (2013), who reported that forwards ran fewer total metres than both the inside and outside backs. The front-row forwards are the players who run significantly less over the duration of the match, but they have other responsibilities, which is shown by the other load variables and other key performance indicators. The forwards experience much higher contact loads during matches compared to the backs, as the forwards are more involved in scrums, mauls and tackles (Quarrie *et al.,* 2013). This agrees with the findings by Roberts *el al.* (2008), who also found that front-row forwards covered the least total distance. Austin *et al*. (2011) showed that the inside backs covered a larger total distance than the outside backs. The backs run larger distances in matches as they generally run from deeper positions than their forward counterparts, thus creating more space to gain speed for their runs with ball in hand (Lacome *et al.*, 2013; Roberts *el al.*, 2008). The different velocity zones of high-speed running distances during the matches showed that the front-row and back-row forwards had run the least distance at higher speeds. However, forwards were found to produce higher acceleration values after standing or walking compared to the backs. Therefore, by measuring distance in different velocity zones and accelerations, a coach may gain a stronger knowledge of the players' workloads (Lacome *et al.,* 2013).

[3] Refer to Tables 4.3 and 4.4

The total PlayerLoad of the outside backs was the largest, showing the demand of a high work rate for this position. The inside backs and back-row forwards had similar values for their PlayerLoad. In contrast, the energy expenditure of the PlayerLoad (slow) showed that the front-row forwards might have higher workloads at slower distances than any other position. The outside backs also have a high PlayerLoad (slow), with the inside backs and front-row forwards showing the least work expended at slower speeds. The outside backs had the highest number of accelerations and RHIEs, which is line with the results of the study by Austin *et al*. (2011). Consequently, the game demands differ for players in specific positions, and backs are found to generally have higher external loads than forward players. High-intensity play is greater for the outside and inside backs compared to the forwards, which is consistent with the findings of Cahill *et al.* (2013) and Lacome *et al.* (2013). Nevertheless, other key performance indicators show the forwards doing more than the backs, which must be considered when analysing the influence of positions on matches. These indicators include tackles and collisions at scrums, rucks and mauls (Quarrie *et al.*, 2013). A player's load is the combination of many variables, and therefore, as many variables as possible should be considered to ensure that the player is playing optimally and is well-conditioned (Bourdon *et al.*, 2017).

Even though the matches compared for this objective may have differed in law variations and in the divisions of professional and non-professional sport, it was found that the results of the studies were similar (Cahill *et al.*, 2013; Lacome *et al.*, 2013). Thus, demonstrating that the base analysis of match demands of rugby union players is parallel regardless of the differences between the match situations (Cahill *et al.*, 2013; Lacome *et al.*, 2013). When developing periodisation plans and conditioning programmes, coaches should take these differences in match demands into account in order for the players to be optimally fit and in peak condition for the positional demands. These periodised plans can be specific to positions in order to gain the most success out of a programme, and they should also be specific to each individual, as when monitoring a team, each player must be monitored individually for optimal results.

5.3 Research Objective 2: To examine how the law variations have influenced the match running performance in the rugby union Varsity Cup competitions from 2016 to 2018

The study revealed few major differences between the years of 2016, 2017 and 2018 in the FNB Varsity Cup when comparing the overall team's external load.[4] The total distance covered by the players was larger in 2016 than in 2017, while in 2018 the players ran the least overall total distance. Previous studies have found that the forwards ran total distances ranging from 4,500 m to 7,000 m, while the backs ran total distances of 5,000 m to 8,000 m (Austin *et al*., 2011; Cahill *et al.*, 2013; Lacome *et al.*, 2013; Quarrie *et al*., 2013). This study shows that the forwards and backs ran 4,000 m and 5,100 m, respectively, which indicates low totals compared to what has been examined previously. This may be as a result of the competition being non-professional, university level. Although the sprinting distance of the players was greatest in 2018, the most high-speed and very high-speed running metres were run in 2016. The finding for metres per minute was largest in the 2016 season. In 2016, the FNB Varsity Cup experienced the first year of the 'point of origin' law addition, allowing the teams to score nine points for a try involving a run from their own 22 m line. After this season, the law was altered and no more nine-point tries could be scored. This may indicate that in the year when the tries counted for more points, the players ran more metres compared to seasons when the tries counted as less points (FNB Varsity Cup, 2018).

The PlayerLoad of the players was largest in 2017, but the high-intensity movements of RHIEs and the number of accelerations made by the players was much larger in 2018. However, maximal running speeds change between players, and therefore should be grouped into positions that allow comparison in a more effective manner (Reardon *et al.,* 2015). These differences between each year as an overall team average do not give a clear idea of the variances between the years. This implies a more detailed examination is required to examine the extent of the players' demands in a match.

[4] Refer to Tables 4.5 and 4.6.

5.4 Research Objective 3: To determine the extent to which the law variations had an impact on the match running performance of rugby union based on specific playing positions during the Varsity Cup competitions

The objective of this study was to evaluate how each position in a rugby union team was affected by the varied laws which were either introduced or amended over the period from 2016 until 2018 (refer to Appendix A). Several relevant laws were introduced either just prior to this time period or during this time period. Although the current study focuses on how law variations affected players' performance, it is acknowledged that this may not be the only factor causing these changes.

The results showed that front-row forwards[5] covered a greater total distance in 2016, before any relevant law variation was introduced. In 2016, the 'point of origin' law[6] was introduced, with teams learning how to adapt and find new strategies. This law variation aimed at promoting attacking rugby and holding on to possession (FNB Varsity Cup, 2018), and the forwards may have ran more in 2016 than in the following years because of the team further adapting to the laws and a change in team strategies. The same trend is observed with the external load metrics of the higher-speed running distances as well as the overall PlayerLoad for these players. This may indicate that the front-row forwards ran hardest and expended the most energy during 2016 compared to 2017 and 2018. In contrast with this trend, the short bouts of RHIEs and the number of accelerations were highest in 2018. The 'strategy break' law variation may have led to this trend, as the players had more regular breaks, allowing them to rest between periods of play (Russell, West, Harper, Cook, & Kilduff, 2014).

The back-row forwards[7] can be measured and classified as more like the backline players than the front-row forwards (Quarrie *et al.*, 2013). The conditioning and high-exertion running bouts of these positions are similar to the backline players due to the high-intensity nature of match play (Flanagan *et al.*, 2017). The results

[5] Refer to Tables 4.8, 4.9 and 4.10.
[6] A law where a team receives 7 or 9 points from running from a certain point on the field and scoring a try.
[7] Refer to Tables 4.8, 4.9 and 4.10.

of this study found that the back-row forwards covered their greatest distances in 2017, and they additionally had similar amounts of metres run during each season. This shows that the 'point of origin' law change in 2017 may have made a larger impact on these players than in 2016, before the law was varied, and in 2018, after the law had been in place for a longer period (FNB Varsity Cup, 2018). The sprinting distance of the back-row forwards follows this trend, but it was discovered that these players ran further at high speeds in 2018.

The PlayerLoad of the back-row forwards was largest in 2017, showing that the workload of the front-row forwards was highest before the change of the 'point of origin' law variation and before the introduction of the 'power play' and 'strategy break' law variations. The aim of these laws was to create excitement and promote attacking rugby, but the front-row forwards seemed to run less after the 'power play' and 'strategy break' laws were introduced, and before the 'point of origin' law was amended[8] (FNB Varsity Cup, 2018). The trend for RHIEs and the number of accelerations was similar to that of the front-row forwards, whereby, in 2018, they experienced most of the high-intensity, short-duration efforts. During match play in the competition, the back-row forwards experienced the high-intensity nature of the match just like the backline players. Therefore, the conditioning of these players must be more similar to the backline players as opposed to that of the front-row forwards (Flanagan *et al.*, 2017; Tee & Coopoo, 2015). It is shown that the forwards, both front-row and back-row, will commonly run less and at slower speeds than the backs, but the forwards will experience higher match demands of more physical outcomes such as tackles, rucks, scrums and lineouts (Campbell, Peake, & Minett, 2018).

The backline players have different match requirements and specific traits, such as achieving higher speeds, to those of the forwards (Campbell *et al*., 2018; Flanagan *et al.*, 2017). The total distance of the inside backs[9] was largest in 2017, allowing us to conclude that they ran greater distances after the 'point of origin' law was amended; however, their total distance decreased in 2018. This decrease may

[8] In 2016, tries could be scored for 5, 7 or 9 points, depending on where the attack started from, while in 2017 the law was changed to only having 5 and 7 point tries that could be scored.
[9] Refer to Table 4.8, 4.9 and 4.10.

indicate that coaches may have made tactical or strategic changes to the team to adapt better to the new law. The inside backs also ran the most metres during the high-speed running metrics in 2017 as compared to the 2018 and 2016 seasons. The work rate of the inside backs was also highest in 2017, as the PlayerLoad of these players was larger than in 2016 and 2018. In 2018, the metrics decreased from the previous years for the inside backs, possibly indicating that during the ‘power play’ periods of the matches, the ball was played less to the inside backs, as their running distances decreased after this law was introduced (FNB Varsity Cup, 2018).

The roles of the inside and outside backs tend to be slightly different from each other, which will therefore show a difference in external loads. The inside backs have been found to assist more in rucks and with tackles as compared to the outside backs, which creates a role for the outside backs to try to carry the ball more often and therefore achieve more running distance and at higher speeds during match play (Quarrie *et al.*, 2013). This is in agreement with the current study, which found that the outside backs[10] ran the highest distances in 2018 as compared to any other year. The total distance and the running distances at high speeds were all largest in 2018, while in 2016 these metrics were larger than in 2017. In the first year that the ‘point of origin’ law was introduced, the outside backs ran more than when they adjusted to the law in 2017. Therefore, as the law changed, the team may have tried a new strategy in which the outside backs had less work to do as compared to the year before. However, in 2018 the external load of the outside backs increased significantly, showing that the team now used the outside backs more often as they were running more during matches. This is likely the result of the outside backs trying to score more points within the ‘point of origin’ law system, as they must run from deeper positions to score higher-point tries. During the power plays in 2018, the outside backs may have been used more, as this law was introduced to achieve excitement in the game as well as to promote attacking rugby (FNB Varsity Cup, 2018).

[10] Refer to Tables 4.8, 4.9 and 4.10.

Each position has different roles and impacts on the match, all being important for the team to achieve victory in the matches (Flanagan *et al.*, 2017). In order to achieve optimal performance of players, coaches need to create training sessions that are specific and individualised to each position (Campbell *et al*., 2018; Tee & Coopoo, 2015). This training includes technical as well as tactical training in order for the team to optimise their performance and to get the best results out of each match (Campbell *et al*., 2018; Dawson *et al.*, 2004).

5.5 Research Objective 4: To assess the influence of match location, match outcome and quality of opposition on match running performance of rugby union players during the Varsity Cup competitions

The current study investigated the influence of situational variables such as match location, match outcome and quality of the opposition on running performance among rugby union players. Players covered greater total distances when playing at home compared to when playing away, a finding which supports that of a previous study on soccer (Lago *et al*., 2010). Players also covered significantly greater sprinting distances when playing at home compared to playing away. Vaz, *et al*. (2012) found that teams achieve more winning results when playing at their home ground, giving an insight that the variable of total distance may be affected by the match location. In addition, there were significant differences for other key performance indicators in rugby union matches, such as scoring tries and penalties, as well as the number of passes completed and tackles made, in favour of games played at home (Vaz *et al*., 2012). The influence of 'home advantage' could have contributed to the increased match running distances among rugby union players observed in this study (Kempton & Coutts, 2016).

The PlayerLoad experienced by the players was greater when playing at home,[11] but there were no differences in the players' RHIEs and accelerations. If the coach feels that the players are not reaching their peak running performance in away games, they can take this information and attempt to change the game plan for a

[11] Refer to Table 4.11.

tactically stronger running performance. However, the coach may have changed the team's tactics to play safer when away from home, as it has been found that home advantage does exist, and this may be a factor to consider when playing away from home (Du Preez & Lambert, 2007).

In the current study, no significant differences were observed between the metrics of the players' external loads when playing stronger or weaker opponents.[12] This could be attributed to the fact that the rugby union team examined played more against weaker opponents than stronger opponents. Consequently, this led to an imbalance in matches observed, as the data shows more players playing against weaker opposition rather than against stronger opposition.[13] However, teams covered a greater distance when playing against stronger opponents than weaker opponents. The present results indicate that when playing against stronger opposition, the players run further and at higher speeds. In agreement with the current research, Rampinini *et al.* (2007) and Aquino *et al.* (2017) found that soccer players ran larger total distances and more metres during high-speed running when playing against stronger opposition. Competitive intensity is said to be larger when teams of equally matched abilities play against each other, as opposed to when a stronger and weaker team play against one another (Wright, 2014). The players can be physically prepared specifically for playing against stronger opponents, as the intensity and physical demands will be higher (Aquino *et al.*, 2017; Rampinini *et al.*, 2007).

Examination of the different metrics of the players' external loads shows that when winning,[14] the players generally covered a greater total distance and a greater distance at high speeds compared to when they lost. However, the sprinting distance covered in the drawn match was larger than that of the winning matches. The data shows a significant difference between the different match outcomes in terms of the metres run per minute. The players may feel confident in the way they play when

[12] Refer to Table 4.12.
[13] Opposition teams which finished above the team being analysed in the final table at the end of each season.
[14] Refer to Tables 4.13 and 4.14.

winning, thus motivating them to increase their efforts. Winning teams tend to score a higher number of points, which may be due to a higher work rate (Ortega *et al.*, 2009).

Regarding the PlayerLoad accumulated by the players, the results were similar to the majority of the metrics showing total distance and distance at high speeds, with higher values when winning. Nevertheless, the RHIEs and accelerations were shown to be greatest when drawing as compared to losing or winning. Thus, it appears that a larger number of metres gained during sprinting speeds involves a larger amount of RHIEs and accelerations. Therefore, winning matches can be directly related to the players running further distances and at higher speeds. However, when the psychophysiological aspects were compared between winning and losing teams, there was no significant difference (Cunniffe *et al.*, 2015).

This research can have a practical impact on teams throughout rugby union, allowing a greater understanding of the objective performances of the players due to the different influences on how they play. By applying this research, coaching strategies may improve team performance by maximising successes throughout the team (Jones, Mellalieu, & James, 2004). This study did not examine other variables that may affect performance, such as hormone levels pre and post competition (Cunniffe *et al.*, 2015).

5.6 Summary

The results of this research were examined and discussed in this chapter. Each of the four research objectives were closely investigated and analysed based on previous findings. The study examined the overall match running variables of the players. It then examined the effects of law variations on players when grouped as a team and clustered into specific playing positions. Lastly, it examined the effect of match influencing factors on how the players' external loads changed. The next chapter will conclude each objective of this study and review the recommendations and limitations of the study while also looking at how this research can be developed further in the future.

CHAPTER SIX

CONCLUSION

6.1 Research Summary

The study's objectives were to investigate how the external loads of rugby union players would differ after considering law variations, as well as match location, match outcome and the quality of opponents.

When examining the external load of the forwards and backs in a university rugby union team over the course of three FNB Varsity Cup seasons, it was found that, the backline players covered greater total distances than the forwards, as well as achieving higher distance at high speeds. This concurs with the research of Austin *et al*., 2011; Cunniffe *et al*., 2009; Lacome *et al*., 2013; Read *et al*., 2017 and Roe *et al*., 2016. These total distances were less than that presented in other literature (Austin *et al*., 2011; Cunniffe *et al*., 2009; Flanagan *et al*., 2017; Lacome *et al*., 2013; Read *et al*., 2017; Roberts *et al*., 2008; Roe *et al*., 2016), which indicated that there may be certain factors influencing these variances. These could include law variations, match influences or style of play during matches. On further analysis, it is concluded that the energy expenditure according to the PlayerLoad of the players was higher for the backs, and there were more RHIEs and accelerations by the backline players.

However, when considering more specific positions, the outside backs ran the greatest average distance over the seasons, while the front-row and back-row forwards did not run as much as the inside backs. There were clear differences between the specific positions, indicating the difference in loads experienced by each position. This can be assessed by coaches and assist them in training their players for their specific roles. When relating this research to other literature, it was found that the external loads were less in this research (Austin *et al*., 2011; Flanagan *et al*., 2017; Roberts *et al*., 2008). This may be a result of law variations or the way in which players play at the South African university level.

The investigation of the external loads of all the players between the three seasons showed minimal differences. The total distance was largest in 2016, with 2018 having the smallest distance. In contrast, there were more high-intensity actions in 2018. The small differences show how analysing position-specific loads can be vital to identify the trends of changes in external loads due to the difference in roles of each position.

The law variations introduced to the FNB Varsity Cup may have affected the players' external loads. The front-row forwards had their largest total distance, high-speed running distances and overall PlayerLoad in 2016. The introduction of new laws such as the point of origin may have affected how much the front-row forwards ran, as the team had to adapt and change their tactics to suit the new laws. The variation and introduction of laws such as point of origin and power plays may have affected the back-row forwards, as their external load was higher in 2017 compared to before the point of origin law was amended in 2017 and after the power play was introduced in 2018. These trends indicate how the law variations may have affected the front-row and back-row forwards, while also indicating that the back-row forwards can be compared to the backline players more than the front-row forwards.

The inside backs ran the furthest distance in 2017 after the point of origin law was amended, and therefore the decrease in 2018 may be as of a result of this law variation causing tactical differences during the second season of implementation. This trend continues for the inside backs when considering that their high-speed running metrics changed in the same manner. The power play law may have affected the team's tactics, forcing them to play the ball out wide to the outside backs to find more space to run on the outskirts of the field. The outside backs had an interesting trend for their external load during these three seasons. They experienced the most running metres in 2018, while in 2017 they had run the least out of the three seasons. This shows that when the point of origin law was introduced in 2016, the outside backs ran larger distances during match play, as after the law was amended[15] in 2017, their external load decreased. Following the first year of the law variation in 2017, as well as the introduction of a new law – the power play – in 2018, the outside backs' external load increased, whereby they experienced the highest load of all the positions in all the years investigated. In addition to this law, the strategy break may have influenced the increase of high-intensity efforts in 2018, as these breaks could assist the players' recovery, better preparing them for the next phase of play.

The current study found that home advantage seemingly affected how the players' external loads differed. The team's total distances and PlayerLoad were higher when playing at home. However, the team covered more metres during the high-speed running metrics when playing away, with the sprinting distance being significantly larger. The matches played against stronger and weaker opposition showed mostly insignificant differences in the external loads experienced by the players, apart from metres run per minute and the RHIE and accelerations. However, the data did suggest that when playing stronger opponents, the team will have marginally larger external loads than when playing weaker teams. When winning, the team was found to have higher external loads for total distance, PlayerLoad and when running at high speeds compared to when winning and drawing. However, the drawn match showed higher sprinting distances, RHIEs and accelerations than when winning. This suggests that when winning matches, the players will most likely have higher external loads than when losing.

6.2 Recommendations

This research has examined the external loads on players due to law variations and other match factors, which should be taken into account by coaches and technical staff to improve the performance of players with effective training programmes. Based on the findings of this study, the following recommendations are proposed:

- The training regimes of the team must be adapted for the law variations made, as these laws will influence how the players play during a match.

[15] Refer to Appendix A.

- The match and training loads could be managed individually due to the difference in external loads among all positions.
- Each player position has different roles, which can be trained and taken into account when conditioning to optimise performance.
- Adjusting the training regimes will not only improve the performance of the players but will also assist in the prevention of injuries.
- When the coaches and the team are preparing for matches, consideration should be given to match location and the quality of their opponent to be well prepared for the external loads that will be experienced in the match.

6.3 Limitations

The following limitations are acknowledged as part of this study:

- Only one team in the competition was assessed.
- When considering the match outcomes, there was only one drawn match, which may skew the findings.
- The team examined is strong, and therefore played against more weaker teams than stronger teams.
- The set speed zones should be reconsidered in terms of the common practice within the research field.

6.4 Direction of future research

This research only examined the external loads of one university rugby union team playing in the FNB Varsity Cup from 2016 to 2018, and it investigated how match influencing factors may have affected the match demands on the players.

Further research could examine the following:

- Including more teams to get a better overview of the trends.
- Include more locomotive characteristics such as accelerations and decelerations.
- Including the use of video-based performance analysis in the results for the research to establish more specific running positional profiles of university rugby players..

- Examining how law variations and other match influences may impact the external loads on players at professional and international levels.
- Future studies should make a longer-term study which can examine how long it takes a team to adapt to a certain law variation and how that affects the team in term of external loads.
- Additional match influencing factors could be assessed and compared in order to reveal how they affect the external loads on players.
- Future studies should involve technical indicators to obtain a better understanding of the effects of match influences.

6.5 Summary

This chapter focused on concluding the four research objectives of this study. Furthermore, recommendations, limitations and possible future research directions were discussed.

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APPENDICES

Appendix A: Summary of the law changes from 2015 to 2018, including the reasons for their introduction

Law Variation	Explanation	Reasoning	Year of implementation and discontinuation
Offside line for scrum half	The scrum half may not go past the middle of the scrum, compared to when the ball is considered as the offside line.	To create space and promote more attacking rugby.	2015–Present
Free catch	Any catch made by a player from any kick in the air (except from a kick-off or restart of the match) means that a free kick will be awarded for the receiver right away. The receiver/defender does not have to call a mark; however, the referee will play advantage and have the ability to bring the play back to the point where the catch was made if an advantage has not been gained, and can then award a free kick to the receiver's team.	To reduce the number of kicks in the game and promote "intelligent" kicking strategies.	2015–Present
Red Card	If a player is sent off for a red card offence, another player may replace that player after 15 minutes. The player sent off may not return, but any other player may take his place.	To ensure that a red card does not "end a contest" for the teams and spectators.	2017–Present
White Card	The white card can be requested by a team when they dispute a decision from the referee. This system is only used in the semi-finals and finals. The white card may only be called once per half. A team can retain their review if they were correct. In 2015, this law was used in all matches. From 2016 onwards, this law was only used in the semi-finals and finals.	To ensure that a clear and obvious mistake is not missed by all match officials.	2015 2016–Present

Power Play	The power play entails that you may remove any two nominated backline players from the opposition for a period of three minutes playing time. Only the team calling the power play may nominate who will leave the field. These players may only re-join the match after three minutes playing time and may only return from their own dead-ball line. A hooter will sound the start and end of the power play. If the defending team scores a try during this play, they will be awarded two extra points. The power play may only be taken in your own half of the field. It must be called before the start of a first phase. It must be taken before the strategy break in the 2nd half. If the team has not taken a power play, it will be nominated directly after the strategy break when that team is in their own half and at the start of a first phase (scrum or lineout) or as soon as a yellow/red-carded player returns. This will be indicated by the referee. Each team only gets 1 power play in a match. It may not be called whilst the opposition is a player down due to a yellow card or red card. A power play may be taken by the team that conceded a try or successful penalty kick to the posts. The restart in play may be anywhere inside their own half with the following provisions. A scrum may only be taken between the 15m line and line of touch. The lineout option may take place anywhere inside their own half of the field.	To create some excitement and talking points in the game. To promote opportunities to attack.	2018–Present

Point of Origin	Teams earn extra points for a try if the run originates in their own half of the field. They can only earn the bonus points if they retain possession throughout. In 2016, if a team scored a try after starting to run from behind their own 22 m line, they received 9 points. If they started to run from anywhere between their 22 m line and the opposition’s 22 m line, they received 7 points. If they scored after starting to run from within the opposition’s 22 m area, they received 5 points. In 2017, if a team scored a try after starting to run from within their own half, they received 7 points, and if they started running from within the opposition’s half, they received 5 points.	To promote attacking rugby and encourage teams to hold on to possession.	2016 2017–Present
Point-scoring System for Kicks at Goal	In 2015, a team received 3 points for a successful conversion and received 2 points for a penalty or drop goal. In 2016, the law changed back to the normal scoring system used globally.	To encourage teams to attack and score tries rather than kick for the posts when awarded a kickable penalty.	2015– (discontinued)

Strategy Break	There is a 2-minute break in each half. The referees will call it between the 18th and the 22nd minute of each half, with some discretion depending on the passage of play. The coaches are allowed to enter the field during this break.	To enable coaches to change or discuss strategy with their teams. It is also a water break for teams. Bear in mind that the Varsity Cup starts at the end of January, which is in the middle of the South African summer, with temperatures reaching the mid-thirties degrees Celsius.	2018 –Present

Appendix B: Certificate of Editing from Cambridge Proofreading

EDITORIAL CERTIFICATE

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Appendix C: Letter from Higher Degrees Committee

FACULTY OF HEALTH SCIENCES
HIGHER DEGREES COMMITTEE

29 October 2018

TO WHOM IT MAY CONCERN:

Student: GORDON, G
Student Number: 201471851

TITLE OF RESEARCH PROPOSAL: The Impact of Law Changes on Match Loads in University Rugby Union Players during the FNB Varsity Cup

DEPARTMENT OR PROGRAMME: **SPORT AND MOVEMENT STUDIES**

SUPERVISOR: Dr H Morris- Eyton **CO-SUPERVISOR:** Dr NA Kubayi

The Faculty Higher Degrees Committee has scrutinised your research proposal and confirms that it complies with the approved research standards of the Faculty of Health Sciences; University of Johannesburg.

The proposal has been awarded a Code 2A – Approved with suggestions, without re-submission. Attached recommendations were made by the Committee which will add value to your proposal.

Please make these amendments to the satisfaction of your supervisor/s and submit a corrected copy of the proposal to the Faculty Research Administrator after which your clearance number will be issued.

The HDC would like to extend their best wishes to you with your postgraduate studies.

Yours sincerely

Prof H Abrahamse
Vice Chair: Faculty of Health Sciences HDC
Tel: 011 559 6550
Email: habrahamse@uj.ac.za

Appendix D: Letter of Ethical Clearance

FACULTY OF HEALTH SCIENCES
RESEARCH ETHICS COMMITTEE

NHREC Registration: REC 241112-035

ETHICAL CLEARANCE LETTER
(RECX 2.0)

Student/Researcher Name	Gordon, G	Student Number	201471851
Supervisor Name	Dr H Morris- Eyton	Co-Supervisor Name	Prof Y Coopoo
Department	Sport and Movement Studies		
Qualification	M9S06Q		
Research Title	The Impact of Law Changes on Match Loads in University Rugby Union Players during the FNB Varsity Cup		
Date	30 October 2018	Clearance Number	**REC-01-159-2018**

Approval of the research proposal with details given above is granted, subject to any conditions under 1 below, and is valid until 31 January 2019.

1. Conditions:
None

2. Renewal:
It is required that this ethical clearance is renewed annually, within two weeks of the date indicated above. Renewal must be done using the Ethical Clearance Renewal Form (REC 10.0), to be completed and submitted to the Faculty Administration office. *See Section 12 of the REC Standard Operating Procedures.*

3. Amendments:
Any envisaged amendments to the research proposal that has been granted ethical clearance must be submitted to the REC using the Research Proposal Amendment Application Form (REC 8.0) prior to the research being amended. Amendments to research may only be carried out once a new ethical clearance letter is issued. *See Section 13 of the REC Standard Operating Procedures.*

4. Adverse Events, Deviations or Non-compliance:
Adverse events, research proposal deviations or non-compliance must be reported within the stipulated time-frames using the Adverse Event Reporting Form (REC 9.0). *See Section 14 of the REC Standard Operating Procedures.*

The REC wishes you all the best for your studies.

Yours sincerely,

Prof. Christopher Stein
Chairperson: REC
Tel: 011 559 6564
Email: cstein@uj.ac.za

Secretariat: Ms Raihaanah Pieterse
Tel: 011559 6073 email: rpieterse@uj.ac.za

Appendix E: Memorandum for permission of the use of data from the University of Johannesburg

MEMORANDUM

To: Heather Morris-Eyton

From: Marianne Viljoen
Senior Manager: Performance Excellence

Date: 01/010/2018

Subject: Permission Granted for Data Use

This letter is to grand permission for Data usage, collected by the Rugby Strength and conditioning coach within the UJ Sport Performance Excellence Unit over a period of three years.

No names to be revealed within this study.

Regards,

Marianne Viljoen
UJ Sport: Senior Manager Performance Excellence
011 559 3362
mariannev@uj.ac.za

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Appendix F: Letters for Plagiarism

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